Sinimaaria Ranki

Exchange Rates in European Monetary Integration

SUOMEN PANKKI
Bank of Finland

BANK OF FINLAND STUDIES E:9 • 1998

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Abstract

This study, "Exchange Rates in European Monetary Integration", is an empirical contribution to exchange rate theory and international monetary cooperation. The first essay, "Realignment expectations in the ERM: 1987-1992", studies the five-year period of convergence and stability in the European Monetary System (EMS). Existing literature on target zones is utilized to model and estimate devaluation expectations. The results suggest that the exchange rates gained credibility towards the end of this five-year period. German Monetary Unification (GMU) initially had positive spill-over effects on partner countries. Later these effects reversed and the system became increasingly burdened by the consequences of high German interest rates.

The second essay, "Monetary policy in the ERM: Internal targets or external constraints?", focuses on the role of the membership in the Exchange Rate Mechanism (ERM) as a determinant of monetary policy. We derive a monetary policy rule that trades off costs of interest rate instability against benefits from successful demand management and stable exchange rate in the ERM. The model is then used to interpret the empirical evidence from a VAR estimated on data from the member countries. The three main observations emphasized are the relatively stable role of the domestic variables, the declining importance of the foreign variables and the growing importance of domestic interest rate history as a determinant of monetary policy decisions.

The content of the third essay, "On monetary policy in a bipolar international monetary system", focuses on the possible difficulties in reconciling a domestic inflation target with exchange rate stabilization when the currency is an international key currency. We analyse the international transmission of shocks, and the role of the exchange rate therein, within the framework of a model of two large symmetric open economies. The model's implications are then discussed in the context of the empirical evidence from a VAR estimated on data from Germany and the US. From the model's perspective, the inflation rate seems to be driven by domestic supply shocks in both countries. If the initial source of the disturbance is a US supply shock, Europe can stabilize the exchange rate only at the cost of domestic price stability. Alternatively, Europe has to let the exchange vary to sustain domestic price stability.

Keywords: ERM, exchange rates, devaluation expectations, reaction function, monetary policy, international spillovers

Tiivistelmä

Tutkimuksessa tarkastellaan valuuttakurssiteoriaa empiirisesti sekä analysoidaan häiriöiden välittymistä kansainvälisessä valuuttajärjestelmässä. Ensimmäisessä esseessä käsitellään Euroopan valuuttajärjestelmän (EMS) vakaata viisivuotiskautta 1987—1992. Devalvaatio-odotukset johdetaan käyttäen hyväksi tavoitevyöhykemallia. Tulosten mukaan valuuttakurssien uskottavuus kasvoi tarkastelujakson loppua kohden. Saksan yhdentymisellä oli positiivisia vaikutuksia myös naapurimaihin, mutta vaikutusten hävittyä Saksan korkean korkotason seuraukset kävivät pian kestämättömiksi.

Toisessa esseessä tarkastellaan valuuttakurssimekanismin osuutta rahapolitiikassa. Tarkastelut perustuvat rahapolitiikan sääntöön, jossa painottuvat korkovaihtelun haitat ja onnistuneesta kysynnän säätelystä sekä valuuttakurssin vakaudesta saatavat hyödyt. Mallin avulla tulkitaan vektoriautoregressiivisen (VAR) mallin estimointituloksia. Tulokset osoittavat, että kotimaisten muuttujien merkitys on säilynyt suhteellisen vakaana, ulkomaisten muuttujien painoarvo on vähentynyt ja kotimaisen korkohistorian merkitys kasvanut rahapoliittisessa päätöksenteossa.

Kolmannessa esseessä pohditaan mahdollisia vaikeuksia, joihin kansainvälisen avainvaluutan keskuspankki voi joutua tasapainoillessaan inflaatiotavoitteen ja valuutan vakauden tavoitteen välillä. Valuuttakurssin merkitystä rahapolitiikassa analysoidaan kahden suuren avotalouden mallilla. Teorian avulla tulkitaan VAR-mallin estimointituloksia kahden suuren avotalouden, Yhdysvaltojen ja Saksan, havaintoaineistossa. Tulokset viittaavat siihen, että pääasiallisesti kotimaiset tarjontahäiriöt aiheuttavat muutoksia inflaatioon. Jos häiriön alkuperäinen lähde on tarjontahäiriö Yhdysvalloissa, Eurooppa voi vakauttaa valuuttakurssin vain uhraamalla kotimaisen hintavakauden. Vaihtoehtoisesti Euroopan täytyy hyväksyä valuuttakurssin epävakaus, mutta säilyttää kotimainen hintavakaus.

Asiasanat: ERM, valuuttakurssit, devalvaatio-odotukset, reaktioyhtälö, rahapolitiikka, kansainväliset riippuvuudet

Acknowledgments

Exchange rate theory and experiences with the European Monetary System (EMS) in particular, have been close to my heart since I spent a scholarship term at the Gothenburg School of Economics and Commercial Law in 1990. During seven years I have enjoyed the fascinating world of exchange rates. I have been lucky enough to deepen my knowledge in the theory and to work with real-world applications. As I started my career at the Bank of Finland in 1993, I was priviledged to prepare the Finnish participation in the EMS, which was a most exciting and challenging task. In 1994, I had the opportunity to spend three months at the Commission of the European Communities, where we analyzed the possible design of the international monetary system after the single currency has been introduced in Europe. In 1996–1997, I worked at the Research Department of the Bank and the Bank generously allowed me to devote myself full-time to exchange rate theory. The result of this period in the Research Department is this Doctoral Dissertation. With it I have fulfilled my lifelong dream: when I used to visit my older sister Annamari as a child, I always used to play with her doctoral sword and dream of having one of my own one day. Now that dream will come true.

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Sinimaaria Ranki
Helsinki, January 1998

Contents

1 Introduction

There is a long tradition of research in international monetary arrangements, that is, exchange rate regimes. Roughly, these studies fall into three groups. The first group is concerned with developing theoretical models of exchange rate determination. The second group is involved with empirical testing of exchange rate behaviour. The third group focuses on analysis of international shock transmission, the appropriate exchange rate regime for a single country or group of countries and models of international monetary cooperation. The three essays in this study range over both the second and third group, which is to say that the analysis presented is both empirical and forward-looking. The essays are entitled "Realignment expectations in the ERM: 1987–1992", "Monetary policy in the ERM: Internal Targets or External Constraints?" and "On monetary policy in a bipolar international monetary system."

The European Monetary System (EMS) provides challenging, many-sided empirical research material in the field of exchange rate theory. Basically, the EMS is an agreement among the central banks of the European Union (EU) to stabilize exchange rates in the EU area. At the centre of this agreement is the Exchange Rate Mechanism (ERM), whereby the participating currencies have fixed central parities vis-à-vis each other. From the standpoint of exchange rate theory, the ERM is premised on a traditional view of openness that says that when there is a substantial amount of internal trade among a group of countries, it is beneficial to all of them to fix their relative exchange rates among themselves. The argument here is that when agents are freed of exchange rate risk, the resulting exchange rate stability will promote trade.

Obviously, ERM-like systems have serious implications for monetary policy. Once exchange rates are commonly agreed, no participant country can gain competitiveness with respect to other participants by devaluing their currency to lower the price of their exports.

Exchange rate theory has evolved beyond the simple distinction of fixed and floating rates. This is due in part to the ERM experience, which has yielded a great deal of empirical material for research, and forced researchers to consider the complexities of a system where the exchange rates are both adjustable and free to move within margins of fluctuation around a central rate. As a result, a good deal of modern exchange rate theory is concerned with two themes. The first is the disinflation process, which in the ERM's case means studying the effects of German dominance. The literature here is concerned with determining whether, in a system of fixed exchange rates, a country suffering from high inflation can actually "borrow" credibility from a country with a strong anti-inflation track record and otherwise successful monetary policies. The second theme is target zone theory. Part of the discussion here involves analysis of devaluation expectations, and the current study addresses this particular issue. We analyse exchange rate management on a global level and, focusing on the current major currencies, postulate what might happen when fourteen European currencies are replaced by a single currency. Surely, in a strongly bipolar world, exchange rate theory discussions will be different than they are today. At the core will be analysis of the relationship the two main currencies, and other issues will likely reflect the degree of capital mobility on a global level. As money moves ever more freely across borders and information technology develops, one could expect that market efficiency and the formation of expectations will be crucial factors in exchange rate determination, leaving even less room than today for traditional underlying fundamentals.

The first essay, "Realignment expectations in the ERM: 1987-1992", examines a five-year period of convergence and stability in the EMS. While the EMS was initially meant to be a symmetric system, soon after its establishment in March 1979, Germany became the anchor currency country. The Deutschmark, or DEM, entered the ERM backed by a long tradition of monetary stability and, via the peg, provided monetary discipline for EMS countries with high-inflation legacies. During the five-year period studied, inflation rates in Belgium, Denmark, France, Great Britain, Italy and the Netherlands converged remarkably to the low inflation rate in Germany. After Germany's unification in July 1990, the convergence process was further helped by a rise in German inflation. The result was a very high degree of inflation convergence, which reflected in diminishing interest rate differentials and increasing exchange rate stability.

Yet, the early successes of the ERM's designers suddenly fell apart in September 1992. A currency crisis forced major realignments; two currencies left the system.

The first essay therefore poses two questions. First, we ask whether the expected rate of devaluation really diminished during this period, as the narrowing interest rate differences indicated. For this purpose, the target zone methodology is applied, whereby the interest rate differential is adjusted with the expected rate of depreciation of the currency within the band to measure the expected rate of devaluation of the central rate. We estimate the expected exchange rate movement within the band by an equation that is consistent with the theoretical derivation of an equation for measuring expected change of the exchange rate within the band. Theory states that the exchange rate always reverts towards the central rate. However, in the regression equation, previous studies have allowed for a constant that implies that the exchange tends to converge towards a level different than the central rate. In this study, we drop the constant. Notably, the results obtained display a smoother movement of the exchange rate within the band than in previous studies. By using the estimation results calculated, we then estimate expected rates of devaluation. Again, the model is shown to perform better without a constant for expected rate of depreciation than with a constant. The results indicate that several exchange rates acquired remarkable credibility towards the end of the five-year period. Nevertheless, impending crisis was not sensed by the markets until a few weeks before the crisis actually hit. The estimates of the expected rates of devaluation, which use no constant in estimation of the spot exchange rate movement, give a slightly better indication of the crisis than earlier models including the constant.

The second question in the first essay asks what factors anticipate or explain the currency crisis in 1992. These factors are identified by regressing the obtained measures for the expected rates of devaluation on selected macroeconomic variables. The constructed model incorporates commonly recognized factors of exchange rate determination. Selection and interpretation are based on previous theoretical and empirical work within exchange rate theory. Crucial variables in the model are the inflation rate differential, relative money supplies, industrial production and foreign exchange reserves of the central bank. None of these variables signals impending crisis, which suggests that the rise in the German interest rate, that is further interest rate convergence, was not the decisive cause of the crisis. The rise was apparently accepted by partner countries because the interest rate effect of German Monetary Unification (GMU) was accompanied by a positive spill-over effect. As excess German demand dampened the slow-down in the business cycles of the partner countries, the contradiction of the anchor country's policy mix with other EMS countries seemed to cause little anxiety. Only after the positive spill-over effects were absorbed were the consequences of higher interest rates perceived.

If any generalization can be drawn here, it is that devaluation expectations start with policy conflicts that are clearly unsustainable over the longer term. Devaluation expectations, in turn, are connected with the credibility of the system as a whole rather than a single exchange rate. Thus, we consider if there might be a threshold after which participation in the system could be considered or expected to bring greater costs than gains. Further, in a situation where changes in variables are immediate and transmitted through the financial markets, the monetary autonomy of the participating countries in the system is considerably reduced. This implies that the system must be experienced as meaningful to get domestic monetary authorities to surrender their autonomy. When the system fails to work in a way that contributes to the goals of domestic authorities, then the likelihood that domestic authorities will continue to commit to the system decreases. When market agents perceive that this threshold has been exceeded, devaluation expectations arise.

The above conjecture brings into question the ability of the target zone methodology to measure the credibility of a fixed, but adjustable, exchange rate system such as the EMS. If the cooperative nature of such a system makes the commitment of domestic authorities to fixed parities more important than the development of single variables traditionally used as determinants in exchange rate models, then it might be worthwhile to identify those elements that diminish political willingness to participate in such a system. In any case, it is clear that target zone models alone cannot be used to test such an assumption. While the literature on speculative attack might provide some help in this respect, this fascinating question must be left for future consideration.

The second essay, "Monetary policy in the ERM: Internal targets or external constraints?", analyses the EMS from 1980 up to mid-1996. The period is divided into three subperiods: 1980-1987, the time of the "adjustable peg"; 1987-1992, the time of "stability"; and 1992-1996, the time of the "wide band". In order to focus on the role of the Exchange Rate Mechanism (ERM) participation as a determinant of monetary policy, a reaction function is constructed for the central banks of selected non-German ERM participants. We derive a monetary policy rule, an interest rate rule, from a minimization problem faced by the central bank. The loss function trades off costs of interest rate instability against benefits from successful demand management and stable exchange rate in the ERM. ERM-related considerations, particularly exogenous effects from German interest rates as well as deviations from the ERM central rates, are introduced into the analysis through the latter channel. Thus, the contribution of this essay is the introduction of the ERM as an individual part in the reaction function.

Participation in the ERM has two dimensions. On the one hand, the central bank tries to minimize devaluation expectations because they have to be compensated for with a higher interest rate, i.e. such expectations are costly. On the other hand, once full credibility is reached, the central bank can choose between holding the exchange rate as close to the central rate as possible or allowing exchange rate variation within the band and thus more stable domestic interest rates. Actions in this dimension are tested empirically using the vectorautoregression (VAR) method. The results show that the restrictiveness of ERM participation on domestic monetary policy has varied. We note the relatively stable role of domestic variables, the declining importance of foreign variables and the increasing importance of the domestic interest rate itself in monetary policy decisions. We also consider the degree of convergence of the countries and divide the countries into groups based on their convergence performance. There are "early-phase" countries, whose economies, and especially whose inflation rates, differ markedly from ERM core countries. In early-phase countries, domestic monetary policy targets dominate and the exchange rate is changed as adjustment is needed. "Intermediate" countries are those whose inflation rates converge towards the lowest level among the participants. In these countries, central banks are not overly concerned with the exchange rate as ERM participation strongly restricts their monetary policy options. Finally, there are the "advanced" countries who have reached a high degree of convergence and, as a consequence, a high degree of credibility. These countries are in a position to let the exchange rate move within the band and thus stabilize domestic interest rates and domestic inflation. At the same time, the influence of the German interest rate is diminished in these countries.

One could interpret EMS history as a gradual acceptance of the belief that the EMS was an implicit coordination mechanism through which countries could improve their interest rate convergence by coordinating their economic policies. Eventually, the EMS evolved into a group of countries with mutually consistent targets with the degree of convergence becoming a transparent indicator of the success of economic policies in each country. At a more general level, this could be interpreted so that – given increasing liberalization of capital mobility – the functioning of a target zone system varies according to the degree convergence among the participating countries.

The content of the third essay, "On monetary policy in a bipolar international monetary system", deals with the possible difficulties in reconciling a domestic inflation target with exchange rate stabilization when the currency is a key international currency. Once EMU is established and the euro, or EUR, is in use, we can expect the international monetary system to develop towards a more pronounced bipolar system based around the USD and the EUR. Such a position of the currency can affect – as previous experience with the USD shows – not only the technical conduct of monetary policy but also monetary policy preferences in the issuing country. We know, for example, that the value of an international currency is determined by demand. That demand, in turn, depends on the stability of the currency, the smooth functioning of the underlying financial markets and the extent to which the currency is used in invoicing in international trade. All these factors can be expected to develop favourably in the case of the EUR: the stated objective of the European Central Bank (ECB) is to maintain price stability; a Europe-wide financial market is larger and more liquid than any of the financial markets in a single EU country; and Economic and Monetary Union (EMU) is expected to become an important trade bloc in the world economy. Given this, it is quite reasonable to expect that the EUR will assume the position of second-most-important currency in the international monetary system.

We then analyse the role of the exchange rate for monetary policymaking. We start by investigating transmission of economic shocks and their consequences for the exchange rate and domestic variables, the inflation rate and output. We construct a symmetric Mundell–Fleming type IS-LM-AS model for two large economies and then apply five kinds of shocks: demand shock, supply shock, money demand shock, money supply shock and a "peso"-type exchange rate shock. We show the qualitative effects of these disturbances on inflation rates, interest rates and output in the two countries as well as the effects on the exchange rate. The analysis indicates that a positive exchange rate shock, a positive money supply shock and a negative money demand shock can all increase domestic prices and weaken the domestic currency. These can all be dealt with straightforward monetary policy responses. We are left with two more problematic cases. Positive domestic demand and supply shocks increase the price level. The demand shock appreciates the currency, while the effect of the supply shock on the exchange rate is a (positive) domestic supply shock can either depreciate or appreciate the exchange rate, depending on whether the goods-market (output) or the money-market (interest rate) effect dominates. This reflects the relative size of two effects. On the one hand, the supply shock increases the price level. This diminishes the real stock of money, and as a consequence, the interest rate rises. Since that interest rate exceeds the equilibrium world interest rate, there is an inflow of capital that tends to appreciate the domestic currency. On the other hand, an increase in the price level diminishes output, because the foreign demand component of demand diminished due to the worsened competitiveness of domestic products in the international markets. To restore this equilibrium, the exchange rate has to depreciate. Thus, the ultimate effect of a supply shock on the exchange rate depends on which of the two effects dominates. Due to this ambiguity, it is possible to have a situation where the target variable's inflation rate and exchange rate require opposite and contradictory monetary policy actions.

In order to get some reflection for the future monetary policy prospects, we analyse the recent experience of two key currency countries, the US and Germany. Germany is taken to represent the future EMU economy, and we use German data only – not a weighted average for the EU – because the EMU starters have yet to be decided and because, as shown in the other essays of this study, Germany has traditionally provided monetary leadership in the EMS. We test the period 1983–1996 and apply the VAR method to see the reactions of all variables to various types of shocks.

The results indicate that the inflation rate is driven by domestic supply shocks in both countries. Theoretically, the effect of a supply shock on the exchange rate is ambiguous. The empirical results show that a US supply shock tends to increase the price level and depreciate the USD. The price level also increases in Germany, implying that Germany faces a combination of higher inflation and an appreciating currency. For the US it does not matter whether monetary policy is directed at stabilizing inflation or the exchange rate, because any policy action directed at stabilizing a target variables also works to stabilize the other. In the German (ie European) case, however, the exchange rate is destabilized. When the initial source of the disturbance is a US supply shock, the European side can stabilize the exchange rate only through sacrificing domestic price stability. Alternatively, the European side can accept the destabilizing effect on the exchange rate while maintaining domestic price stability.

Taken together, the three essays show how the EMS, a target zone system, has evolved as capital mobility has been liberalized. We also have the opportunity to examine the importance of a stable anchor. When capital mobility is restricted, countries having difficulty in achieving monetary stability can peg to the anchor currency to reach lower levels of inflation. When capital mobility is free, speculation can arise quite suddenly if expectations shift. Hence, future policymaking will need to address expectations to make sure that other economic policies are carefully attuned to exchange rate stability policy.

The study ends with a few careful conclusions about the future. Of course, the world with EMU is unknown to all of us, and unforseen events lie ahead. But even with this caveat in mind, we may reflect on the differences in the weights of the monetary policy targets in the US and Germany in a world with EMU. The ECB, for example, could face a dilemma of having to give great weight to building credibility through maintaining price stability while simultaneously maintaining EUR-USD exchange rate stability. Conflicts between domestic targets and the exchange rate target could then lead to dissention between the ECB and the Ecofin Council, the institution of EMU that decides on exchange rate agreements with third countries.

Realignment Expectations in the ERM: 1987–1992

Contents

1 Introduction

1.1 Background

The European Monetary System (EMS) represents an agreement among the participating countries to set exchange rate parities, to manage intra-European Community exchange rates and to finance exchange market intervention. The EMS established intervention rules that would produce a symmetric system of adjustment, create a mechanism to finance exchange market interventions and set out a code of conduct for realigning parities. At the same time, the system does allow for some exchange rate flexibility. This means that the exchange rates can be adjusted if needed. This is expected to occur when the underlying economies differ to such an extent that internal stability can only be re-established by adjusting exchange rate.

Although the agreements establishing the EMS do not specify that the system should be asymmetric, it has been claimed that it has de facto worked asymmetrically with Germany as the center country. This can very clearly be seen from the inflation recod of the EMS countries, as compared to realignments. In the early 1980s, inflation differentials were wide, and realignments were frequent. The lowest inflation rate was in Germany, and the DEM was, thus, never devalued against any other EMS currency. Toward the end of the 1980s, inflation rates in the non-German EMS countries declined, and, as a result of this inflation rate convergence, also the need to adjust the exchange rates diminished. In 1990, this convergence was reinforced, as the German inflation rate started to rise due to the German Monetary Unification (GMU). Many of the EMS countries reached zero inflation differentials against Germany, and the very beginning of the 1990s was regarded as a period of historical exchange rate stability.

However, in autumn 1992 the system surprisingly fell into turmoil. The GMU required a policy-mix in Germany that suited badly in the business cycles of the other EMS countries. As the positive spill-over effects of the GMU faded, the discrepancy of the business cycles was suddenly there: the prevailing exchange rates were experienced, by the markets at least, as too strong a restriction in a situation where room for different economic policies was needed. Market agents became doubtful about the willingness of some EMS countries to continue their commitment to the exchange rate rule. The liberalization of capital movements made speculation possible to an unprecedented extent. The difficulties lasted one year, until in August 1993 the EMS was radically changed. A joint decision of the member states led to the fluctuation bands around the central parities being extended from ± 2.25 % to ± 15 %.

1.2 Purpose of the study and methods of analysis

The purpose of this study is to analyze the credibility of the EMS in the five-year period during which no realignments were made. In its early years the EMS served as a flexible system that allowed for a nominal exchange rate adjustment when the real variables so indicated. In the mid-1980s, attitudes changed. Exchange rate realignments were no longer an automatic solution to domestic economic needs; rather, the EMS was used as a disciplinary framework to support the stability-oriented goals of domestic monetary policy makers. Hence, it is of general interest to understand how nominal exchange rates remained unchanged in the late 1980s and early 1990s. If the exchange rates remained unchanged for five years because of a stronger political commitment to the EMS, stability was due to an administrative decision to keep the parities unchanged, regardless of how the economies of the member states developed. In this case, one could have expected greater interest rate differences as a result of increasing devaluation expectations. On the other hand, if the reason truly was increasing convergence and stability in the underlying economic factors, then one wonders what actually caused the upheavals on the European foreign exchange markets in the autumns of 1992 and 1993.

In a situation where changes in variables are immediately and correspondingly transmitted through financial markets, the monetary autonomy of the participating countries in the system is considerably reduced. This implies that the system must be looked on as meaningful in order for the domestic monetary authorities to be ready to give up their autonomy. If the system does not contribute to the goals of the domestic authorities, then the willingness of the authorities to commit themselves to the system decreases. Such a situation could be one where an asymmetric shock hits the system. Within the EMS, GMU was such an asymmetric shock: it reversed the business cycle in Germany, and the effects spilled over into other EMS countries in the short term, (but this could not prevent recession in the rest of the EMS). As a consequence, Germany conducted a monetary policy adequate to cope with its domestic problems, whereas the other countries could only let the effects be transmitted into their domestic economies.

This simple method is then developed further. By using a model that breaks the interest rate differential into two components, the expected rate of depreciation within the allowed fluctuation band and the expected rate of depreciation of the central parity rate, we arrive at a measure for the credibility of the exchange rate. We estimate the expected rate of depreciation of the exchange rate within the band, subtract the results from the interest rate differential and obtain values for the expected rate of devaluation.

Finally, the estimated values for the expected rate of devaluation are regressed on selected macroeconomic variables in order to find out the extent to which the expected rate of devaluation depends on economic fundamentals. Since we know that no exchange rate model performs perfectly, we build the model here by including the most common important factors for determining the exchange rate. Judgement is based on information from previous theoretical and empirical works within exchange rate theory.

1.3 Outline of the study

In Chapter 2 a model to measure devaluation expectations in the EMS exchange rates is constructed. In Chapter 3 potential explanations for the behaviour of the expected rates of devaluation are analyzed. We use standard exchange rate theories in order to find macroeconomic variables that affect the actors' devaluation expectations. The results indicate that due to GMU the needs for monetary policy in Germany had become very different from those in the other countries. Germany's economic policy on the eve of the crisis was characterized by slightly loose fiscal policy and tight monetary policy. Despite a slow growth in output in Germany, the chances of German interest rate cuts seemed bleak. The growth of the German money supply was still above the target range and the inflation rate was considered too high. Markets are sensitive to such conflicts over the appropriate course of monetary policy in an area of fixed exchange rates, and may have reasoned that the anchor country would have preferred a realignment of the DEM to a reduction in German interest rates. That, in addition to the cumulative losses of competitiveness in some EMS countries with relatively high inflation rates and the constraints on interest rate increases in some weak-currency countries, clearly presented speculators with a "one way bet" that merely fuelled exchange market pressures. The rejection of the Maastricht Treaty in the Danish referendum in June 1992 finally triggered the first crisis, raising expectations among speculators that Economic and Monetary (EMU) would be delayed beyond the date set by the Maastricht Treaty. This would make commitment to the EMS meaningless in a situation where the anchor country was experiencing recession and applying a policy mix that did not correspond to the needs of the partner countries.

Finally, Chapter 4 provides a summary of the study, concluding with a discussion of the main results of the empirical aspects of the study. In general, the spot exchange rate can remain stable quite independent of devaluation expectations, and devaluation expectations, in turn, are not observed as long as certain underlying macroeconomic variables converge. If the empirical results of this study can be generalized, they indicate that devaluation expectations become visible first when there are obvious policy conflicts, and these conflicts are considered as unsustainable over the longer term. Moreover, it is natural to think that devaluation expectations relate to the attractiveness of a system as a whole rather than a single exchange rate. In other words, a system must be experienced as meaningful: if it does not contribute to the goals of domestic authorities, the willingness of those authorities to commit to the system decreases. When the market agents think that that threshold has been exceeded, devaluation expectations arise.

2 Survey of target zone theory

The idea of analyzing the importance of the existence of a target for the exchange rate was introduced by Krugman (1991), who found that in a target zone, the exchange rate behaves in a very special way because of the band. Given that an announced target zone is credible, the exchange rate within the band is a non-linear function of macroeconomic fundamentals; the famous S-shape exchange rate function reflects smooth pasting at the edges of the band, which, in turn, results from arbitrage. Flood & Garber (1989) introduced interventions in their analysis of exchange rate behaviour within a target zone. Their analysis allows both discrete interventions and the possibility that intervention may be triggered randomly. The exchange rate is treated as an asset price, ie the exchange rate is represented as a present value of future expected macroeconomic fundamentals derived from a monetary model. The forcing variable, which is described as a linear combination of macroeconomic fundamentals, follows a random walk with a drift that is independent of the exchange rate. The main conclusion of the analysis is that within such a framework, the exchange rate is a non-linear function of the forcing variable. In other words, the analysis is focused on the behaviour of the exchange rate at the limits of the announced fluctuation band.

The underlying assumptions of the elegant pioneer work do not, however, reflect reality. Empirical work shows turn that, first, target zones are not always credible and, second, central banks also intervene intramarginally. These problems, as well as their implications have been analyzed and discussed by Svensson (1991a,b,c), whose empirical work does not support the hypothesis of an S-shaped exchange rate function. The analysis further shows that in a target zone model, mean any type of intervention, including intramarginal interventions, gives rise to mean reversion.[1]

Svensson (1991c) extends the standard target zone to include the possibility of devaluation. Devaluations are assumed to reoccur with some given constant probability, regardless of where in the band the exchange rate lies. The fundamental can move either to the edge of the new band, or to somewhere inside the new band. The devaluation is, however, the same jump in both the fundamental and its lower and upper bounds. The aim of the paper is to analyze the effect of such a devaluation risk on the interest rate differential. The result is that the constant expected rate of devaluation is added to the interest rate differential. The empirical implication of the model is that a measure of devaluation expectations can be extracted from interest rate data.[2]

A recent finding in the target zone literature is that the interest rate differential, as such, as a measure of expected realignment, is imprecise. In their pioneer work on devaluation risk in a target zone, Bertola & Svensson (1990) and Svensson (1990, 1991), found mean reversion in the exchange rate within the band and showed that the expected rate of devaluation is very close to the interest rate differential

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[1] Similar results were obtained by Miller & Weller (1991), who analyze the behaviour of the exchange rate in a target zone at the limits of the band. Their study shows that when a nominal currency band is given, the exchange rate can spend finite periods of time at the top or bottom of the band. The model also allows for discrete realignments of the band, defined so that whenever the exchange rate hits the top or bottom of the band, the band will be shifted upwards or downwards by an amount equal to half the total width of the band. This extension of the model shows that there is no smooth-pasting in the transition because of the locally irreversible nature of the regime shift.

[2] See eg Svensson (1991a).

adjusted for the expected depreciation within the band. This result is derived below following the presentation in Svensson (1991a).

2.1 Modelling devaluation expectations

A problem with measuring devaluation expectations with the interest rate differential is that the interest rate differential is affected by both the possibility of a realignment and the possibility of exchange rate movements within the bilateral ERM bands. Hence, it is necessary to adjust the interest rate differentials to obtain reliable measures of devaluation expectations.

The covered exchange rate parity is revised for two identical investment alternatives with the same maturity j

$$(r-r^*)_t = \frac{E(s_{t+j}-s_t|I_t)}{j} + \rho \tag{2.1}$$

where the interest rate differential, $(r-r^*)_t$, equals the expected (average) rate of depreciation of the domestic currency, $E_t(s_{t+j} - s_t)$, during the time interval j corresponding to the maturity and conditional upon a given information set at time t, I_t and ρ is the exchange rate risk premium. The exchange rate risk premium, ρ, has been shown by Svensson (1991b) to be negligible within the EMS. The expected rate of depreciation, $E_t(s_{t+j} - s_t)$, can then be decontracted into two parts: expected change in central parity an expected change in the percentage deviation from central parity:[3]

$$E(s_{t+j}-s_t|I_t) = E(c_{t+j}-c_t|I_t) + E(x_{t+j}-x_t|I_t) \tag{2.2}$$

If the exchange rate band was completely credible, $E(c_{t+j} - c_t)$ would equal zero, and the interest rate differential be a maximum 2.25 % per respective period. In that case, the method of studying the interest rate credibility bands could be applied without further adjustments.

[3] The expected change of the central parity is the expected rate of devaluation. It is equal to the product of the probability of a realignment and the expected size of the realignment. When a realignment takes place, the central rate, thus, undergoes a discrete change. However, it is convenient to assume that the exchange rate position within the band is unchanged by a realignment. This leaves the analysis of the movements of the exchange rate within the band unaffected from the technical change of the central rate.

Equation (2.2) also shows that in order to trace devaluation expectations, the interest rate differential has to be adjusted for the expected exchange rate movement within the band, $E(s_{t+j} - s_t)$ so that:

$$E(c_{t+j}-c_t)=(r-r^*)-E(s_{t+j}-s_t) \qquad (2.3)$$

The difficulty is finding a value for Δs^e. In the analysis, the risk premium is defined as proportional to the instantaneous variance of the exchange rate. These properties imply that the risk premium is bounded by the instantaneous standard deviation of the exchange rate. This means that for small bands, when the exchange rate's responsiveness is insignificant, the risk premium does not have any substantial effect on the exchange rate function. This applies also for large bands. Hence, we are left with the problem of calculating Δs^e. In this study, the method suggested by Lindberg, Svensson & Söderlind (1991) and Rose & Svensson (1991) will be used. Their combined results indicate that a simple linear regression of realized rates of depreciation within the band on the current exchange rate consistently generates sensible results.[4] Thus, using simple linear regression the expected rate of depreciation may be obtained from the equation

$$\Delta s_t = \alpha + \beta s_{t-j} \qquad (2.4)$$

The estimates for α and β are then used in order to calculate the expected change of the spot exchange rate:

$$\Delta s^e_{t+j} = \hat{\alpha} + \hat{\beta} s_t \qquad (2.5)$$

2.1.1 The role of the constant

Equation (2.4), however, leaves us then with the problem of interpreting α. If the expected change of the exchange rate within the band depends on the position of the exchange rate in the band, then a change should be expected only when the spot exchange rate deviates from the central rate. But if the spot exchange rate equals the central rate, then there is no reason to expect a change in the spot exchange

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[4] Flood et al. (1990) also report that the presence of additional non-linear terms does not produce better "ex-post" forecasts than those of linear models. Siklos & Tarajos (1996), in turn, add political events as explanatory variables for the expected rate of depreciation within the band. They find that GMU, the Basel-Nyborg accord, and national elections had a significant impact on expectations of depreciation.

rate. However, if we allow for a constant in the equation, we allow the equilibrium exchange rate to be different from the central rate. This can be seen if we solve equation 2.4 for the spot exchange rate. By writing

$$\Delta s_t^e = s_{t+1} - s_t \tag{2.6}$$

inserting this into equation 2.4, and knowing that s_{t-j} denotes the deviation of the spot rate from the central rate, we can rewrite 2.4 as

$$s_{t+1} - s_t = \alpha + \beta(s_t - c_t) \tag{2.7a}$$

Solving equation 2.6 for the steady state exchange rate, $\bar{s}$ (= s_{t+1} = s_t) say, yields

$$\beta\bar{s} = \beta\bar{c} - \alpha$$
$$\Rightarrow \bar{s} = \bar{c} - \frac{\alpha}{\beta} \tag{2.7b}$$

Hence, the exchange rate always converges towards a value different from the central rate, if α is different from 0.

A significant value for the constant would, thus, contradict the theoretical derivation of the equation for the expected exchange rate change within the band. The theoretical model assumes that, within the band, the exchange rate always displays reversion to the central rate. However, if we allow for a constant in the regression equation, we allow for the possibility that the long-term equilibrium exchange rate is different from the central rate. Even though this is, in practice, possible, it cannot be given an interpretation within the present model. Hence, in order to be consistent with the theoretical derivation of the estimation of the expected exchange rate movement within the band, the constant should be dropped from equation (2.4).

In other studies the constant is included in the regression but is not the subject of special discussion. In Svensson (1991a), a regression is run for the period from 1987 to 1990. The slope is kept constant throughout the period, whereas the constant is allowed to vary between realignments. It is then interpreted as measuring the degree of mean reversion in various regimes. Rose & Svensson (1991) also use a dummy constant to characterize different regimes.[5] As the period of the

[5] Siklos & Tarajos (1996) apply the method of letting the constant vary across regimes. They argue that the probability of a devaluation, which is reflected in the constant, should decrease from regime to regime if the target zone is credible and the underlying fundamentals remain unchanged.

current study, however, constitutes a single homogenous non-realignment period, it is not necessary to distinguish between various regimes. Thus, equation (2.4) is also estimated so that the constant is dropped.[6]

2.2 Empirical results

In order to test devaluation expectations within the EMS, we estimate equation (2.4) for a maturity of three months. Regressions are run separately for each of the seven DEM exchange rates: BEF, DKK, ESP, FRF, GBP, ITL and NLG. Since the evaluation is conditional upon no realignment, three observations before each realignment are excluded. The data is compiled as follows. The end-of-month spot exchange rates are taken from International Financial Statistics, while three-month interest rates are from Reuters. Bilateral exchange rates were obtained by calculating the cross rates over the ECU market rates. The period covers the five-year non-realignment period from January 1987 to September, 1992.[7] This is the longest continuous interval in the EMS history without realignment.

The results are presented in Table 2.1. In the case of the ITL/DEM exchange rate, we have also run a regression with a regime dummy. In October 1990 the band width was narrowed from ± 6 % to ± 2.25 %. To see whether this regime shift had any major effect on the credibility of the ITL/DEM exchange rate we include dummy in one regression for this regime shift. Otherwise, columns 1 and 3 in Table 2.1 show the results for the regressions with a constant, and columns 2 and 4 display the results of the regressions without allowing for a constant. Plots of

[6] An attempt was also made to capture speculative pressures in the expected rate of depreciation within the band. Regressions of equation (2.4) were modified so that the level of foreign exchange reserves was included. Low foreign exchange reserves may cause doubts about the ability of the central bank to defend the exchange rate parity, provoking speculative attacks. Also the interest rate differential was included as an explanatory variable in order to capture the existence of speculative pressures. The probability of a regime change is expected to rise with an increase in the interest rate differential. As reported by Ötker & Pazarbasioglu (1994), periods immediately prior to a regime collapse are usually characterized by the existence of high domestic interest rates and increased deviation of the spot exchange rate from its central parity. The results did not, however, yield any further information on the expected behaviour of the exchange rate within the band.

[7] The period for the ESP/DEM and GBP/DEM exchange rates is limited by the shorter participation of these currencies in the ERM. The ESP joined the ERM in June 1989 and the GBP joined in October 1990.

the resulting time series are presented in Figures 2.1a–g. Figures 2.2a–g present the results of the regressions without α. The scale is the same for all exchange rates and is constructed so that the bounds correspond to an annual expected depreciation within the band of 5 % more.[8] We see that the expected rates of depreciation within the band are sizeable, usually around one per cent annually, although occasionally they are as large as around four per cent annually. For this reason, adjusting the raw interest rate differential for the expected rate of depreciation within the band is empirically well founded.

Table 2.1 **Expected future exchange rate within the band. Estimation results of equation (2.4)**

	with constant		without constant	with constant, with dummy			without constant, with dummy	
Exchange rate	α	β	β	α	β	D	β	D
BEF/DEM	.006 (.006)	-.12 (.08)	-.08 (.08)					
DKK/DEM	.005** (.002)	-.45** (.12)**	-.21** (.09)					
ESP/DEM	-.03** (.007)	-.93** (.18)	-.16* (.08)					
FRF/DEM	.006** (.002)	-.62** (.15)	-.26** (.08)					
GBP/DEM	-.014* (.001)	-.87** (.23)	-.31* (.18)					
ITL/DEM	.004** (.002)	-.49** (.14)	-.38** (.14)	0.004* (.002)	-.41 (.23)	-.08 (.30)	-.52** (.21)	.17 (.28)
NLG/DEM	-.00001 (.0003)	-.58** (.20)	-.58** (.19)					

* significant at 5 % level
** significant at 1 % level

The standard errors in the parenthesis are heteroscedastic-consistent, computed by the Newey-West method. This method also allows for serial correlation, which is necessary since the data overlapp.

[8] For the ESP/DEM, GBP/DEM and ITL/DEM, the plot would have extended beyond the top edge of the graph. Therefore, the scale in panels c, d and e is extended.

Figure 2.1a **Belgium, the estimated expected rate of depreciation within the band**

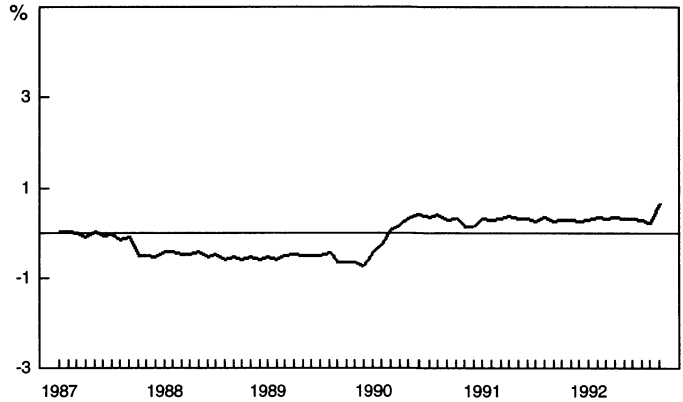


Figure 2.1b **Denmark, the estimated expected rate of depreciation within the band**

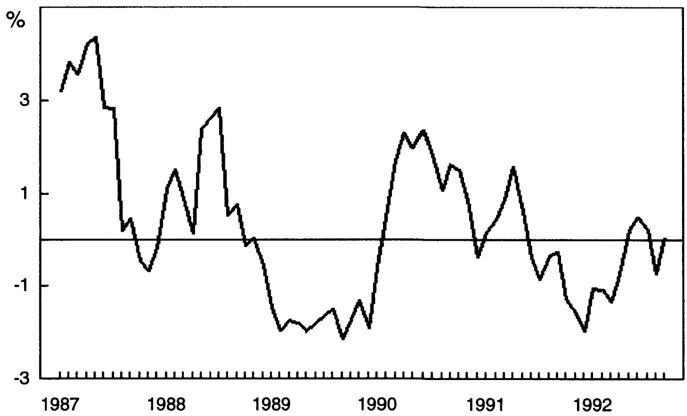


Figure 2.1c **France, the estimated expected rate of depreciation within the band**

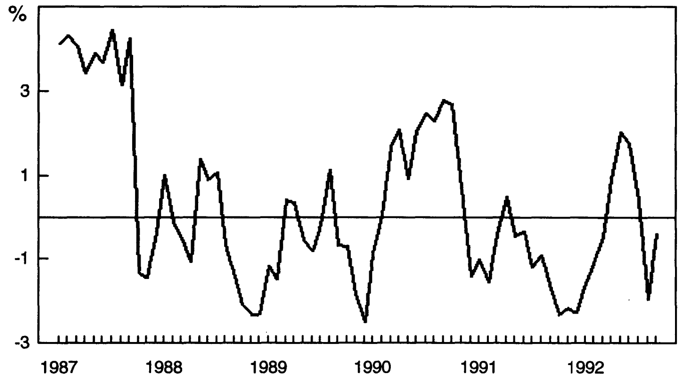


Figure 2.1d **Great Britain, the estimated expected rate of depreciation within the band**

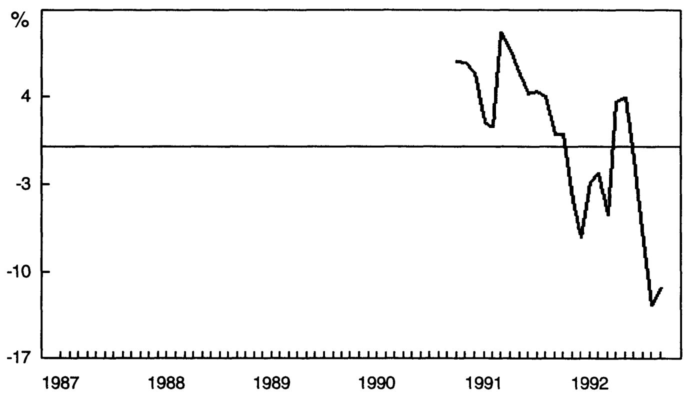


Figure 2.1e **Italy, the estimated expected rate of depreciation within the band**

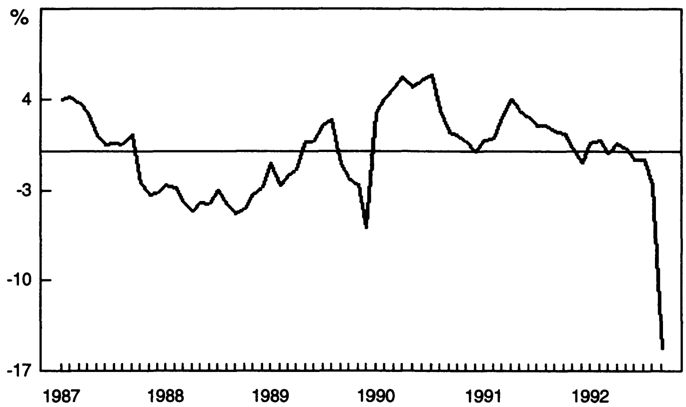


Figure 2.1f **Spain, the estimated expected rate of depreciation within the band**

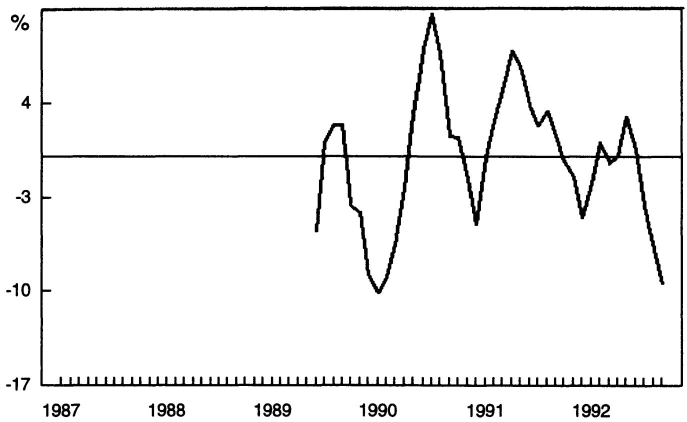


Figure 2.1g **The Netherlands, the estimated expected rate of depreciation within the band**

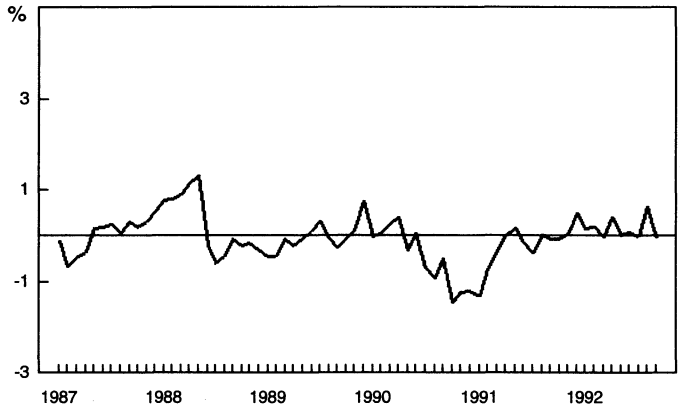


Figure 2.2a **Belgium, the estimated expected rate of depreciation when the constant is not allowed**

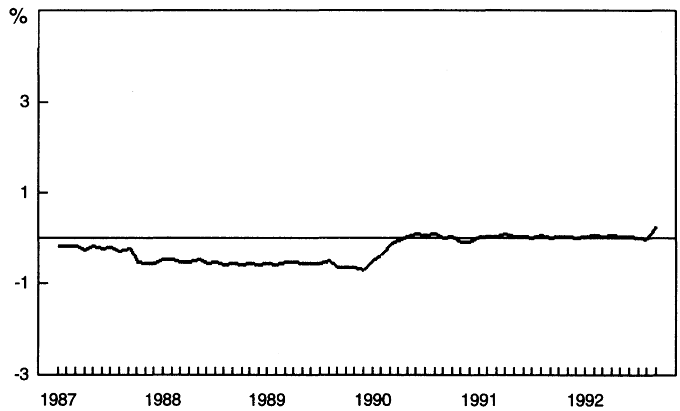


Figure 2.2b **Denmark, the estimated expected rate of depreciation when the constant is not allowed**

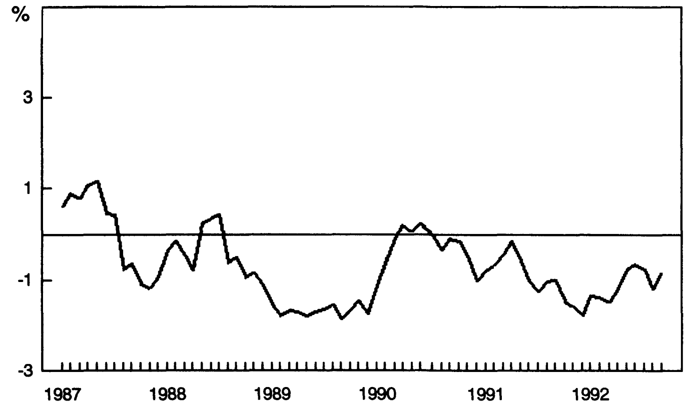


Figure 2.2c **France, the estimated expected rate of depreciation when the constant is not allowed**

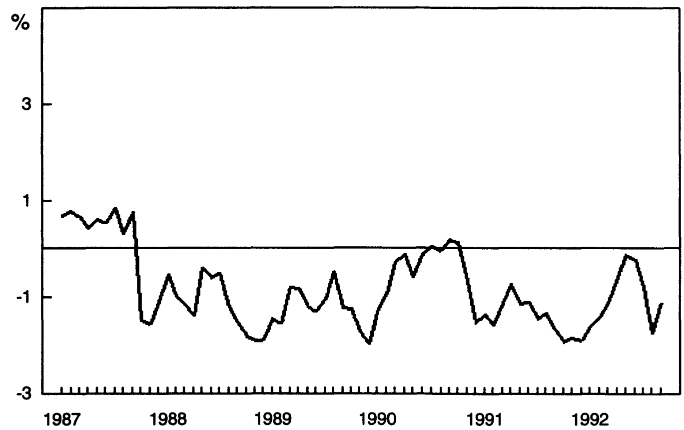


Figure 2.2d **Great Britain, the estimated expected rate of depreciation when the constant is not allowed**

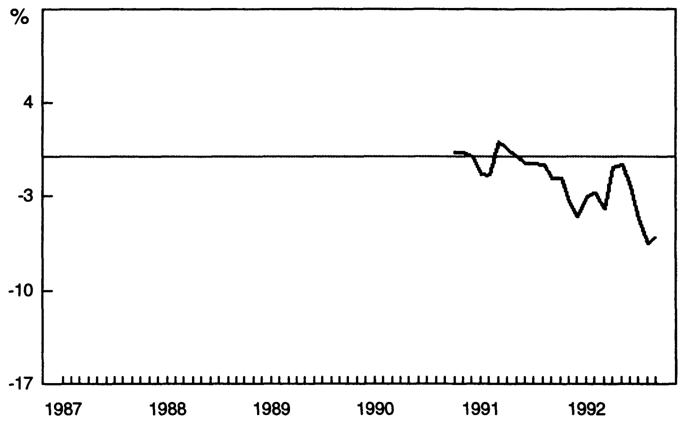


Figure 2.2e **Italy, the estimated expected rate of depreciation when the constant is not allowed**

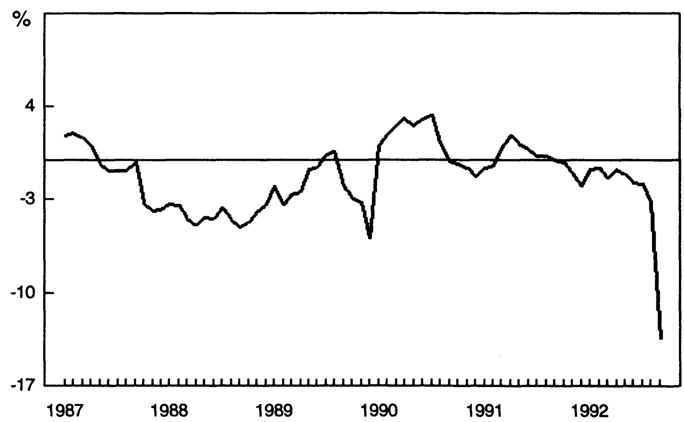


Figure 2.2f **Spain, the estimated expected rate of depreciation when the constant is not allowed**

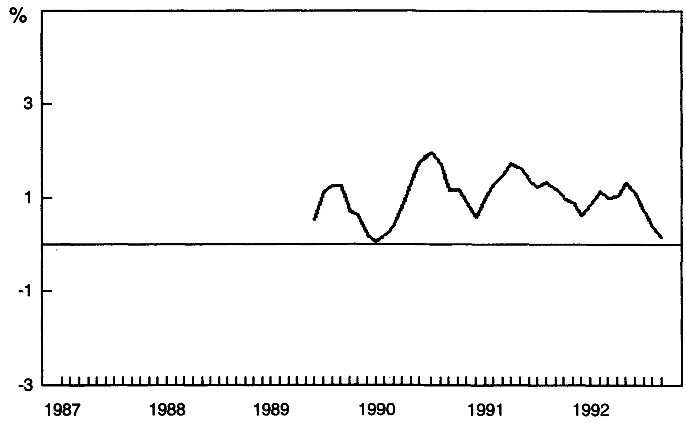
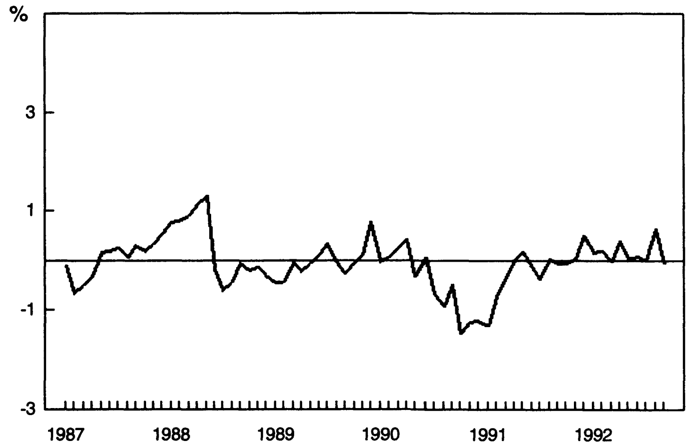


Figure 2.2g **The Netherlands, the estimated expected rate of depreciation when the constant is not allowed**



As stated in Svensson (1991b), equation (2.4) highlights the mean-reversion in the data. The coefficient for the exchange rate within the band, $\hat{\beta}$, is far less than 1. When the expected rates of depreciation within the band are compared with the plots of the deviation of the current spot rate from the central parity (Figures 2.3a–g), a feature supportive of mean reversion and intra-marginal interventions can be observed. When the exchange rate is above its central parity, an appreciation is generally expected, and vice versa. The larger the deviation from the central parity, the larger the expectation of an opposite movement. Furthermore, the Dickey-Fuller test rejected the unit root in all cases. These results, being in accordance with the results obtained by Svensson (1991b) and Chen & Giovannini (1992), imply that the deviations of the exchange rate from the central rate within the band are transitory, and that the fluctuations within the band are generally mean reverting processes.

Figure 2.3a **Belgium, deviation of the current spot rate from the central parity**

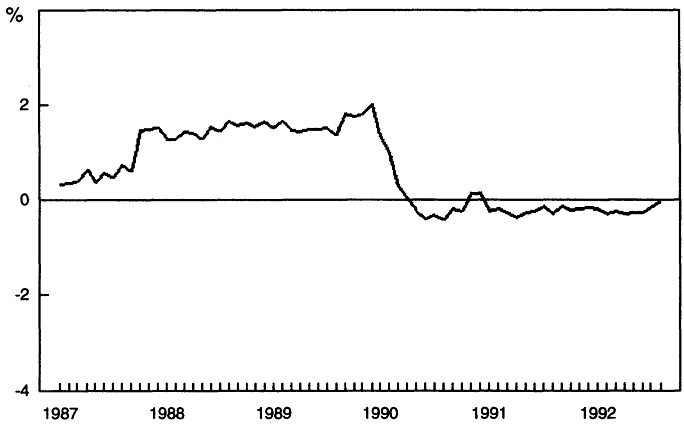


Figure 2.3b **Denmark, deviation of the current spot rate from the central parity**

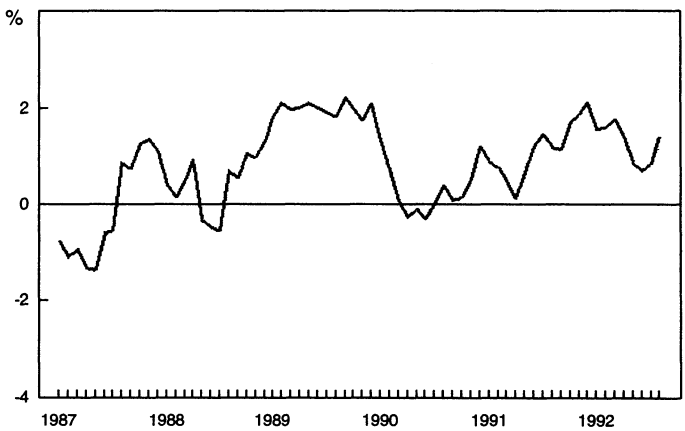


Figure 2.3c **France, deviation of the current spot rate from the central parity**

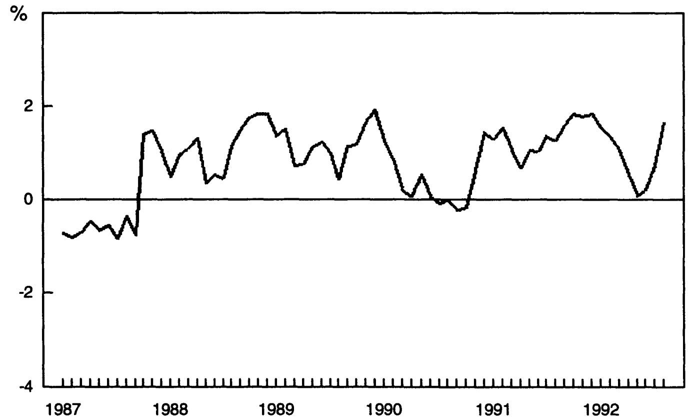


Figure 2.3d **Great Britain, deviation of the current spot rate from the central parity**

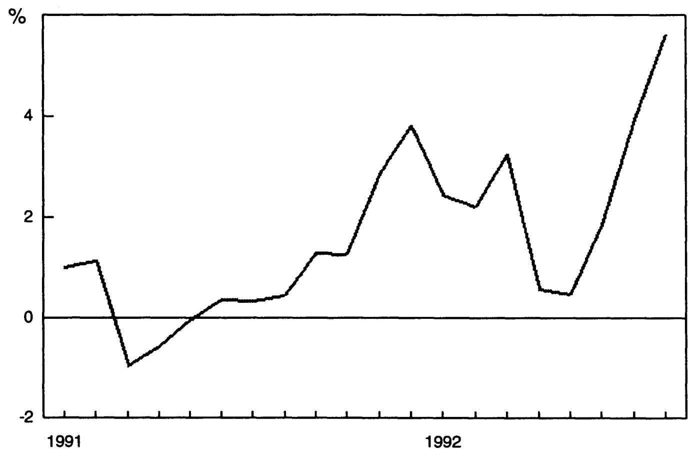


Figure 2.3e **Italy, deviation of the current spot rate from the central parity**

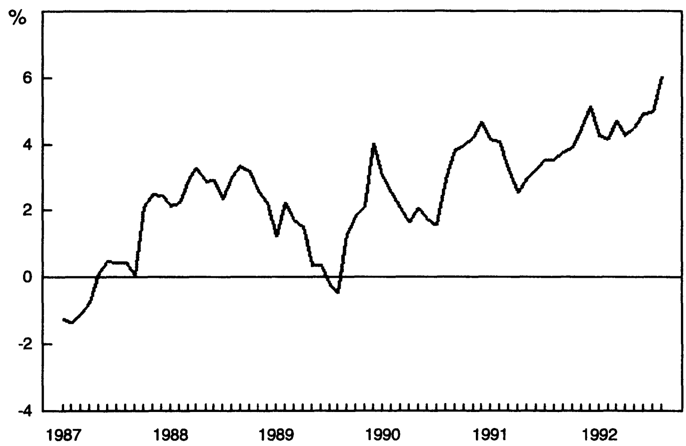


Figure 2.3f **Spain, deviation of the current spot rate from the central parity**

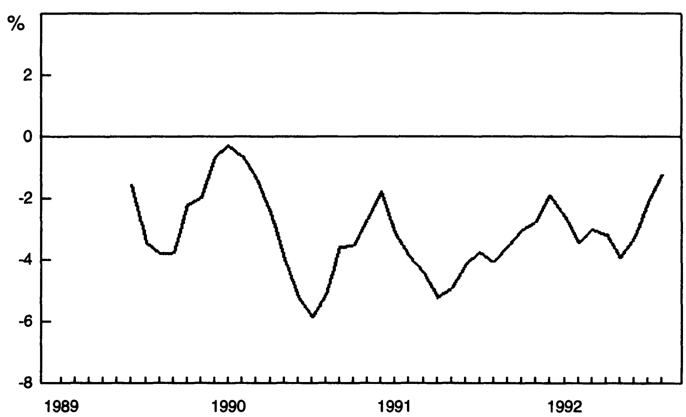
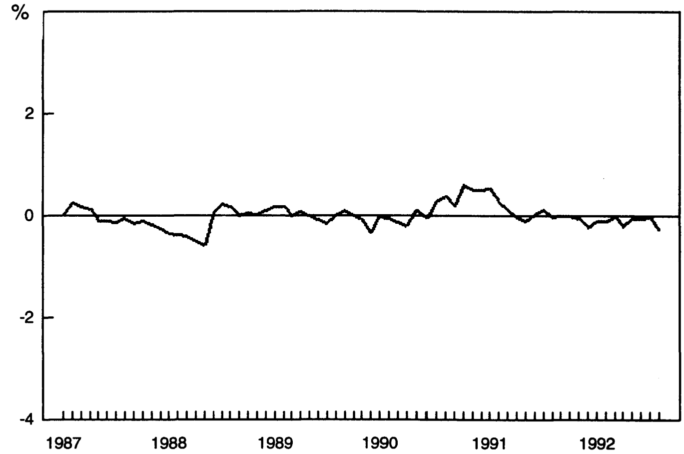


Figure 2.3g **The Netherlands, deviation of the current spot rate from the central parity**



2.3 Devaluation expectations measured by expected rates of devaluation

In order to estimate the expected rates of devaluation, interest rate differentials should be adjusted for the estimated expected rates of depreciation within the band as shown in equation (2.3) above. Hence, the results obtained from the estimation of the expected exchange rate change within the band are inserted in (2.3) to calculate the expected rate of devaluation, δ. Previous studies have shown that the exchange rate risk premium is minimal for ERM exchange rates, so we may assume an insignificant foreign exchange risk premium and, hence, set $\rho = 0$. Alternatively, if the underlying assumption of uncovered interest rate parity is rejected, what is measured is the sum of the expected rate of devaluation and the foreign exchange risk premium. The resulting time-series of estimated expected rates of devaluation are displayed in Figures 2.4a–g. Again, the scale is the same for all exchange rates and constructed so that the limits correspond to an annual expected devaluation rate of approximately 2 %.

Figures 2.4(a)–(g) show that the EMS exchange rates were not perfectly credible in the period from 1987 to 1992. The positive values for realignment expectations foreshadow a devaluation vis-à-vis the DEM. If the expected rates of the devaluation are calculated using the fitted values of the regression of equation (2.4), there are, allowing for the constant, occasional signs of the expected rate of the devaluation of the DEM. Such expectations, however, disappear if we do not allow for the constant. The results of these regressions are displayed in Figures 2.5a–g. Since it is commonly believed that there have been no DEM devaluation expectations, this finding can be seen as supportive of the theoretical argument that the model itself actually implies/assumes that there should not be any continuous change in the exchange rate unless the spot rate diverges from the central rate. Hence, the discussion that follows refers only to the results that have been calculated on the basis of the fitted values for the expected rates of depreciation within the band and *not* allowing for a constant.

Figure 2.4a **Belgium, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is allowed**

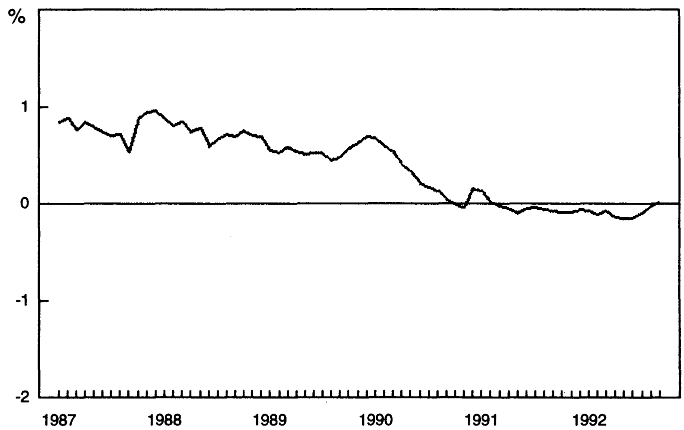


Figure 2.4b

Denmark, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is allowed

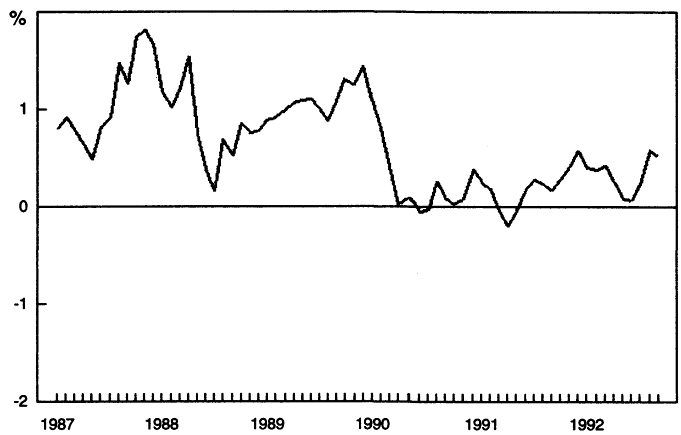


Figure 2.4c

France, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is allowed

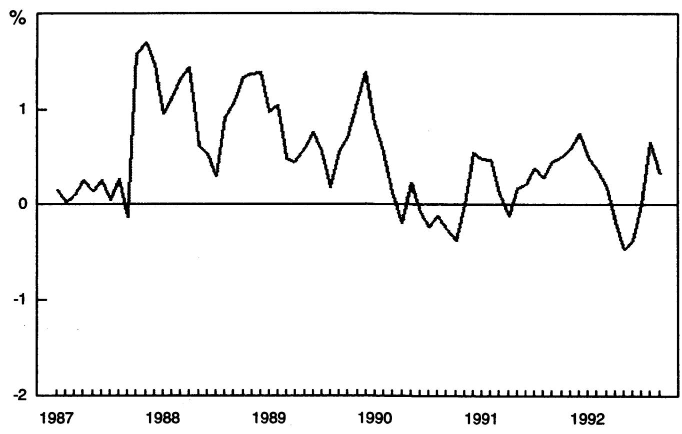


Figure 2.4d **Great Britain, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is allowed**

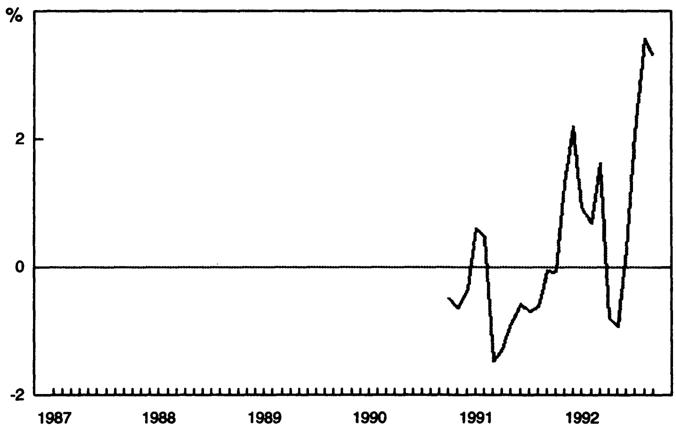


Figure 2.4e **Italy, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is allowed**

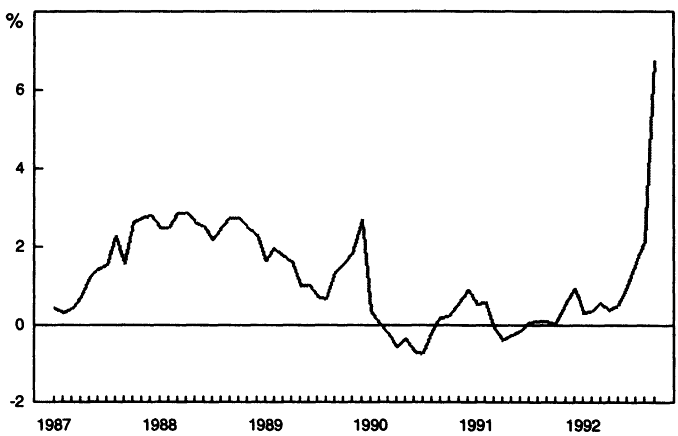


Figure 2.4f

Spain, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is allowed

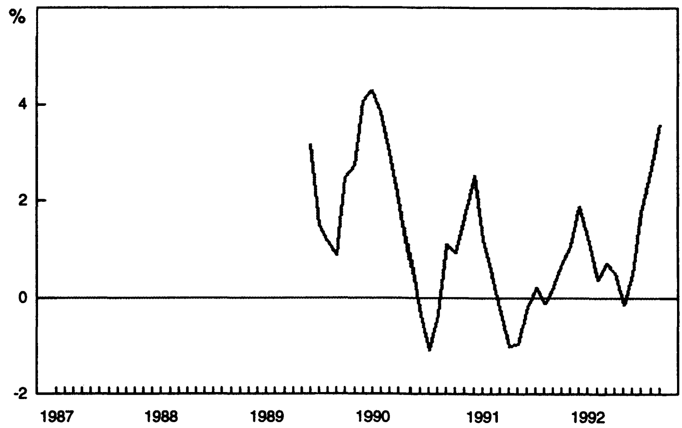


Figure 2.4g

The Netherlands, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is allowed

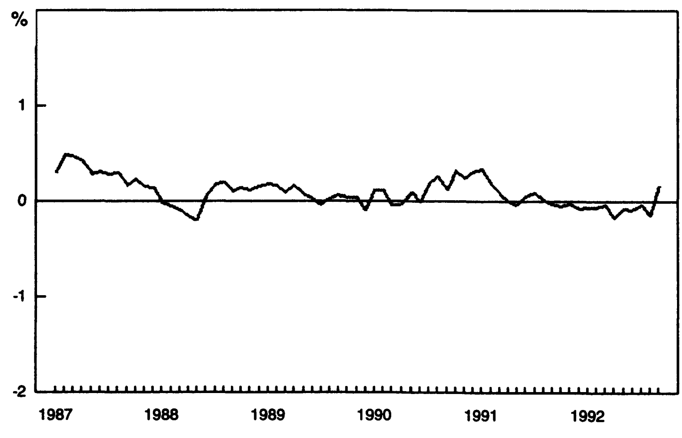


Figure 2.5a **Belgium, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is not allowed**

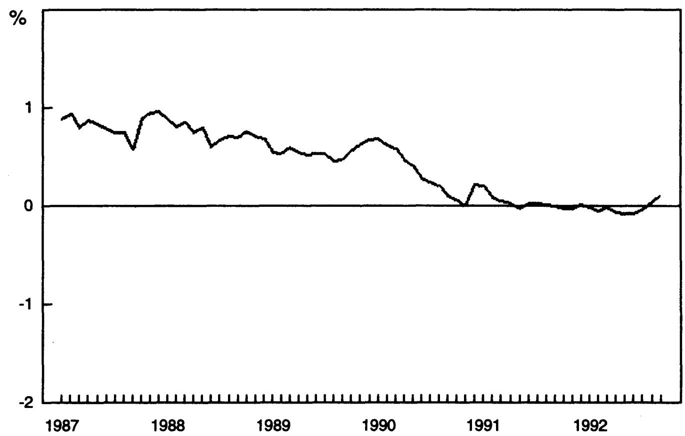


Figure 2.5b **Denmark, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is not allowed**

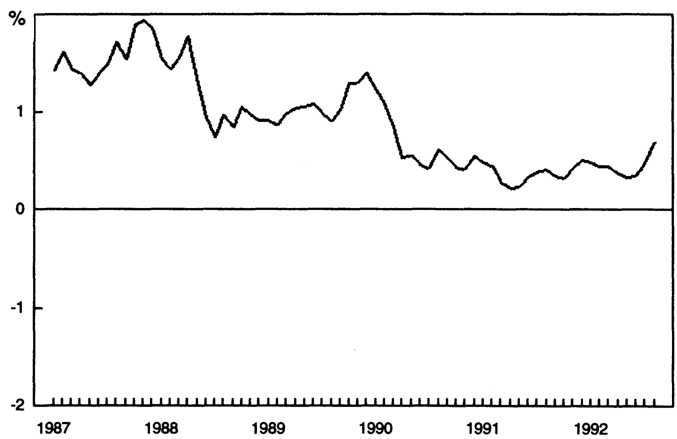


Figure 2.5c **France, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is not allowed**

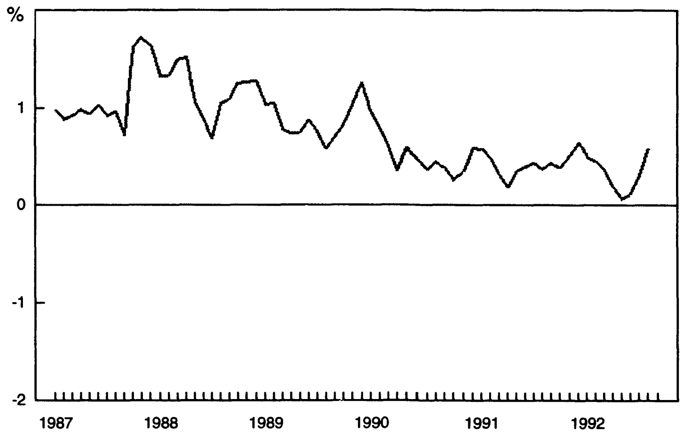


Figure 2.5d **Great Britain, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is not allowed**

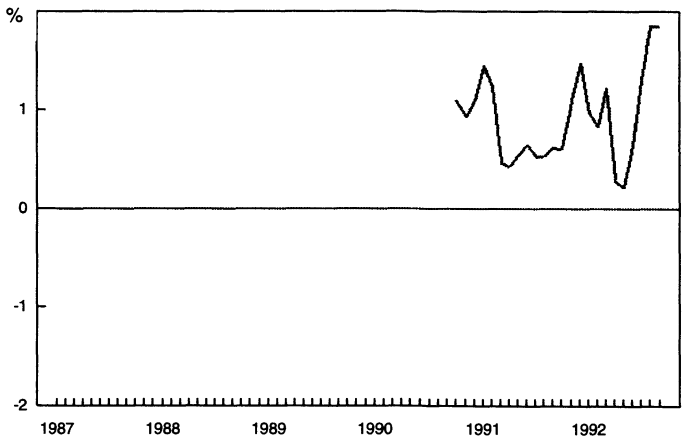


Figure 2.5e **Italy, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is not allowed**

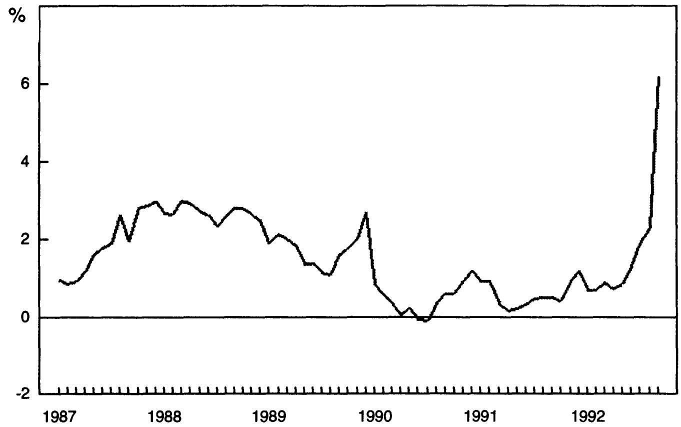


Figure 2.5f **Spain, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is not allowed**

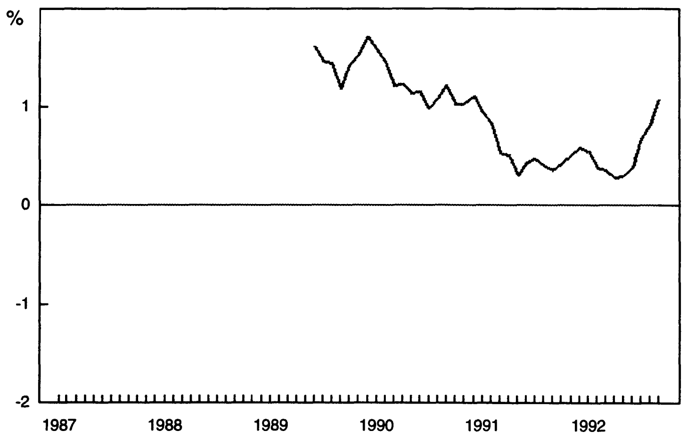
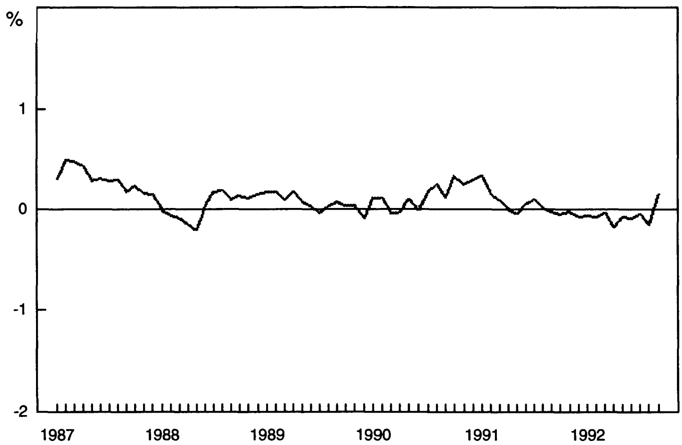


Figure 2.5g **The Netherlands, estimated expected rate of devaluation calculated on basis of the expected rate of depreciation within the band when the constant is not allowed**



2.3.1 General overview

In general, currencies could be divided into three groups according to their degree of credibility. The BEF/DEM and NLG/DEM exchange rates have the smallest devaluation expectations, staying below 1 % at an annual basis throughout the period. In the case of the BEF/DEM exchange rate, the devaluation expectations also diminish throughout the period, and the effect of the regime change in 1990 can be clearly seen.

In the second group, we may place Denmark, France and Spain. DKK/DEM and FRF/DEM exchange rates improve in credibility throughout the period. The expected rate of devaluation decreases quite steadily from about 2 % annually to under 1 % on annually. In the case of the ESP, the ± 6 % width of the fluctuation band allowed a certain degree of flexibility in the exercise of the exchange rate policy. In fact, during most of the period studied, the monetary authorities managed to keep the ESP/DEM exchange rate within the lower half of the official fluctuation band. This exchange rate policy generated an effective - though not official - exchange rate regime which would have been somewhat credible, regardless of whether the official exchange rate regime was credible. Ayuso et al. (1993) note that because of this effective regime, the conventional reading of the target zone approach tends to provide a measure with a downward bias of the credibility of the exchange rate commitment. They suggest that the results of the traditional measure of the expected rate of devaluation should be applied as a measure of the effective fluctuation regime but not of the maintenance of the official central parity.

The third group consists of Italy and Great Britain. These countries suffer from poor credibility throughout the period. Even though the expected rate of devaluation of the GBP/DEM exchange rate never exceeds an annual rate of 2 %, the great volatility can be interpreted as uncertainty about the rate of the GBP. In Italy's case, the expected rate of devaluation runs between two and three per cent annually. In mid-1990, the credibility of the ITL/DEM exchange rate seem to have increased more than earlier in the EMS history. This can be explained, however, by the fact that in June 1990, the fluctuation band of the ITL was narrowed and, in that context, the ITL was effectively devalued. Since the change in the fluctuation band, the expected rate of devaluation of the ITL/DEM exchange rate has increased, indicating reduced credibility relative to the end of the 1980s. The fact that the credibility of the ITL/DEM exchange rate is clearly worse than that of the other exchange rates analyzed here might be affected by the fact that the policy of the central bank of Italy is to make quite large intramarginal interventions and subsequently to raise interest rates to a significant degree. Such a policy yields a large interest rate differential relative to countries which do not use the interest rate tool to the same extent as the Italian authorities.

In general, the period seems to have been a period of increased convergence and diminishing devaluation expectations. In the first half of 1990, in fact, all exchange rates gained greater credibility than at any time in EMS history.[9] Subseguently, the expected rates of devaluation seem to stabilize at a low and "acceptable" level. What is interesting here is that despite great expectations of a change in the value of the DEM as a result of GMU, the results do not show that the expected rate of devaluation of any of the currencies analyzed would have permanently changed because of GMU. It is also remarkable that the crisis that occurred in September 1992 cannot be seen in the expected rates of devaluation. The estimated results do not reveal that the credibility of the EMS exchange rates would systematically have worsened after 1990. Only in the very last months preceding the realignment in September 1992 do we observe an increase in the

[9] From previous studies, eg Chen & Giovannini (1992) and Svensson (1991a), we know that the expected rates of devaluation have been the lowest in absolute terms during the five-year period from 1987 to 1992.

expected rate of devaluations. This seems to indicate that the currency crisis of 1992 was not anticipated by financial markets. The description of the actual events is followed by a discussion on the target zone model as a measure for devaluation expectations.

2.4 The crisis in the autumn of 1992 and the method of measuring devaluation expectations

Eichengreen (1993) notes that the striking feature of the 1992 EMS crisis is the absence of turbulence in the EC foreign exchange markets earlier that same year. In fact, divergencies between ERM exchange rates actually moderated. The BEF and the NLG moved closer to the central rate; the FRF moved up from the bottom of its band. The GBP, though relatively weak in 1992, remained comfortably within its fluctuation band. The Danish referendum of June 2 seems to be the turning point.

Tensions after Denmark's rejection of the Maastricht Treaty were further fuelled by uncertainty surrounding the outcome of the referendum on the same issue in France, scheduled for September 20. The prospects for monetary union, which in the past had played an important stabilizing role in the EMS, generated strong expectations of a realignment, which increased as the referendum date drew closer. Subsequent, parliamentares elections in other European countries provided new "critical" dates on which market expectations could focus. Further, there was an increase in the market's awareness of the conflict between the domestic needs of monetary policy and those connected with the defence of the exchange rate, especially in France.

Pressure on the exchange rate became notable first in Italy where the discount rate was raised over the summer of 1992 in several steps from 12 % to 15 %. In early August, the approval of an austere interim budget brought some relief. At the end of August, however, opinion polls showed an apparent majority of voters opposed to ratification of the Maastricht Treaty. This bolstered growing concerns about possible realignment. Meanwhile the ERM became increasingly polarised as the three currencies of the wide band, ie the ESP, the GBP and the PTE (not analyzed in this study) weakened noticeably. Pressure mounted in August and September with the approach of the French referendum. On August 26 the GBP fell to the floor of its fluctuation band despite official intervention. Other ERM member countries intervened in support of their currencies. The ITL was the most prominent target of the ERM currencies. The Bank of Italy allowed short-term rates to rise more than 30 per cent. At the same time, the German, Dutch and Belgian authorities intervened heavily. Ultimately, the rise in domestic interest rates did not save the ITL. On September 13, the central rate of the ITL was devalued 7 %.

On September 16 the Bank of England intervened massively on the foreign exchange market to prevent the GBP from falling below the margin of its DEM band. It started the day by raising the base lending rate from 10 % to 12 %. Later in the day it announced a further rise to 15 % effective the following morning. These measures failed to relieve the pressure on the GBP. According to Del Giovane (1994), the distinctive feature of Britain's defence of the GBP was the virtual lack of interest rate policies. The size of the rise in the domestic interest rates was rather small, and the timing was late. Hence, on the evening of September 16, the British monetary authorities announced the temporary suspension of the GBP from the ERM. On the same evening, the Bank of Italy announced to the Monetary Committee that the inadequacy of its reserves in the face of speculative pressure had forced it to suspend foreign exchange market intervention and float the ITL. At the same meeting the Monetary Committee authorized a 5 per cent devaluation of the ESP.

It was stated in section 2.3.1 that the results of estimating the expected rates of devaluation do not indicate pressure on the foreign exchange markets prior to the crisis of 1992. When, however, we study the developments ex post, we know that there were speculative capital flows, and that central bank intervention or interest rate action was needed to guarantee exchange rate stability. This contradiction between the empirical results of the model and real-world events raises the question of the ability of the model to depict reality. Clearly, previous empirical studies with a similar model have proved that it does show that devaluation expectations increase prior to a realignment of the central parities. Towards the 1990s, devaluation expectations diminish across the currencies. After 1990, the EMS seems to have gained a high degree of credibility.[10] So how then should the crisis of 1992 be explained?

In this context a crucial characteristic of the model applied here for measuring devaluation expectations could be that it uses interest rate differentials as the only variable. Expected rates of depreciation within the band are estimated using the exchange rate itself as an explanatory

[10] Eg Svensson (1991a), Caramazza (1993), Chen & Giovannini (1993) and Thomas (1994).

variable. Other studies also show that it is difficult to find an equation that would give more information on the expected rate of depreciation within the band. Thus, while we use this simple method to measure exchange rate movements within the band, we know that other factors also affect the behaviour of the exchange rate within the band. Interventions are certainly very crucial in this respect.[11] Intra-marginal interventions have increased especially after the signing of the Basle-Nyborg Agreement in 1987, which should affect at least the ex post behaviour of the EMS exchange rates.

If interventions have become the most popular tool in exchange rate management, then other tools such as interest rate differential have evidently lost importance. As a consequence, we can observe diminishing interest rate differentials that are maintained by central bank interventions.[12] Hence, if the model uses interest rate differentials only as a measure of credibility, the results can be misleading in the absence of an important piece of information. One should take the number of interventions as an additional indicator of credibility. There are, however, difficult problems with the inclusion of interventions in an empirical model. First, the published series on foreign exchange reserves are an imperfect measure of the magnitude of foreign exchange market intervention. Central banks may report only gross foreign assets, even though it is standard operating procedure to arrange for standby credits in foreign currency. When the authorities intervene, they draw on the credit lines without having to sell any of the reported foreign assets. Off-sheet operations such as swaps and forward contracts typically undertaken during periods of speculative pressure are also omitted even if data on other foreign liabilities is available. Moreover, as Eichengreen et al. (1994) note, intervention by foreign central banks can be hard to detect. This applies especially to the EMS, where compulsory interventions are undertaken simultaneously by two central banks. Moreover, it is not just the amount of intervention that affects devaluation expectations. As pointed out by DelGiovane (1994), the effectiveness of interventions increases when they are coordinated; the effectiveness of such

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[11] For reference, the exchange rate strategies of some EMS central banks during the period from 1987 to 1993 are described by DelGiovane (1994).

[12] DelGiovane (1994) also reports that the size of increases in interest rates depends on the timing of the operation. If interest rates are raised promptly to check emerging pressures, the increases necessary to overcome the tensions are smaller. On the contrary, if the action is delayed, a large increase is needed.

interventions is further connected to the degree of symmetry with which they are carried out.

This discussion leaves us with the conclusion that the model, when applied empirically, does not capture all information that would be necessary to find an accurate measure for devaluation expectations. Complementary analysis is needed in order to be able to draw more informative conclusions. In chapter 3, we try to find out more about the working of the EMS by using the method of regressing the estimated expected rates of devaluation against a set of fundamental macroeconomic variables.

3 Devaluation expectations and macroeconomic variables

In the previous chapter we calculated devaluation expectations for selected EMS exchange rates. As a purely technical exercise, no explanations of the change in the devaluation expectations changed over time was provided. The aim of this chapter is to use standard exchange rate theories to find macroeconomic variables that we know potentially affect the actors' devaluation expectations. We will also estimate an empirical model to determine the extent to which each of the suggested variables affects the devaluation expectations.

3.1 Previous studies

In the target zone literature we find an increasing number of studies applying econometric tests for determining relationships among certain macroeconomic variables - other than interest rates - and the expected rate of devaluation. One of the earliest study of this type was made by Edin & Vredin (1993), who analyzed the behaviour of the Nordic currencies by constructing a simple exchange rate model for a small, open economy with a standard money demand equation, an equation for the real exchange rate and the uncovered interest rate parity. From this model they derive an index of "fundamentals" in terms of nominal money, foreign price level, real exchange rate, domestic output and foreign interest rate. They also include lagged central parity in their equation. Their results show that, for Nordic countries, the lagged central parity and industrial production enter with significant negative coefficients, while the money stock has a marginally significant positive coefficient. Foreign interest rates, foreign prices and the real exchange rate are significantly different from zero.

Pesaran & Samiei (1992) also use a macroeconomic model to explain devaluation expectations. They estimate three well-known two-country specifications of the exchange rate model, adjusted to take account of the limits. The first model is based on the monetary model determining for exchange rates ie the exchange rate is determined by expectations, relative money supplies and relative outputs. If this model is used, the coefficient of exchange rate expectations is significantly different from zero, as is the coefficient of the lagged interest rate differential. The second model is a portfolio balance model, where the variables included are the current interest rate differential and the relative current account surpluses. The empirical results are similar to those obtained for the monetary model. The third model is essentially a combined portfolio-balance model and a monetary model. Here, the empirical test shows that, in addition to the exchange rate expectations and the interest rate differential, the lagged money supplies also have a coefficient significantly different from zero.

Caramazza (1993) has studied the devaluation expectations associated with the FRF/DEM exchange rate. His explanatory variables for the observed devaluation expectations are the change in the foreign exchange reserves, the government financing requirement, inflation differentials, export price competitiveness, the unemployment rate, the deviation of the FRF/DEM exchange rate from the upper edge of the band, relative money growth rates and the trade balance. Of these, all but the last two turn out to be significant, explaining over 70 % of the variation in the expected rate of devaluation.

Chen & Giovannini (1993) have analyzed the FRF/DEM and the ITL/DEM exchange rates. In their model they include relative foreign exchange reserve position, percent change in budget surplus, the difference in the trade balance surpluses, relative industrial production indices, the position of the exchange rate within the band, time since the last realignment, an index of relative CPI's, an index of relative wages, relative liquidity and, finally, the DEM/USD exchange rate. Their results show that the variables with consistently high explanatory power are the length of time since last realignment and the deviation of exchange rates from central parity.

Vajanne (1993) also examined a Nordic currency applying a monetary model for a small, open economy with free capital movements. In her study the exchange rate is treated as an asset price dependent on expectations concerning exogenous real and monetary factors that will affect price levels in the future. Vajanne's empirical model is constructed from the following variables: domestic money supply, domestic GDP, real exchange rate, domestic inflation rate, unemployment rate, government net borrowing requirement, foreign reserves of the central bank and, the current account balance. The results show that for the FIM the rate of unemployment, the growth rate of the domestic GDP and the foreign exchange reserves are highly significant explanations for the devaluation expectations, whereas the current account balance has only minor significance.

Eichengreen et al. (1994) have sought to establish stylized features concerning the behaviour of macroeconomic variables around the time of speculative attacks on fixed exchange rates. Attacks are defined as large movements in exchange rates, interest rates and international reserves. The theory is tested empirically using data for ERM and non-ERM currencies. They derive an index of speculative pressure which says that pressure increases as domestic reserves of foreign exchange decline, as interest rates rise and as the exchange rate depreciates. The theoretical underpinnings then suggest that speculative pressure should be a parametric function of fundamentals, such as the rate of growth of domestic credit, the level of income and the interest rate differential. In their empirical analysis, they use the following variables: exchange rate vis-à-vis the DEM, changes in interest rates and international reserves relative to those of Germany, short-term money market interest rates, the ratio of central government budget position to nominal GDP, the real effective exchange rate, the ratio of exports to imports, domestic credit and CPI inflation.

For first-generation crisis models the results show that key macroeconomic and financial variables do not behave as predicted. In the ERM countries money growth and inflation have an opposite effect compared with the theoretical predictions. Alternatively, ERM crises could be interpreted as self-fulfilling speculative attacks and multiple equilibria in foreign exchange markets in which policy shifts in a more expansionary direction in response to the attack. The results, however, show little evidence of such a pattern. The final finding of the paper is that the behaviour of macroeconomic variables differs significantly around the time of speculative attacks on the one hand and realignments and changes in exchange rate regimes on the other: ERM countries underpinning realignments have significantly higher inflation rates, interest rates, rates of money and credit growth and budget deficits, and their trade balances are significantly weaker. The authors conclude that although they fail to turn up strong evidence favouring second-generation models (ie they detect no significant shifts in macroeconomic variables in the wake of speculative attacks), their results tend to shift the burden of proof toward the proponents of first-generation models.

Mundaca & Vik (1994) concentrate on calculating the probability of a realignment of Nordic and several other EMS exchange rates by projecting the interest rate differential on a set of variables that are included in the information set of the actors when these are forming expectations about the future exchange rate. Using the ARCH method, they first try to capture expectations of future exchange rates by looking at the difference in spot exchange rates from central parity. Next, they take the time elapsed since the last realignment to see whether the time since the last realignment has been conferred increased credibility of the band or awakened expectations of realignment. Third, they use the DEM/ECU exchange rate to establish the strength of the DEM in the EMS.[13] The authors argue that the explanatory variables, the expected rate of depreciation within the band and the expected rate of realignment, cannot be regarded as independent from each other since the market's expectations of both are conditional upon a single information set. Hence, they define a credible currency band as one where an exchange rate deviation from parity gives rise to expectations that the exchange rate is most likely to revert towards its central parity, rather than deviate from parity, which causes realignment expectations. The results show that all exchange rates except the ITL have followed the mean reversion process in the sense that a weak position of the exchange rate within the band has caused a decrease in the interest rate differential and, therefore, expectations of appreciations within the band. They also find, however, that simultaneously there were strong positive relationships between the exchange rate deviation from parity and the expected rate of realignment. In the case of the ITL any positive deviation from parity only increased the interest rate differential because of the lack of mean reversion in the exchange rate and its large positive effects on realignment expectations.

Thomas (1994) challenges the notion that interest rate differentials are appropriate measures of the risk of devaluation and that they reflect the movements of internal and external balance variables. The derivation of the measure for the devaluation risk follows the standard model derived in Svensson (1991a). The determinants of the expected

[13] For the Nordic currencies, they use the USD/ECU exchange rate.

rate of devaluation are then examined in light of the perceived macroeconomic objectives of the government. Internal balance is defined as the difference between the current unemployment rate and the level that is consistent with a non-accelerating rate of inflation. External balance, in turn, is defined as the value of the current account that is consistent with the investment and demographic needs of the country in question. External balance is influenced by the level of competitiveness given as a ratio of unit labour costs. In addition to these potential determinants of devaluation expectations, the author includes other explanatory variables: the inflation rate differential, the difference between domestic and foreign government debt/GDP ratios, the deviation of the spot exchange rate from the central rate and the rate of change in the stock of foreign exchange reserves. The results of the empirical analysis suggest that the dominant explanatory variable is the position of each currency in its target band. In other words, as the author notes, a considerable share of the variability in devaluation expectations seem to be explained by a variable that is only weakly related to standard macroeconomic fundamentals. When this variable is excluded from the analysis, official holdings of foreign exchange reserves become a significant determinant. The effect of the standard macroeconomic variables is, however, weak.

Ötker & Pazarbasioglu (1994) propose a speculative attack model of currency crises. Their main attempt is to identify the roles of macroeconomic fundamentals and speculative market pressures in an adjustable fixed exchange rate system such as the EMS. Using a stochastic version of monetary approach to exchange rate determination, they derive an index of macroeconomic fundamentals that is used to determine the equilibrium shadow exchange rate. The model describes a small, open economy whose government and monetary authorities are committed to maintaining their exchange rate within an adjustable peg system. It consists of equations for the demand for money, money supply, uncovered interest rate parity, real exchange rate and, the money market equilibrium. When foreign exchange reserves used to maintain money market equilibrium become exhausted, the central bank must abandon its announced fixed exchange rate. The rate which would clear the market when the central bank stops defending its fixed parity can then be obtained from the model. This shadow exchange rate is never observed unless the central bank changes its policy to preserve the announced fixed exchange rate. In their study the authors relate a speculative attack and the probability of a regime change to the condition that the shadow exchange rate exceeds the announced exchange rate by a certain margin. This approach lets the authors first calculate the probability of a regime change as a function of speculative factors only. Such factors are the interest rate differential, the deviation of the exchange rate from central parity and the level of foreign exchange reserves. The analysis is then extended by adding the fundamentals as explanatory variables into the equation. The authors use a profit model and estimate the explanatory power of the following macroeconomic fundamentals. An increase in the current level of domestic credit is expected to increase the probability of a devaluation. An increase in the real effective exchange rate is expected to induce expectations of an exchange rate adjustment and result in a higher probability of a regime change. A low level of foreign exchange reserves is expected to increase the probability of a regime change. Higher foreign interest rates exert pressure on the domestic currency. A high level of unemployment is expected to pressure the central bank to reconsider its exchange rate policy and thus increases the probability of a regime change. Higher prices in the anchor country reduce inflation differentials and thus the probability of a devaluation. Finally, the authors include the central rate in the equation with the expectation that an increase in the existing fixed rate implies an adjustment of the exchange rate with respect to economic fundamentals and thus decreases the probability of a further devaluation. The probability of a regime change is expected to rise with an increase in interest differentials and deviations in the exchange rate from the central parity, and to fall with an increase in the level of foreign exchange reserves available to the central bank to defend its currency. The empirical results show, according to the authors, that both speculative and fundamental factors were important in generating the recent crises in the EMS. In particular, the worsening of the trade balances of the countries, increases in German prices, the rise in the rate of unemployment, the level of domestic credit and the loss of foreign exchange reserves as well as the loss of external competitiveness increased the probability of a regime change.

Rose & Svensson (1995) measure realignment expectations by using the standard method of subtracting the estimated change of the spot exchange rate from the interest rate differential. They then choose five macroeconomic variables to explain the observed realignment expectations. They derive money and output as potential explanatory variables from traditional monetary models of exchange rate determination with flexible prices. Monetary models with sticky prices, on the contrary, give inflation as a determinant for the exchange rate. Various models of balance-of-payments crises assign key roles to actual or expected levels of international resevres, trade balances, and the real exchange rate. In addition, the authors investigate the link between implicit bandwidth, monetary independence, and realignment expectations. They argue that not exploiting potential monetary independence improves credibility. Therefore, they measure the amount of monetary independence by the standard deviation of expected future exchange rate drift within the band and investigate possible linkages between that variable and realignment expectations.

The results of the regression run by Rose & Svensson (1995) show that inflation has a large and precisely estimated impact on credibility. Similarly, decreases in international reserves are correlated with increased realignment expectations. Increases in exchange rate variability and therefore the degree of exploited monetary independence are also associated with significant increases in realigment expectations. In order to find out whether permanent changes in the macroeconomic variables are associated with permanent changes in the level of realignment expectations, the authors also run a VAR regression for these explanatory variables. However, with the exception of a strong link from inflation differentials, there are few clearly significant channels of macroeconomic influence on realignment expectations.

The main conclusion in Rose & Svensson (1995) is that the currency crisis of 1992 was not preceded by a gradual deterioration in ERM credibility. Indeed, realignment expectations were essentially constant through the period after German unification. The authors conclude that the data appear to indicate that financial markets were surprised by the events of September 1992: indications of a pending crisis did not emerge until late August.

Siklos & Tarajos (1996) estimate the probability of devaluation using pooled data with dummies for four ERM countries. They also use lagged variables in their empirical analysis. They found that industry production and German interest rate had significant negative influences on the probability of a devaluation. The real effective exchange rate remained insignificant. The domestic money supply, on the contrary, had a significant positive coefficient. The coefficient on the German inflation rate was significant, but positive and, thus, inconsistent with theoretical predictions. The authors interpret this so that politiciants have resited devaluations but that, in doing so, have awaken expectations of a higher probability of devaluation at some future date. Finally, the German interest rate and the censored central parity have significant negative effects. The authors summarise their results being incapable of producing accurate estimates of the size and probability of devaluations. However, in predicting the expected rate of depreciation

Table 3.1

Study	Pesaran & Samiei (1992)	Caramazza (1993)	Chen & Giovannini (1993)	Edin & Vredin (1993)	Vajanne (1993)	Eichengreen et al. (1994)
Dependent variable / Explanatory variables	Exchange rate Expectations	Expected rate of devaluation	Expected rate of devaluation	Expected rate of devaluation	Expected rate of devaluation	Speculative pressure
Deviation of spot rate from central parity	o*	o*	o*	o		
Domestic credit	o*	o	o*	o*	o	o
Real exchange rate		o*		o	o	o
Trade balance	o	o	o		o*	o
Unemployment		o*			o*	
Interest rate differential	o*			o		o*
Production	o		o*	o*	o*	
Foreign exchange reserve		o*	o*		o*	o*
Government expenditure		o*	o		o	o
Inflation rate differential		o*	o		o	o
Time elapsed since last realignment			o*			
Foreign interest rate			o*	o*		
Foreign inflation rate				o*		
Third DEM exchange rate			o			

o = variable used in regression * = variable significant

Study	Mundaca & Vik (1994)	Thomas (1994)	Ötker & Pazarbasioglu (1994)	Rose & Svensson (1995)	Siklos & Tarajos (1996)
Dependent variable Explanatory variables	Expected rate of devaluation	Expected rate of devaluation	Probability of devaluation	Expected rate of devaluation	Probability of devaluation
Deviation of spot rate from central parity	o*	o*	o	o*	o*
Domestic credit			o*	o	o*
Real exchange rate			o*	o	o
Trade balance		o	o*	o	
Unemployment		o	o*		
Interest rate differential			o		
Production			o	o	o*
Foreign exchange reserve		o	o*	o*	o*
Government expenditure		o*	o		
Inflation rate differential		o*		o*	
Time elapsed since last realignment	o*		o		
Foreign interest rate					o*
Foreign inflation rate			o*		o*
Third DEM exchange rate	o				

o = variable used in regression * = variable significant within the band, the inclusion of political variables yields satisfactory results.

Table 3.1 summarizes the empirical findings of previous studies. The left-hand column lists all macroeconomic variables used to test determinants of the expected rate of devaluation. In the following columns, the left-hand symbol shows which variables have been used in the actual study and the right-hand symbol shows the variables that turned out to be significant. Armed with this knowledge we can now attempt to construct a useful model. The set of macroeconomic variables we will investigate is relatively broad, limited although they are deliberately limited for the sake of utility. The set includes all of the most plausible candidates either implied by theoretical work, or, following Rose & Svensson (1993), that have been mentioned in the popular press.

3.2 Variables used in exchange rate modelling

The hypothesis has been that a devaluation involves a change from one target zone to another, ie a change in the central rate parity, and is related to fundamentals other than interest rates differentials.

The breakdown of the log of the exchange rate s into the log of the central parity c and the log of the percentage deviation from the central parity

$$s_t = c_t + x_t \tag{3.1}$$

Following Chen & Giovannini (1993), the one-period expected change in the exchange rate can be broken down into.

As is apparent, all expectations depend on the information set (I) available at time t. If the interest rate parity holds as assumed, the left-hand side of equation (3.2) can be replaced by the interest rate differential $(r-r^*)$. Hence, the expected rate of devaluation can be written as:

$$E(C_{t+i} - C_t | I_t) = (r - r^*) - E((X_{t+i} - X_t) | I_t) \tag{3.2}$$

Since the interest rate differential is known, the equation yields that the expected rate of devaluation can be calculated by measuring the expected change in X. Using these data, we can easily calculate the ex post measure of the devaluation as

$$C_{t+i} - C_t = (r - r^*)_{t+i} - (X_{t+i} - X_t) \qquad (3.3)$$

To determine the variables to choose for the information set, it would, naturally, be ideal to have a theoretical model that formally links the fundamental variables to the expected rate of devaluation. As stated by Chen & Giovannini (1993), however, existing theoretical models have not succeeded in clearly identifying the impact of fundamentals, rather they suggest potential impact. An important aspect here is that factors that have the most influence on exchange rates over the short term are not necessarily the same ones that exercise the most influence over the longer term. Further, as found by Taylor & Allen (1992), non-fundamentalist advice may be an important influence in foreign exchange markets. It is assumed rather that in forming expectations of a currency's possible realignment, agents consider a number of factors, both at home and abroad, that may induce a change in the central parity. We will discuss, therefore, a set of variables important for the determination of an exchange rate without trying to construct a technical model for them. In sections 3.2.1 to 3.2.8 factors considered to be relevant for the current study are presented. In sections 3.2.1 to 3.2.3 variables reflecting the external competitiveness of the country are discussed. Sections 3.2.4 to 3.2.6 include factors that reflect the general state of the economies. Finally, in sections 3.2.7 and 3.2.8 more speculative variables affecting devaluation expectations are discussed.

3.2.1 Competitiveness

External competitiveness is chosen as an explanatory variable because if there is a gain or loss in competitiveness relative to a period in which the external position was regarded to be in equilibrium, there is a presumption that the exchange rate is no longer consistent with the underlying external position of the country. If the purchasing power of a currency is weaker or stronger than the purchasing power of other currencies for long periods, a persistent trade balance deficit or surplus will occur. A continuous current account surplus or deficit affects the demand for the currency in question, and this must finally show in the price of the currency, ie in its exchange rate.

In previous studies, the competitiveness of a country in international markets has been measured either by the trade balance or the real effective exchange rate.[14] Current account factors have generally been introduced into exchange rate modelling through the portfolio balance approach. In these models the financing of current account deficits affects the supply and holdings of domestic and foreign assets. Balance of payments and monetary equilibrium occur when wealth holders are satisfied with the relative proportions in which different financial assets are held in their portfolios. A surplus in the current account implies that domestic residents are accumulating foreign assets. The accumulation of foreign assets creates an excess supply of them and a corresponding excess demand for domestic assets. *The excess supply of foreign assets causes their price to drop so the price of foreign exchange declines.* The appreciation of the local currency then gradually eliminates the current account surplus. Since large and persistent current account imbalances can cause pressures within the EMS, this variable is included in the current regression.

3.2.2 Inflation rate differential

An important conclusion of the monetary model is that a country cannot follow an independent monetary policy under fixed exchange rates - nor, as a consequence, can it choose price levels or an inflation rate different from that of the rest of the world. Under fixed exchange rates in the monetary model, starting from a position of equilibrium, the result of a rise in domestic prices will be a decrease in reserves stemming from a temporary balance of payments deficit, other things equal. In the long run, a persistent balance of payments deficit cannot be sustainable; the country will have to adjust its monetary policy to the inflation rate of the surrounding countries. Alternatively, the adjustment has to come through the exchange rate. The effect of a devaluation is to move the economy to a point where the home country has regained its loss of competitiveness. Hence, *a higher domestic inflation rate should be expected to strengthen devaluation expectations.* Higher prices in the anchor country reduce inflation differentials and thus the probability of a devaluation.

[14] An alternative, more direct method for measuring competitiveness would be to use production costs, which could be compared by using unit labour costs. In order, however, to obtain results that can be compared with the results of the other studies, we have chosen to use the current account as a measure of competitiveness.

3.2.3 Relative money supplies

Since an exchange rate is, by definition, the price of a country's currency in terms of another currency, it makes sense to analyze the determinants of that price in terms of the outstanding stocks of and demand for the two currencies. This is the basic rationale of a monetary approach to the exchange rate. *Within a target zone model, an increase in the level of domestic credit is expected to increase the probability of a devaluation.* An increase in the current level of domestic credit either adds to the money supply or results in lower interest rates, and so increases future inflationary pressures. On the other hand, as noted by Ötker & Pazarbasioglu (1994), if the central bank sterilizes the effect of the increase in the money supply, the decline in foreign exchange reserves will reduce the ability of the central bank to defend the fixed parity and hence, strengthen devaluation expectations.

3.2.4 Relative government budget deficits

The role of fiscal variables as potential determinants of an expected devaluation is debatable. They are generally included in this kind of analysis mainly because high-debt countries may be induced to inflate away the portion of debt denominated in the domestic currency. The inflation rate is then the channel of effect from changes in fiscal stance to changes in expected devaluation. If the inflation rate is already included in the analysis, the inclusion of fiscal variables is justified on the grounds that they are better predictors of future inflation than the current rate.

Frenkel & Razin (1987) and Masson & Knight (1990) find that large autonomous changes in national saving and investment balances - in particular, those induced by shifts in public sector fiscal positions - exert a very strong influence on current account positions, real interest rates and, hence, exchange rates. In the context of target zones, the credibility of a regime may change from period to period if the signal of a reputation for toughness in one period through contractionary government policy leads to excessive costs from not adjusting in a later period. High-debt countries may be induced to inflate away the portion of debt denominated in the domestic currency. As also Drazen & Masson (1993) also note, the influence of fundamentals on the expected change in central parity depends on the credibility of the government and the cost of maintaining credibility in each period. Hence, we include the government net borrowing requirement in the regression equation. We use the flow variable and not the stocks, because *the flow variable reflects the theoretical prediction of a positive relationship between the risk of devaluation and the rise in government debt.*

3.2.5 Industrial production

Industrial production is included in the equation because in one approach the exchange rate is determined by relative outputs. According to the monetary model, *a country with faster economic growth should have an appreciating exchange rate.* For a given level of aggregate demand, an increase in production is absorbed in the long run either at home or abroad. If the excess supply is to be consumed at home, prices have to decrease, which will improve the competitiveness of domestic products on international markets. The exports of the country grow as a result of the decrease in prices. The current account is then brought back into equilibrium through an appreciation of the exchange rate.

The opposite effect is obtained in the macroeconomic balance approach to the determination of an exchange rate. According to this approach, if output is above its potential, inflationary pressures are created. A higher expected inflation rate is then discounted in the exchange rate as depreciation. On the other hand, if higher domestic demand will spill over to increases in imports, so that the current account will deteriorate. This imbalance can be brought into equilibrium through *a depreciation of the exchange rate*, so that the competitiveness of the country's exports improves.

3.2.6 Foreign exchange reserves

It seems quite natural to include the foreign exchange reserves of the central bank in an analysis of the determinants of an expected devaluation. Various models of balance of payments crises assign key roles to actual or expected levels of international reserves. In a fixed exchange rate regime, central banks intervene to stabilize the exchange rate. Therefore, market agents observe the development of the foreign reserve position of the central bank. If the reserve is low, the possibilities for the central bank to maintain the fixed exchange rate smaller than if the central bank has a large reserve. Further, free capital mobility implies that the threat of a speculative attack that will empty the reserves of the central bank is constant. Hence, *if the reserves of the central bank decline, agents begin to suspect a forthcoming devaluation of the currency.*

The foreign exchange reserves are included as a change in the level of the reserves of the domestic central banks. Alternatively, we could use the difference between domestic and German levels. As Eichengreen et al. (1994) point out, analyzing changes in the reserves of each country relative to changes in German reserves would yield results that take into account compulsory simultaneous interventions. Because Germany has been the strong-currency country in the EMS, the Bundesbank is almost always the other actor in such interventions. Voluntary (intra-marginal) intervention by third central banks, however, is not included in the bilateral differential. Because there is also the problem of attributing the interventions of the Bundesbank to a particular country, we have chosen to apply the change in the domestic foreign exchange reserves as the explanatory variable.

3.3 Results

The data was regressed for each country separately, and as a panel for all countries, using ordinary leased squares (OLS) corrected for heteroscedasticity and autocorrelation by the Newey-West method. A description of the data is provided in the Appendix. The results are reported in Tables 3.2a–b. Table 3.2a presents the results of the initial regressions including all data. Table 3.2b gives the results for the set of regressions where the insignificant variables have been dropped. Plots of these fitted estimates are presented in Figures 3.1a–h.

Table 3.2a

Results of the Regressions of Selected Macroeconomic Variables on Expected Rates of Devaluation

All variables	Panel	Belgium	Denmark	Spain	France	Great Britain	Italy	The Netherlands
Constant	Country Specific	0.07519**	0.04133**	0.07516*	0.09404*	-0.26967	0.24240**	0.09693**
		(5.26)	(2.12)	(1.44)	(1.79)	(0.93)	(8.03)	(4.01)
Current Account	0.00145	-0.00227	-0.00335	0.00287	0.01175	-0.02215*	-0.00247	0.00415
	(0.45)	(0.84)	(0.77)	(1.18)	(1.13)	(1.35)	(0.40)	(0.99)
Inflation Differential	0.00070*	0.00020	0.00170**	-0.00002	0.00113**	0.00021	0.00156*	0.00094*
	(1.52)	(0.85)	(7.91)	(0.02)	(2.27)	(0.44)	(1.65)	(1.63)
Relative Money Supply	0.01671	-0.00898	0.00089	0.00620	0.02789	-0.05064	0.07652*	-0.0194
	(0.98)	(0.56)	(0.12)	(0.92)	(0.15)	(0.48)	(1.58)	(0.76)
Relative Government Deficit	0.01765	-0.8661**	-0.01282	-0.18605**	0.05145*	0.00805	0.22083**	-0.02385**
	(1.03)	(3.04)	(0.67)	(3.40)	(1.76)	(0.10)	(4.08)	(2.61)
Industrial Production Differential	0.04957**	0.02855**	0.02114**	0.00342	0.04797**	0.16255**	0.09492**	0.00750*
	(6.76)	(4.13)	(2.30)	(0.89)	(2.51)	(2.74)	(4.77)	(1.70)
Level of Foreign Exchange Reserves	-0.010119**	-0.00805**	-0.00379*	-0.00609*	-0.00844**	0.02701	-0.02041**	-0.00994**
	(5.98)	(5.27)	(1.73)	(1.33)	(1.65)	(0.99)	(7.37)	(3.98)
R^2	0.74	0.80	0.77	0.89	0.56	0.43	0.76	0.35
Standard error	0.0035	0.0017	0.0024	0.0016	0.0028	0.0038	0.0048	0.0013

* significant at 5 % level, ** significant at 1 % level

Table 3.2b **Results of the Regressions of Selected Macroeconomic Variables on Expected Rates of Devaluation**

All variables	Panel	Belgium	Denmark	Spain	France	Great Britain	Italy	The Netherlands
Constant	Country Specific	0.07279** (5.30)	0.04551** (2.39)	0.07981** (2.10)	0.09043* (1.71)	0.01694** (5.54)	0.24097** (7.92)	0.09798** (4.08)
Current Account						-0.02074 (1.44)		
Inflation Differential	0.00075** (4.00)		-0.00171** (7.66)		0.00105** (2.71)		0.00155* (1.68)	0.00039 (1.37)
Relative Money Supply	0.01371* (1.41)						0.07189 (1.65)	
Relative Government Deficit		-0.08679** (3.71)		-0.19529** (4.70)	0.05555* (1.87)		0.22021** (4.07)	-0.01701** (2.00)
Industrial Production Differential	0.04818** (6.80)	0.02785** (4.24)	0.02026** (2.64)		0.05278** (2.67)	0.15614** (3.11)	0.09561** (4.93)	0.00604 (1.42)
Level of Foreign Exchange Reserves	-0.010119** (5.97)	-0.00816** (5.94)	-0.00452** (2.04)	-0.00667* (1.92)	-0.00816 (1.57)		-0.02026** (7.29)	-0.01002** (4.04)
R^2	0.73	0.79	0.77	0.89	0.54	0.35	0.76	0.31
Standard error	0.0035	0.0016	0.0024	0.0015	0.0028	0.0037	0.0048	0.0013

* significant at 5 % level, ** significant at 1 % level

3.3.1 Panel data

In panel the inflation rate, industrial production and foreign exchange reserves appear with a significant coefficient. A positive inflation rate differential tends to increase devaluation expectations, just as was expected. In addition, the level of foreign exchange reserves has a coefficient with the expected sign: an increase in reserves improves the credibility of the fixed exchange rate regime and, as a consequence, the expected rate of devaluation decreases. The coefficient of industrial production is, on the contrary, positive. If there is stronger growth in production compared with Germany, devaluation expectations concerning the domestic currency increase. This indicates that an increase (decrease) in domestic industrial production relative to Germany is regarded as inflationary (deflationary), and these expectations are then discounted in the exchange rate. It could also be that more rapid growth at home affects imports more easily than exports.

The remaining explanatory variables are insignificant, and after they are dropped over 72 % of the variation in the expected rate of devaluation is explained by the inflation rate differential, domestic credit, industrial production and the level of foreign exchange reserves. The inflation rate differential has a positive coefficient, indicating correctly that an increase in the domestic inflation rate relative to the inflation rate in Germany increases devaluation expectations of the domestic currency. Domestic credit becomes significant when the current account is dropped from the set of explanatory variables. An increase in the domestic money supply, or domestic credit, relative to Germany, increases devaluation expectations. An increase in the level of foreign exchange reserves, on the contrary, diminishes the devaluation expectations of the domestic currency, which is in accordance with the theory. Industrial production still enters the equation with a positive sign, indicating that stronger economic growth at home than in Germany increases devaluation expectations of the domestic currency.[15]

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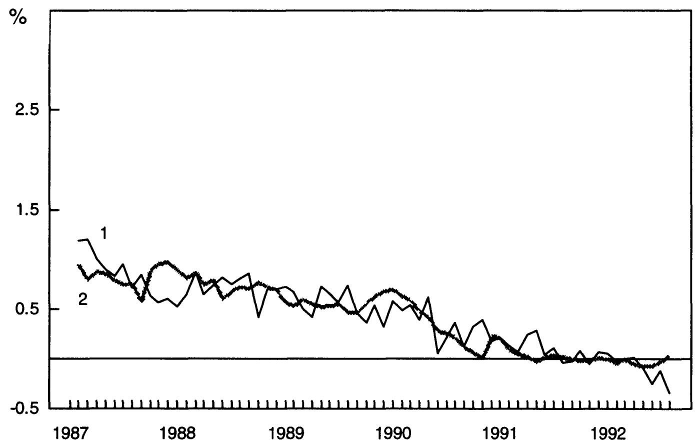
[15] We also made an attempt to model the real side of the economy by including unemployment as explanatory variable in the regression. We also tested the possible existence of the combined effect of two policy variables. We were interested in whether there is a distinct threshold level for the combination of high unemployment and high public debt that induces sudden devaluation expectations. However, these variables did not improve the results.

3.3.2 Belgium

In the regression of macroeconomic variables on devaluation expectations of the BEF/DEM exchange rate, the government deficit and level of foreign exchange reserves are highly significant and have the correct sign. An increase in domestic credit strengthens devaluation expectations, while an increase in the foreign exchange reserves diminishes devaluation expectations. The last variable, industrial production, is also significant, and it is positive. The result indicates that growing industrial production creates expectations of a devaluation of the currency.

After the insignificant variables have been, almost 79 % of the variation in the devaluation expectations of the BEF/DEM exchange rate are explained by the government deficit, industrial production and the level of foreign exchange reserves. A worsening fiscal position increases devaluation expectations, whereas an increase in the foreign exchange reserves diminishes them. A growing differential vis-à-vis Germany in industrial production tends to increase devaluation expectations.

Figure 3.1a **Belgium**



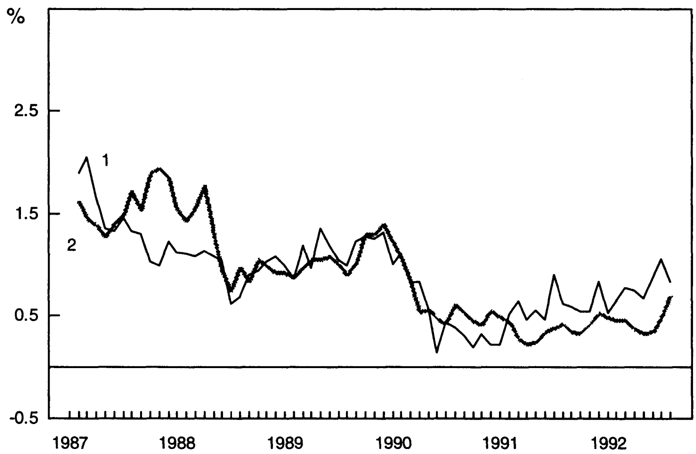
1 Fitted values
2 Devaluation expectations

3.3.3 Denmark

For the DKK/DEM exchange rate the inflation rate differential has, as anticipated, an increasing effect on devaluation expectations. The coefficient is also highly significant. Industrial production is significant and, again, positive. The level of foreign reserves has a negative as well as a significant coefficient.

The results after the exclusion of the insignificant variables are as follows. A positive inflation rate differential vis-à-vis Germany increases devaluation expectations, and an increase in the foreign exchange reserves has the opposite effect. A positive differential in industrial production vis-à-vis Germany increases devaluation expectations. These variables explain almost 77 % of the variation of the expected rate in devaluation of the DKK/DEM exchange rate.

Figure 3.1b **Denmark**

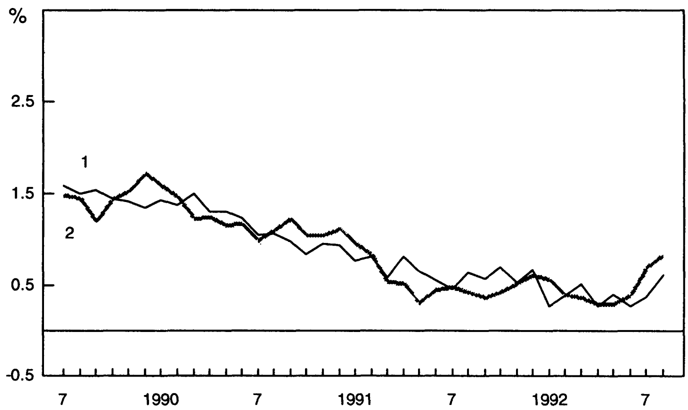


1 Fitted values
2 Devaluation expectations

3.3.4 Spain

In the regression equation for the expected rate of devaluation of the ESP/DEM exchange rate, four of the six variables are insignificant. The two significant variables, the government deficit and level of foreign exchange reserves, have the correct sign. An increase in the government deficit strengthens devaluation expectations, whereas an increase in foreign reserves has the opposite effect. These two variables explain almost 89 % of the variation in the devaluation expectations.

Figure 3.1c **Spain**



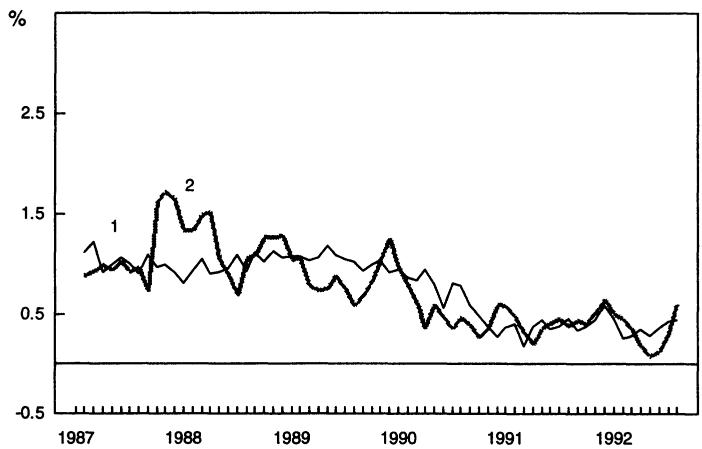
1 Fitted values
2 Devaluation expectations

3.3.5 France

For the FRF/DEM exchange rate four variables are insignificant. The inflation rate differential has a positive coefficient indicating that, as expected, a faster domestic rate of inflation weakens the domestic currency. A decrease in industrial production dampens devaluation expectations. The negative coefficient for the level of foreign exchange reserves indicates correctly that an increase in reserves dampens devaluation expectations. The remaining significant variable, on the other hand, displays the wrong sign. The result shows that a worsening of the government deficit dampens devaluation expectations.

The dropping of the insignificant variables did not change the wrong sign of the coefficient for government deficit. Hence, devaluation expectations of the FRF/DEM exchange rate decrease when the budgetary position in France worsens. The other variables obtain coefficients with correct signs, indicating increasing devaluation expectations with an increasing positive inflation rate differential vis-à-vis Germany, with growing industrial production in relation to Germany, or with decreasing foreign exchange reserves. These variables explain 54 % of the variation in the expected rate of devaluation of the FRF/DEM exchange rate.

Figure 3.1d **France**

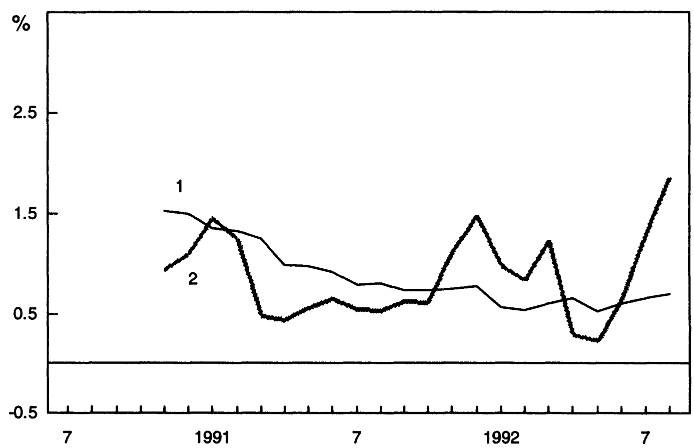


1 Fitted values
2 Devaluation expectations

3.3.6 Great Britain

The devaluation expectations of the GBP/DEM exchange rate seem to be affected mainly by two variables, the current account and industrial production. The current account shows a negative sign, which means that an improvement in competitiveness is expected to strengthen the currency. Industrial production, on the other hand, enters into the equation again with a positive coefficient, indicating that greater economic activity would weaken the domestic currency. Of the remaining four variables, only one, namely the inflation rate differential, shows the correct sign. Domestic credit, the government deficit and level of foreign exchange reserves show wrong signs but are, as is the inflation rate differential, insignificant. The significant variables, the current account and industrial production explain only 35 % of the variation in the expected rate of devaluation of the GBP/DEM exchange rate.

Figure 3.1e **Great Britain**

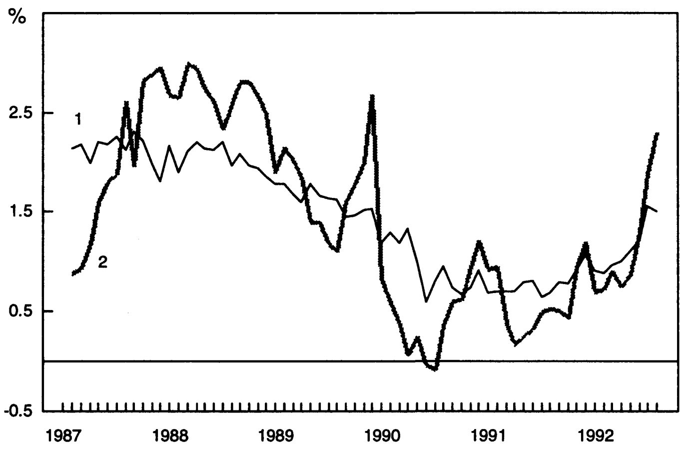


1 Fitted values
2 Devaluation expectations

3.3.7 Italy

The Italian case yields interesting results. Excluding current account, the remaining explanatory variables explain over 76 % of the variation in the devaluation expectations of the ITL/DEM exchange rate. Of these variables, the inflation rate differential and domestic credit have the correct positive sign but are of only slight significance. They indicate that monetary expansion and a faster inflation rate in the home country have an increasing effect on devaluation expectations. Industrial production enters the equation with a highly significant positive coefficient. A decrease in industrial production should, hence, reduce devaluation expectations. Similarly, an increase in the level of foreign exchange reserves has a significant negative sign, indicating, correctly, that larger reserves diminish devaluation expectations. The government deficit enters the equation with a highly significant coefficient that has the wrong sign. A worsening of the government's financial position and a decrease in industrial production tend to dampen devaluation expectations.

Figure 3.1f **Italy**

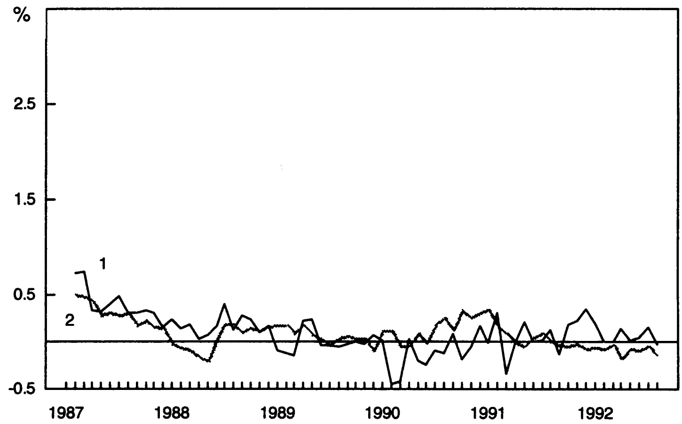


1 Fitted values
2 Devaluation expectations

3.3.8 The Netherlands

In the regression equation for the devaluation expectations of the NLG/DEM exchange rate the coefficients for inflation rate differential and industrial production are of modest significance. A positive inflation rate differential vis-à-vis Germany tends to increase devaluation expectations. The coefficient for industrial production is, even in this case, positive. The coefficients for the government deficit and the level of foreign exchange reserves enter the equation significantly and with correct signs. A worsening of the fiscal situation increases devaluation expectations, whereas an increase in the level of foreign exchange reserves diminishes devaluation expectations. The reduced set of explanatory variables explains only 32 % of the variation in the expected rate of devaluation of the NLG/DEM exchange rate.

Figure 3.1g **The Netherlands**



1 Fitted values
2 Devaluation expectations

3.3.9 Summarizing the results

Summarizing the results from the panel for individual countries shows that there are some patterns in the behaviour of devaluation expectations. The inflation rate differential and domestic credit relative to German domestic credit seem to be quite neutral explanatory variables. They both appear significantly and correctly with positive signs in the panel, indicating that within the ERM monetary expansion in the home country tends to increase devaluation expectations of the domestic currency. For individual countries these variables always enter with the correct sign, but their degree of significance varies.

In reality it always seems, as stated by Cooper (1988), that there is a weak link between a deterioration in the current account and a depreciation of the nominal exchange rate. This relationship, however, is neither strong nor systematic and does not account for a large portion of actual exchange rate movements. In the regressions in this study the current account appears significant only for the GBP. In this case the current account might reflect the effect of external stability because the GBP/DEM exchange rate is the only case where the level of foreign exchange reserves has no effect on devaluation expectations.

The government deficit does not obtain a significant coefficient in the panel. For the BEF/DEM, ESP/DEM and NLG/DEM exchange rates it appears with a negative sign, indicating that a worsening fiscal position tends to increase devaluation expectations. It is quite puzzling, however, that for the FRF/DEM and ITL/DEM exchange rates, the coefficient has the wrong sign and is significant. This inverse result could reflect the difference in what kind of expectations a change in the fiscal position induces. If an increase in the deficit is expected to be followed by a contractionary monetary policy, and this expectation is discounted in the exchange rate, the increase in the deficit arouses expectations of an appreciation of the currency. For example, countries such as Belgium and the Netherlands, which have maintained close links with the DEM, have been successful in convincing markets that their commitment to the exchange rate parity is the most important of their monetary policy objectives. Even though there are some elements of vulnerability to high interest rates, the markets are presumably convinced that those costs would be absorbed to protect the longer-term benefits of exchange rate stability.

On the other hand, in a country with low credibility and a weak fiscal position, a deterioration in the deficit can be easily seen as an incentive for the government to inflate away part of its debt. Such expectations then add to devaluation expectations. Defending the domestic currency with higher interest rates may worsen the situation rather than increase the credibility of the exchange rate commitment. A large increase in interest rates can feed back quickly and powerfully to increase the government's fiscal deficit. At some point, increases in interest rates may actually weaken the attractiveness of the domestic currency if market participants believe that they can increase debt-servicing problems. Moreover, high interest rates – maintained for the purpose of defending the fixed exchange rate parity – will often be viewed as having a high opportunity cost in terms of domestic economic activity, particularly in cases where the economy has been in recession, where unemployment rates are high, where inflationary pressures are moderate and receding, and where the consensus forecast is for slow growth. The greater the differences between the domestic and external requirements for monetary policy in a weak-currency country, the more likely it is that questions will be raised about the meaningfulness of "tying one's hands" on monetary policy. In such a situation, increases in interest rates will be politically unpopular. In the current study, the result – the negative and significant coefficient for the government deficit – for Spain might reflect such arguments. The coefficient for Spain is also larger than the coefficients for Belgium and the Netherlands.

Of the remaining explanatory variables, the level of foreign exchange reserves and industrial production seem to be most crucial. The level of foreign exchange reserves correctly obtain a negative and significant sign in all cases except for Great Britain. As was stated above, in the British case, the current account may, instead, reflect the external position of the home country. Industrial production also behaves very consistently in all regressions. The coefficient is significant in all cases except Spain. The coefficient is also positive, indicating that slower economic growth at home than in Germany tends to strengthen the domestic currency. In other words, among the EMS countries either the significance of a rise in the exchange rate seems to be strongly affected by expectations, or the sensitivity of imports to changes in industrial production is considerably larger than that of exports. The business cycle of the anchor currency country also seems to play an important role. A boom in the country providing the anchor currency is expected to have positive spill over effects on the other countries and, vice versa, a recession in the anchor currency country is expected to have negative spill over effects on the partner countries.

4 German monetary unification and the EMS

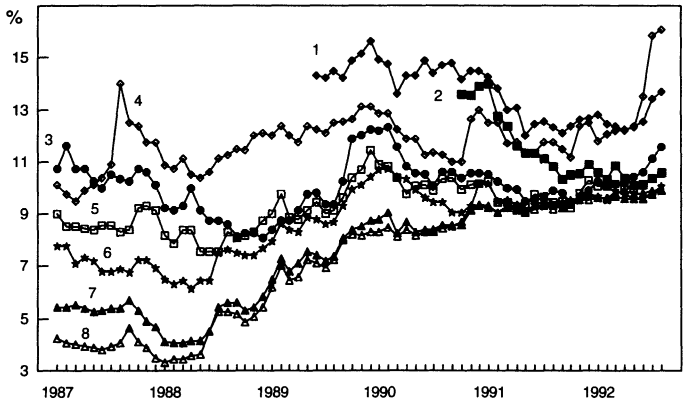
The estimation results suggest that GMU, which took place in July 1990, caused no acute short-term nominal tension within the EMS, as was feared. On the contrary, we observe increased exchange rate credibility in the form of decreasing devaluation expectations. The explanation for the increase in the stability of the EMS exchange rates is that German variables, ie interest rates and inflation, move upwards and hence, approach the corresponding variables of the other EMS countries. It was the convergence of these variables that apparently eases pressure on nominal exchange rates. The model foreshadows no signs of imperading crisis.

4.1 Increased convergence

GMU had positive spillover effects on EMS countries in several respects. First, inflation expectations in Germany were adjusted upwards. This had an effect on the interest rates. Long-term rates rose because of the change in expectations, and short-term rates were raised by the Bundesbank as it tried to fight inflationary pressure. In the other EMS countries, there were no inflationary pressures and, hence, no need for corresponding interest rate increases. This implies that *interest rates converged*, as can be seen in Figures 4.1a–b. This per se diminishes devaluation expectations of the exchange rate parities.

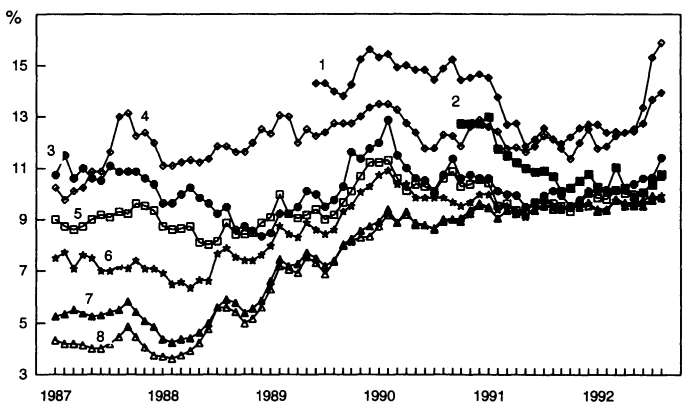
The same pattern can be seen to have happened with inflation rates. As a consequence of GMU, German money supply grew faster than expected, and the monetary aggregate target of the Bundesbank was exceeded in several periods. Wages and prices rose more than what was warranted by growth in productivity. As a result, German inflation rate increased. At the same time, domestic demand in other EMS countries was declining. This boosted the effects of the anti-inflationary policy conducted by the monetary authorities since the end of the 1980s, causing inflation rates in these countries to fall. As Figure 4.2 shows, even here the German rate rose at the same time as the rates of the other countries were stable or even declining. In other words, also the *inflation rates were converging* as a result of GMU. This development also contributed to increased stability of the EMS exchange rates.

Figure 4.1a **Short-term interest rates**



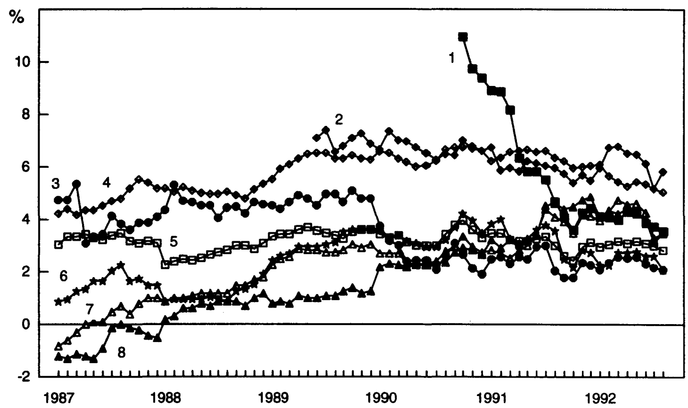
1 Spain	5 France
2 Great Britain	6 Belgium
3 Denmark	7 The Netherlands
4 Italy	8 Germany

Figure 4.1b **Long-term interest rates**



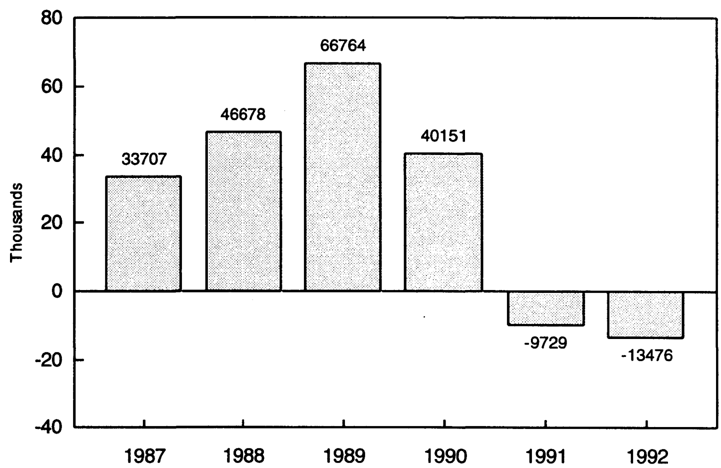
1 Spain	5 France
2 Great Britain	6 Belgium
3 Denmark	7 The Netherlands
4 Italy	8 Germany

Figure 4.2 **Annual inflation rates in selected EMS countries**



1 Great Britain
2 Spain
3 Denmark
4 Italy
5 France
6 Belgium
7 Germany
8 The Netherlands

Figure 4.3 **The German current account balance in DEM million, 1987 to 1992**



On the real economy side, convergence may be seen in the reversing trade balances. Traditionally, EMS partner countries suffer from persisting trade deficits with Germany. However, as the additional demand from rebuilding former East Germany has to be satisfied both through domestic production and imports, the trade balance was reversed. Trade partners wer given the opportunity to remarkably diminish their deficits vis-à-vis Germany, and in some cases even turn them into surpluses. Accordingly, Germany became a net importer, as can be seen from Figure 4.3. Hence, even this effect of GMU added to convergence, diminishing devaluation expectations of the DEM exchange rate and other EMS currencies.

4.2 Divergence

Signs of recession in Europe could be seen at the end of the 1980s. In this respect, the German boom from GMU was extremely well timed. The spill-over effects of GMU kept the recession at bay for Germany's partners. However, this injection to the export sectors of these economies could not fully prevent recession, only delay it.

4.2.1 Business cycle

In Germany, the GMU boom started to fade within 18 months. By early 1992, growth in Germany starts to faulter. In its December 1991 Economic Outlook, the OECD forecasts for Germany that (p. 80): "Slowing private consumption and low public consumption growth complete the picture of declining final demand growth in 1991 and 1992. Import growth can therefore be expected to fall considerably from its recent high rates, and GNP to grow at rates below potential throughout the projection period." Despite of such projections, the Bundesbank was unwilling to cut interest rates. Instead, it announced that it would continue to fight inflation that was, according to the view of the Bundesbank, too high. A disappointment for market agents was that the Bundesbank refused to ease its tight monetary policy. In its Economic Outlook in June 1992, the OECD wrote (p. 66): "All-German real GNP may therefore (slow growth of domestic demand in 1992 and only a small pick up thereafter) increase by some 1 3/4 per cent in 1992 and by between 2 1/2 and 3 per cent in 1993." And the following issue of Economic Outlook (December 1992) was even upbeat about the performance of the German economy (p. 70): ".. in the year to mid-1992, western German investment was on average flat, after several years of strong growth, reflecting deteriorating business expectations and falling exports." Table 4.1 summarizes the projections of the OECD for the German economy in its outlooks in December

1991 and June 1992. As can be seen, in June 1992 the projections (bold numbers in Table 4.1) are revised downwards from the numbers given in its December 1991 Economic Outlook.

Table 4.1 **OECD forecasts for Germany**

		GNP	Industrial Production	Change in Foreign Balance	CPI
1991	I	5.2	4.0	0.2	2.1
		4.4	**4.0**	**-1.1**	**2.4**
	II	-2.0	0	-1.0	5.5
		-1.4	**-2.5**	**0.2**	**6.2**
1992	I	3.3	2.0	0.7	3.5
		2.2	**4.0**	**0.2**	**3.5**
	II	2.6	2.0	0	3.8
		2.1	**2.3**	**-0.7**	**3.4**
1993	I	2.5	2.7	0.1	4.8
		2.5	**2.7**	**0.5**	**4.0**
	II	2.5	3.6	0.1	2.6
		2.3	**3.1**	**0.2**	**2.7**

Source: Economic Outlook

4.2.2 Monetary policy

In order to emphasize the role of the German monetary policy for the break-down of the narrow bands of EMS, we now concentrate on monetary indicators. As monetary indicators, we can count short-term and long-term interest rates, and money supply growth. We apply the method used by Zurlinden (1993) and deGrauwe (1995). We can distinguish between three ways of measuring the stance of monetary policy. First, we use the real short term interest rates. Falling real short term interest rates reflect that the central bank is loosening its monetary policy. Second, the real growth rate of the money stock is analyzed. Evidently, an increase in the money stock indicates an expansionary monetary policy. Finally, we calculate the term structure of the interest rates, ie the difference between the short-term and the long-term interest rates. There is the widely held belief that monetary authorities are able to influence only short-term money market rates, while long-term rates are more relevant in making investment and consumption decisions. Hence, when the central bank follows a tight monetary policy, this tends to show up in a positive interest rate differential[13]. In the term-structure view, if interest rates are related across countries, then foreign short-term interst rate movements are transmitted both directly to changes in domestic short-term rates, and indirectly, via the respective domestic term structures, to changes in long-term interest rates.

Each of these indicators can be measured separately, but they should be used together when judging the stance of monetary policy. As deGrauwe (1995) denotes, these indicators give an unclear and sometimes even conflicting view of the stance of monetary policy. Therefore, it is essential to look at the indicators as a group.

The data for these indicators is collected from the IFS tapes. We use annual changes in order to smooth out volatility that disturbs data with a higher frequency. The countries are the same ones as above, ie Belgium, Denmark, France, Germany, Great-Britain, Italy, and the Netherlands. Figures 4.4–4.10 illustrate the results. In panel a, the real short term interest rate is plotted; panel b shows the change in the money supply; and panel c illustrates the development of the term structure of the interest rate. In all panels, the bars show the annual GDP growth rate.

Let us start by looking at the monetary indicators for Germany. Throughout the 1980s, GDP growth has been relatively stable. Also the stance of monetary policy has varied only little. However, both interest rate indicators reflect a tightening of the monetary policy from 1987 towards 1990. In 1991 and 1992, when the GDP declined, monetary policy was tighter than during the whole preceding decade. In 1993, when GDP growth was negative, monetary policy was eased up.

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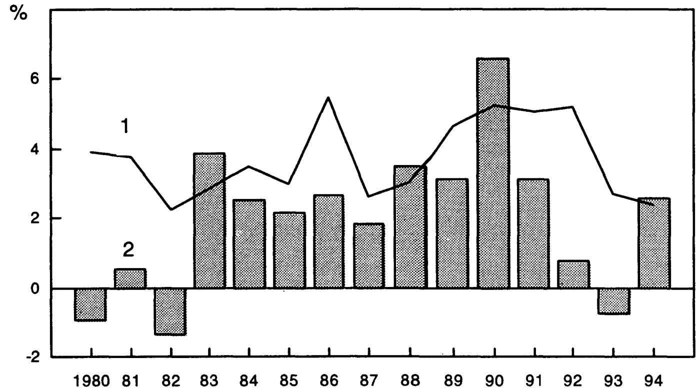
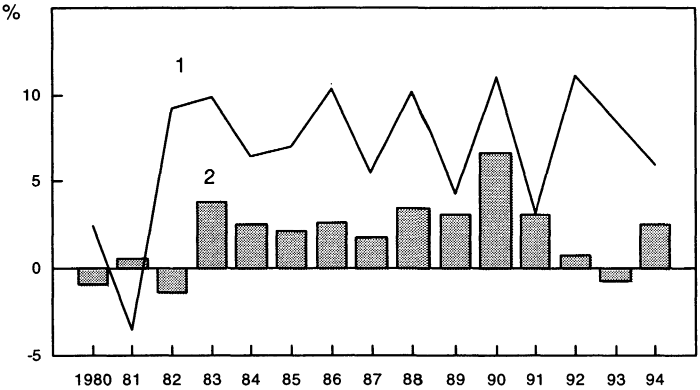
[13] As deGrauwe (1995) points out, it should be noted that that according to the expectations theory of the term structure, the differential is also influenced by the expected future interest rate. Therefore it is important that this indicator is used together with the two other ones when judging the stance of monetary policy.

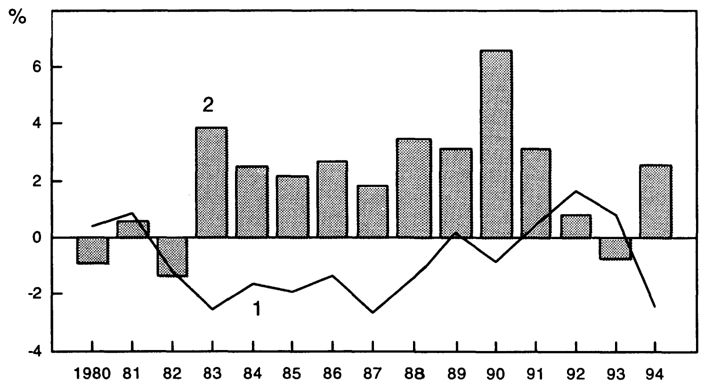
Figure 4.4 **Germany**



1 Real interest rate
2 GDP growth

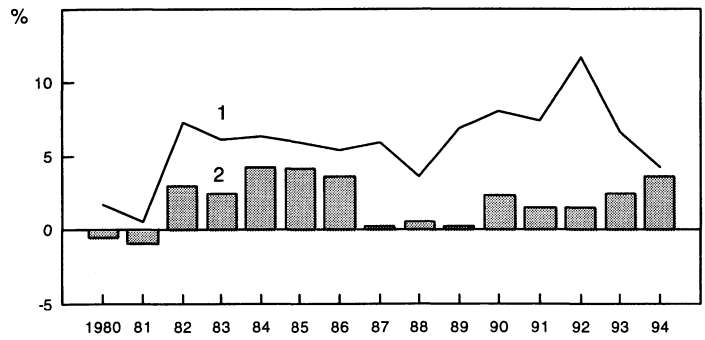


1 Money growth
2 GDP growth

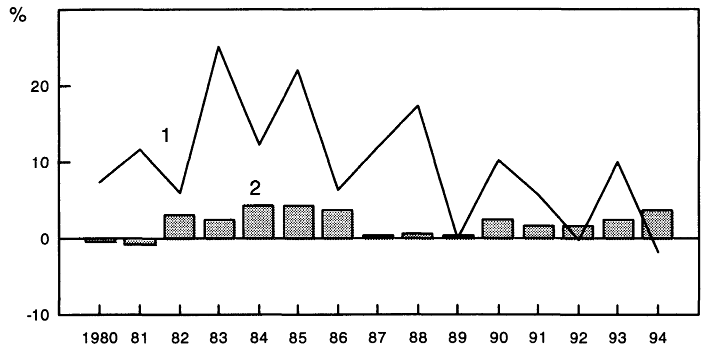


1 Term structure of interest rates
2 GDP growth

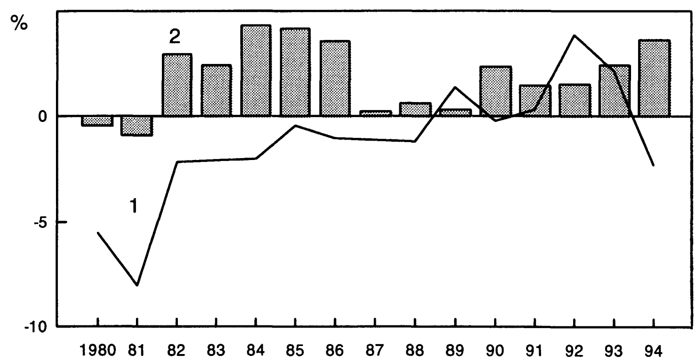
Figure 4.5 **Denmark**



1 Real interest rate
2 GDP growth

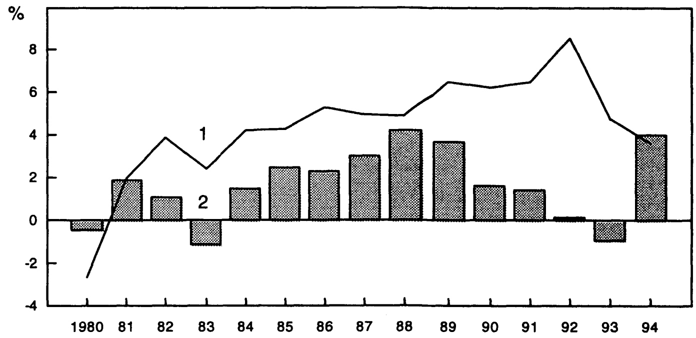


1 Money growth
2 GDP growth

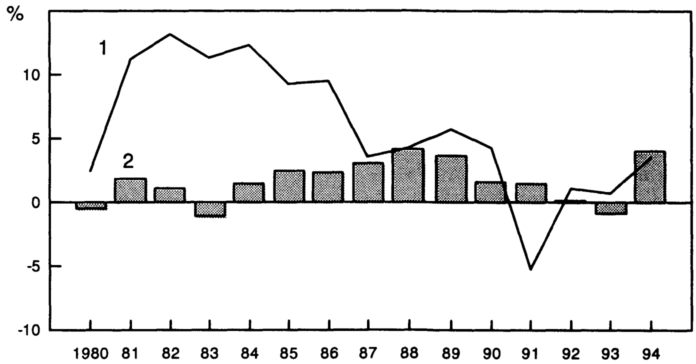


1 Term structure of interest rates
2 GDP growth

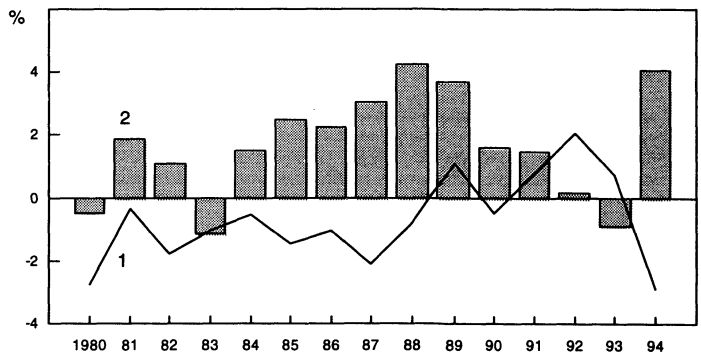
Figure 4.6 **France**



1 Real interest rate
2 GDP growth

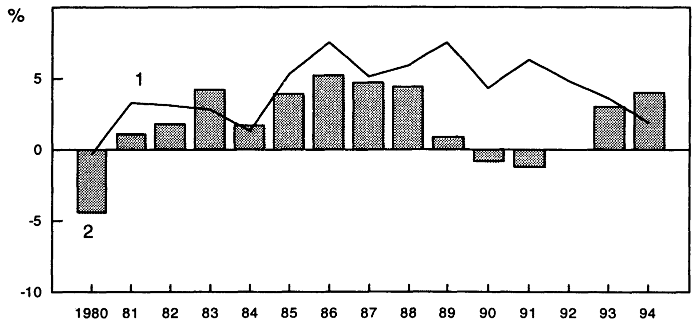


1 Money growth
2 GDP growth

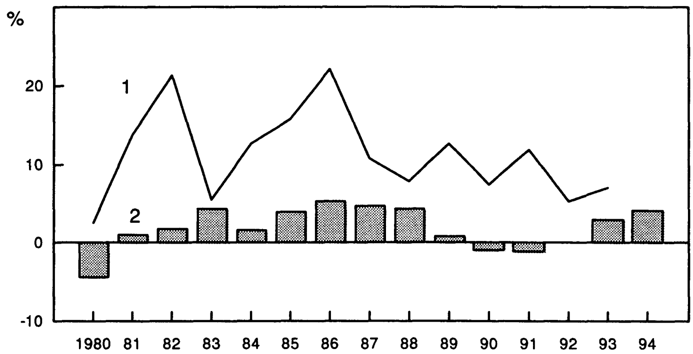


1 Term structure of interest rates
2 GDP growth

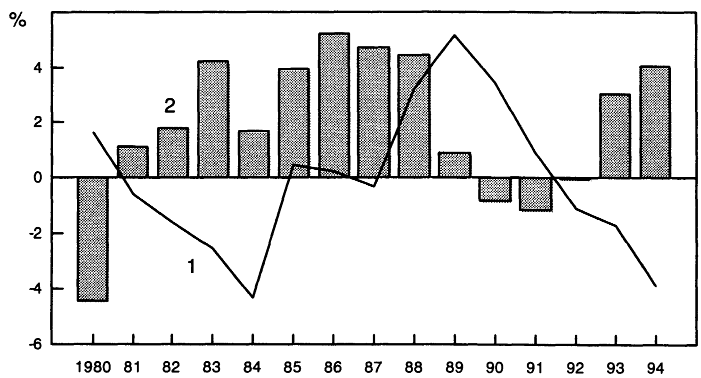
Figure 4.7 **Great Britain**



1 Real interest rate
2 GDP growth

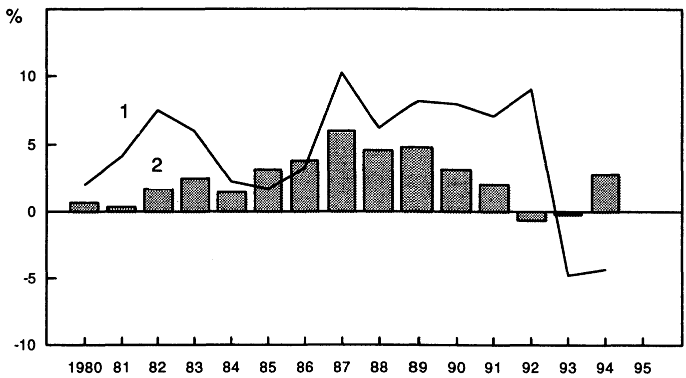


1 Money growth
2 GDP growth

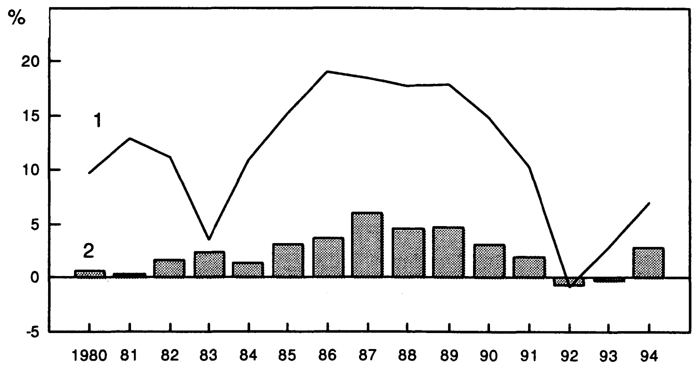


1 Term structure of interest rates
2 GDP growth

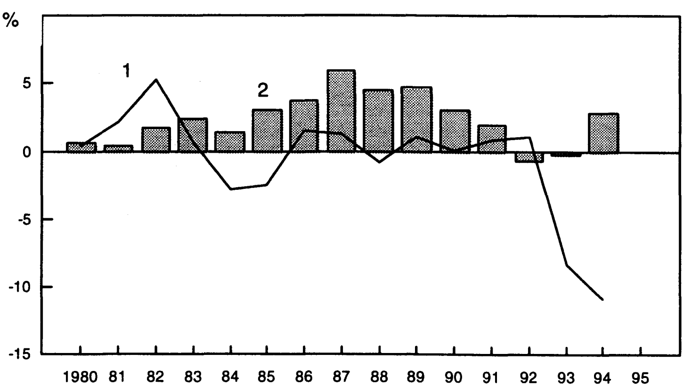
Figure 4.8 **Spain**



1 Real interest rate
2 GDP growth

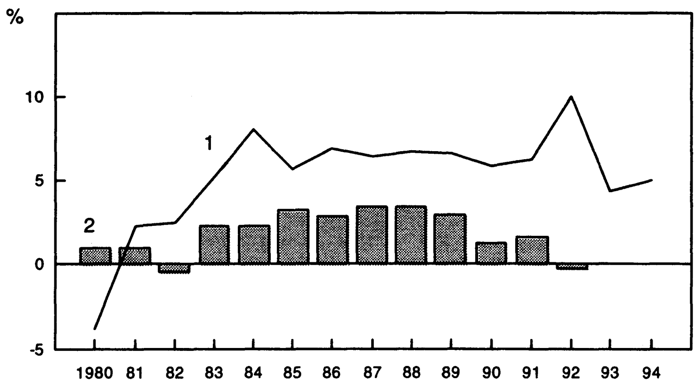


1 Money growth
2 GDP growth

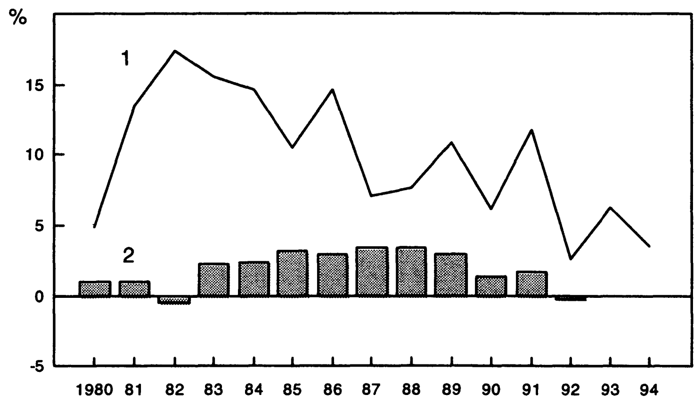


1 Term structure of interest rates
2 GDP growth

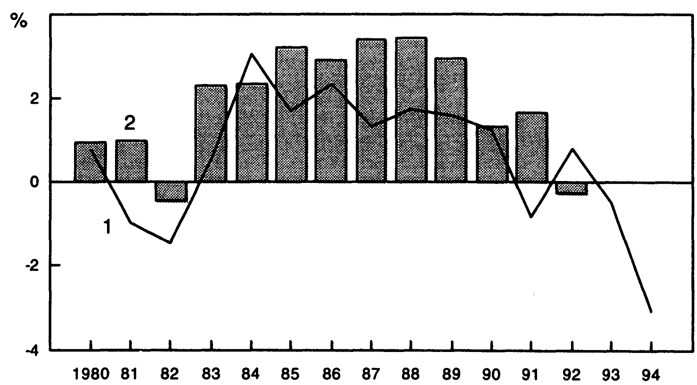
Figure 4.9 **Italy**



1 Real interest rate
2 GDP growth

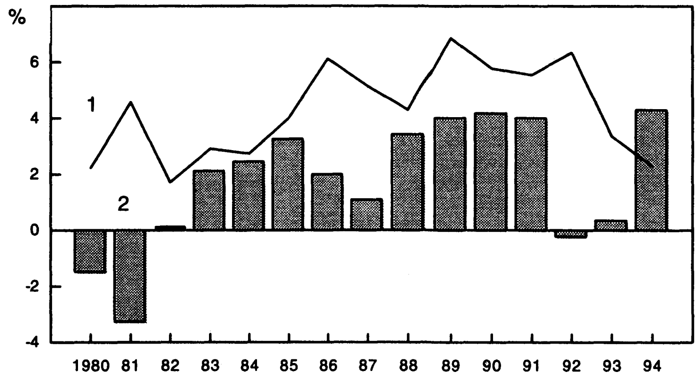


1 Money growth
2 GDP growth

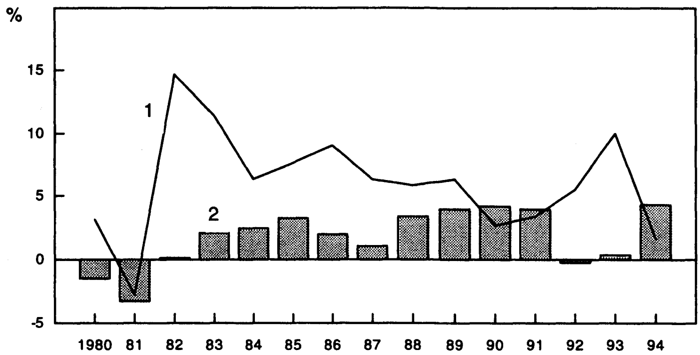


1 Term structure of interest rates
2 GDP growth

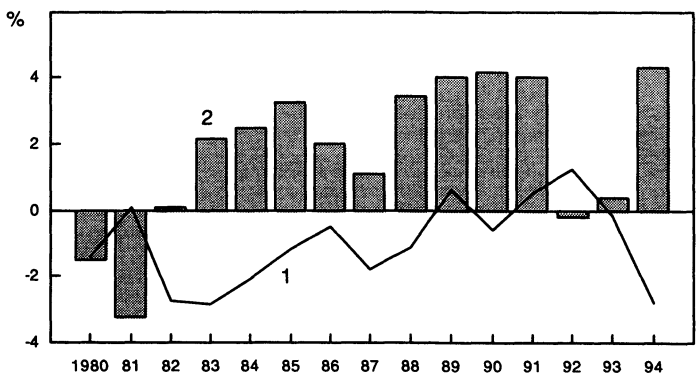
Figure 4.10 **The Netherlands**



1 Real interest rate
2 GDP growth



1 Money growth
2 GDP growth



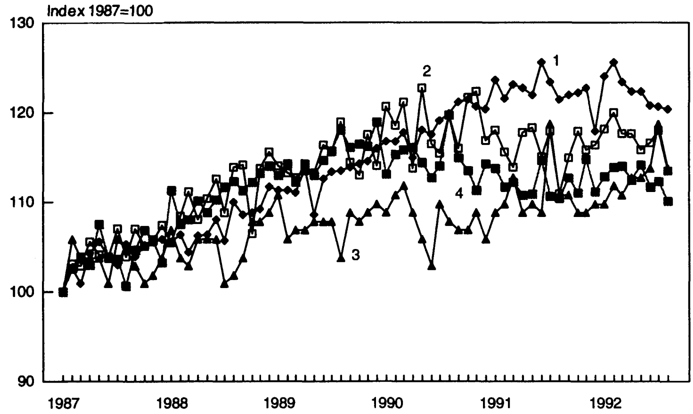
1 Term structure of interest rates
2 GDP growth

Turning to the other countries, we see that after a relatively stable course of monetary policy in the 1980s, there is a change during the first years of the 1990s. At the same time as the recession in the ERM countries started, monetary policy was tightened. In Denmark, all indicators remain relatively stable throughout the 1980s. In the beginning of the 1990s, however, there is a turn towards strictness, and the peak is reached in 1992. In France, monetary policy seems to have been tightened little by little throughout the 1980s. At the same time, the GDP has been growing. Between 1990 and 1993, the GDP declined. However, the course of monetary policy was not changed. Even in France, the peak of monetary tightness falls into the year 1992. For Great Britain, the money supply and term structure of interest rates indicate a tightening of the monetary policy since 1987. Because Great Britain joined ERM first in October 1990, this course cannot be attributed to the exchange rate link to the monetary policies of the other ERM countries. However, the same pattern of monetary policy tightening as in Denmark and France in 1990-1992 cannot be seen in Great Britain. On the contrary, British monetary policy seems to have become looser in those years. Also Spain has participated in the ERM for a shorter period: since June 1989. The GDP growth in Spain has slowed down since that year. The course of monetary policy, however, has been rather towards stricter than looser. According to these indicators, even the Spanish monetary policy has been contractive in 1991-1992. In these years GDP growth was low or even negative. The same pattern can be reconized in the course of the Italian monetary policy: it was relatively stable throughout the 1980s, but tightened towards the year 1992, the year of lowest GDP growth. The Netherlands follow the same pattern: relatively stable or slightly tightening course throughout the 1980s, and then a clear peak of strictness in 1992, the year of lowest GDP growth. This indicates, as deGrauwe (1995) concludes, that the ERM led the EMS countries to follow deflationary monetary policies that were not motivated by domestic reasons.

4.3 Interpreting the results

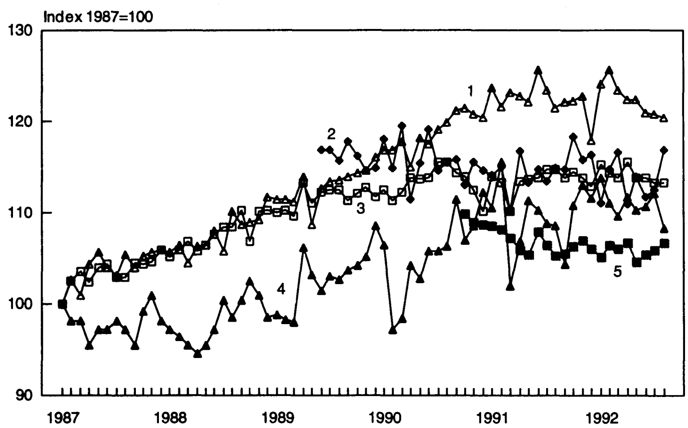
Recalling the results from our regressions of devaluation expectations on macroeconomic variables, we conclude the above discussion with the following argument. The short-run effects of GMU contributed to the convergence of the EMS economies. On the monetary side, interest rates and inflation rates converged; on the real side, trade imbalances vanished, and the boom had positive spill-over effects on neighbouring EMS countries. However, these positive effects were only *temporary.* In the longer term, as the immediate effects of GMU started to fade, the divergence of the business cycles in the EMS economies became more clearly visible. This difference in the business cycle can be seen in Figure 4.11a–b. In other countries, where domestic activity had been weak for some time, their economies were primed through increased activity in Germany. As the slowdown hit Germany, other countries experienced a decrease in aggregate demand, what was seen by the markets as a strong need for expansionary policies. This was impossible, however, given that fixed exchange rates in the EMS were linked to the monetary policies of the individual EMS countries. The interest rates of other EMS countries were tied to the interest rates of the anchor country, ie their monetary policy was dictated to a large extent by the monetary policy conducted by the Bundesbank. The German policy-mix was, however, unsustainable by other EMS countries, eventually forming them to publicly challenge the value of their commitment to the EMS. Expansionary fiscal policy combined with a tight monetary policy resulted in high interest rates, which was not considered as appropriate for the domestic needs of Germany's partners. The level of interest rates that many other EMS countries saw as appropriate for dealing with their domestic economic situation was lower than the level of rates that the anchor country in the EMS saw as appropriate for its own domestic economic conditions and responsibilities. Under a fixed exchange rate regime, the costs associated with weak-currency countries adopting large increases in interest rates are normally diminished by having the strong-currency country share the adjustment burden by reducing its own interest rates. However, this course of action was severely constrained by the Bundesbank's assessment that it would be incompatible with controlling inflationary pressures in Germany. As the GMU locomotive slowed further, the contradiction between the policy preferences of Germany versus other EMS countries became more pronounced.

Figure 4.11a **Industrial production in selected EMS countries**



1 Germany
2 Belgium
3 Denmark
4 Italy

Figure 4.11b **Industrial production in selected EMS countries**



1 Germany
2 Spain
3 France
4 The Netherlands
5 Great Britain

Expectations of possible realignments as a tool of adjustment become relevant only after it is apparent that there is a discrepancy between the cyclical needs of the economies in the other EMS countries and the high interest rates imposed on the ERM by Germany. These discrepancies emerged first in Italy, Great Britain and Spain. The traditional weak-currency countries Italy and Spain faced the most difficult domestic economic situation. The government deficit of these countries, relative to Germany, affected devaluation expectations. In Italy the divergence of the business cycles amplified this effect. In both countries, the falling level of foreign exchange reserves of the central bank were noted by the markets, which put these currencies under speculative attack. Great Britain, in turn, had to fight against the public perception that the GBP rate was fixed at an unappropriately high level in the ERM. As the German locomotive lost steam pessimism wornout and a British recession could no longer be avoided. In hard-currency countries such as the Netherlands and Belgium, devaluation expectations could not be seen even on the very eve of the crisis. For both countries, we obtained the inverse result that a growing government domestic deficit as compared to Germany tends to strengthen the currency of the home country. Also France and Denmark were strongly affected by the turn in the business cycle in Germany. Markets also seem to observe the inflation rate differential in these countries. For the crisis, however, this factor could not play a crucial role because the inflation rates of these countries practically matched the German inflation rate level. All in all, the results of this study suggest that the crisis was due to the reverse in the German business cycle in a situation where the anchor country conducted a strict monetary policy to fight domestic inflation pressures.[14] We now turn to an economic interpretation of these results.

[14] deGrauwe (1995) arrives at the same conclusion theoretically. He has construcuted a simple two-country model of the money markets by means of which he shows that a more pronounced boom in the leader country compared to the other countries in an asymmetric exchange rate system like the EMS leads to a monetary contraction in the other countries. In the light of this theoretical result, he then argues that the business cycles of the EMS countries were dissynchronized as Germany experienced the boom. This situation and the consequent policy conflict between Germany and the other EMS countries explain the crisis of 1992.

5 Conclusions

How can above results be generalized? As the target zone literature suggests, there are two components that determine the interest rate differential: the expected change of the spot exchange rate and the expected rate of devaluation. Moreover, the expected rate of devaluation is the product of the probability of a devaluation and the expected size of the devaluation. The expected spot exchange rate can remain stable quite independent of devaluation expectations. Devaluation expectations, meanwhile, are not observed as long as certain underlying macroeconomic variables converge.

Within the EMS, in the years from 1987 to 1992, crucial variables turned out to be the inflation rate differential, relative money supplies, industrial production and foreign exchange reserves of the central bank. Yet none of these variables signalled the impending crisis. This suggests that the rise in the German interest rate was not decisive for the crisis. It resulted in interest rate convergence. It could be accepted by the partner countries because the interest rate effect of the GMU was accompanied by a positive spill-over effect. The excess German demand dampened the slow-down in the business cycles of the partner countries. Therefore, the contradiction between the policy mix of the anchor country and the other EMS countries was not experienced as urgent. However, as soon as the positive spill-over effect faded, the consequences of the high interest rate level became pronounced.

If any generalization can be drawn here, it is that devaluation expectations seem to become visible first when there are obvious policy conflicts, which are considered unsustainable over the longer term. Moreover, it is natural to think that devaluation expectations are connected with the credibility of the system as a whole rather than to a single exchange rate. There could to be a threshold after which participation in the system is considered or expected to bring more costs than gains. Further, in a situation where changes in variables are immediately and correspondingly transmitted through the financial markets, the monetary autonomy of the participating countries in the system is considerably reduced. This implies that the system must be experienced as meaningful before domestic monetary authorities are ready to give up their autonomy. If the system does not work so that it contributes to the goals of the domestic authorities, then the willingness of the authorities to commit to the system obviously decreases. When the market agents think that that threshold has been exceeded, devaluation expectations are aroused.

The above conjecture brings into question the ability of the target zone methodology to measure the credibility of a fixed, but adjustable, exchange rate system such as the EMS. If the cooperative nature of such a system makes the commitment of the authorities to the respective fixed parities more important than the development of single variables that are traditionally used as determinants in exchange rate models, then it should be of interest to try to find the elements that diminish the political willingness to participate in such a system. Anyway, it is clear that target zone models alone cannot be used to test such an assumption. While the literature in the field of speculative attacks might provide some help in this respect, work on this question shall be left as a task for further studies.

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Monetary Policy in the ERM: Internal Targets or External Constraints?

Contents

1 Introduction

The exchange rate mechanism (ERM) of the European Monetary System (EMS) was established in 1979 in order to promote exchange rate stability in Europe. It is a system with fixed, but adjustable, parity rates. Within the parity grid, the currencies of the participating countries have a central rate vis-à-vis each other. The currencies are then allowed to float in a band around the central rate. If long-lasting discrepancies in the underlying economies cause pressures for the exchange rate, the central rate can be realigned by a common decision of all the participating countries.

ERM functioning has evolved from its original design. The prevalent idea of the course of this evolution is broadly as follows. In the early years, domestic goals were preferred over external targets in monetary policy formulation. Inflation discrepancies were allowed, because they were readily corrected through a change of the exchange rate parity. Towards the end of the 1980s, however, exchange rate stability seems to have gained more weight in the reaction function of the central banks. Domestic inflation was forced down, and there was a reluctance to disturb the central rate. The exchange rate was to be kept close to the central rate, a goal formally expressed in the Basle-Nyborg Agreement. This period of exchange rate credibility was disturbed by a Europe-wide currency crisis in autumn 1992. That turmoil led the ERM countries to widen the fluctuation margins around the central rates from the original ±2.25 per cent to ±15 per cent. Measurement of the changes in policy preferences in the ERM remains an interesting issue, however.

So what does the empirical evidence tell us about the course of monetary policy in the ERM countries? To find out we construct a model based on a loss function that the central bank has to minimize. In the loss function, we have three elements. The first is the cost arising from using the policy instrument: interest rate variability. The second element is the standard short-term Phillips-curve related trade-off, ie the central bank wants to keep the inflation rate as well as the rate of output close to levels that are considered optimal. The third element introduces the ERM into the system. There are two factors related to this. First, the central bank wants to minimize devaluation expectations, ie the expectation that the central rate will be (discretionary) changed. This we could call "stabilisation of ERM membership". Second, a country participating in the ERM can either follow the monetary policy of the anchor country and stabilize the exchange rate, or deviate from the monetary policy of the anchor country and let the exchange rate react to this deviation. This we could call "stabilisation of the nominal exchange rate".

The interesting question is the relative weight put to the different targets or constraints of monetary policy. In order to test this, we derive a regression equation where we have as dependent variable the domestic short-term interest rate and as explanatory variables domestic inflation rate, domestic production, the exchange rate, German short-term interest rate, and the US short-term interest rate as representing the monetary policy of the rest of the world. We analyse the entire period from the establishment of the EMS: from January 1980 up to June 1996, dividing it into three subperiods. The three subperiods, in turn, are designated according to the de facto functioning of the ERM. In the early years, when there were many realignments, the system was more a crawling peg than a fixed exchange rate system. Between 1987 and 1992, no realignments occurred, making the EMS essentially a fixed exchange rate system. In the aftermath of the 1992 currency crisis, the fluctuation margins of the ERM were widened. Theoretically, at least, the system in use since August 1993 offers plenty of room for flexibility.

The evidence suggests that the role of the domestic variables for monetary policy making has been about the same throughout the full period. While they were most important in the first subperiod, they became only slightly less significant in following subperiods. On the foreign side, the German interest rate became a significant coefficient only in two countries – Belgium and the Netherlands. In the other countries, the deviation of the exchange rate from the central rate has been the significant determinant of monetary policy. It is natural that from these two foreign variables only one is observed when making domestic monetary policy decisions. The fact that the deviation of the spot exchange rate from the central rate yields only insignificant coefficients in the third subperiod may indicate that the EMS has become more symmetric over time in the sense that the participating economies and the policy preferences of the participants have converged. During the existence of the wide fluctuation margins, either the amount of sterilized intervention has increased, or deviations of the exchange rate from its central rate have been allowed more generously than before, or both. In any case, the exchange rate restriction originally provided by the ERM seems to have lost its direct constraining influence on domestic monetary policy making.

2 The German dominance hypothesis

The influence of the EMS on the participants' monetary policies has usually been studied in the context of the so-called German dominance hypothesis. Every fixed exchange rate system raises the question of symmetry attached to the conduct of monetary policy among the participating countries. The EMS has been called a "greater DEM area", meaning that the DEM is considered as the monetary anchor of the system. Institutionally, the EMS does not induce an asymmetric working of international adjustment. In general terms, a system is symmetric if the obligations of the national authorities are similar; it is asymmetric if those obligations are different. The German dominance hypothesis states that Germany is the central country in the EMS, ie Germany determines its monetary policy more or less independently of what happens in the rest of the EMS; whereas the other countries, given the bilateral DEM parities, subordinate their monetary policies to German policy.

The main approaches adopted to test the German dominance hypothesis are:

- informal description of rules and outcomes,
- formal exploration of central bank reaction functions, and
- formal testing of outcomes.

The most important empirical contributions to the research around this asymmetric interpretation of the EMS are reviewed below.[1] The assumption to be made about the position of Germany is crucial in this study, because – as we shall see in chapter 3 – that has strong implications for how we formulate the role of the ERM for the conduct of domestic monetary policy.

Giovannini (1988) studies the behaviour of interest rates in correspondence with parity realignments. His test is based on the premise that, while in a symmetric regime international portfolio shifts are reflected in both countries' interest rates, in an asymmetric regime the central country's rate is unaffected. International portfolio disturbances perturb rates only in other countries. Hence, he uses a

[1] For another literature survey on German leadership, see Gros & Thygesen (1992) and Begg & Wyplosz (1993).

simple test of the asymmetry hypothesis, based on the observation of countries' interest rates in correspondence with observable international portfolio shifts, ie parity realignments. The data show large swings in the offshore interest rates of the other EMS countries and a strikingly stable pattern in the domestic and offshore German rates. He then constructs objective functions for the central banks and tests the hypothesis that, in the central country, the deviations of the domestic target from its desired value are white-noise errors. While his results debunk the notion of white noise significance for other countries, this is not the case for Germany. Hence, the empirical evidence in his study agrees with the German dominance hypothesis.

In their study of interventions within the EMS, Mastropasqua et al. (1988) arrive at a similar result. They estimate central bank reaction functions for four countries displaying the expected ordering of sterilization coefficient of the foreign creation of a monetary base. They claim to have find ample evidence that Germany has played the n'th country role of supplying the system with a nominal anchor.[2]

De Grauwe (1988a, b) distinguishes short- and long-term offshore and domestic interest rates. He then tests whether expected exchange rate devaluations of an EMS member country against the DEM affect short-term interest rates only in a given country or both in Germany and the depreciating country. The empirical evidence presented suggests that the EMS constrained short-term interest rates without adding significant constraints to long-run interest rates. He concludes, however, that the EMS works in a highly symmetric way and rejects the German dominance hypothesis.[3]

Giavazzi & Giovannini (1989) study the GDH by looking at evidence from foreign exchange intervention data as well as the volatility of interest rates. The foreign exchange market data show that

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[2] Bini Smaghi & Micossi (1990) also look at intervention data and find that participation by Germany in ERM-related intervention operations always has been minimal, and thereby confirming the asymmetry of the ERM. Bofinger (1991), in turn, argues that the eventual leading position of the DEM is, in practice, due to the asymmetric intervention mechanism of the system. Interventions imply an asymmetric sterilization behaviour among the member countries so that the liquidity effects of interventions are unevenly distributed. As a consequence, in order to prevent major foreign exchange reserve losses, the other EMS countries have had to conform their monetary policies of the strong-currency country, ie Germany. The German authorities in turn, as the providers of the strongest and most important currency in the ECU basket, never have to face monetary pressure from other EMS countries.

[3] The statistical properties of the data used in deGrauwe (1988b) have been carefully analyzed by Beyer & Schmidt (1992). They argue that the interest rates used in deGrauwe (1988b) are cointegrated of order one and should, therefore, be estimated in a different way as that employed in the paper.

most of the intramarginal intervention was carried out by countries other than Germany, while Germany intervened only when bilateral fluctuation margins were reached. Motivated by this empirical finding, the authors construct a theoretical "accounting" model to show that:

- in an asymmetric system, interest rates respond asymmetrically to international portfolio shocks; and
- the center country, by sterilizing foreign disturbances, attempts to control its own money supply while the "satellite" countries attempt to control their foreign exchange reserves.

The authors test their model with short-term interest rates. They obtain a result suggesting that only Germany sets monetary policy independently, while other members accommodate German monetary policies.

von Hagen & Fratianni (1989) focus on monetary policy actions. Their hypothesis of German dominance rests on four assumptions:

- German dominance implies that other countries do not react directly to monetary policies occurring outside the EMS.
- German dominance implies that each EMS country reacts only to Germany's, and not other members', policies.
- German dominance implies that monetary policy in a member country depends on German policy, and
- to make German dominance meaningful, Germany itself must not be influenced by the monetary policy actions of other members.

They then model monetary policy actions and interactions on the basis of money market interest rates in the short-term, and the growth rate of the monetary base in the long-term. They provide empirical evidence to test for two forms of German dominance: a strong form, whereby deviations of the other members' policies from the path prescribed by the Bundesbank are not allowed either in the short- or long-term; and a weak form, which allows deviations in the short-term only. The results speak against German dominance in the EMS both in the strong and weak form. Overall, their results suggest that the system is more interactive, than hierarchical.

Table 2.1 **Studies testing the German Dominance Hypothesis**

Study	Test object(s)	German Dominance yes: +, no: -
Giovannini (1988)	interest rates and realignments	+
de Grauwe (1988a, b)	interest rates - short-term - long-term	 (+) -
Mastropasqua et al. (1988)	interventions	+
Giavazzi & Giovannini (1989)	interest rates	+
von Hagen & Fratianni (1989)	interest rates and money supply growth	(-)
Honahan & McNelis (1989)	realignments and exchange rate predictability	+
Fratianni & von Hagen (1990)	monetary base growth	-
von Hagen & Fratianni (1990)	interest rates	(-)
Karfakis & Moschos (1990)	Granger causality tests with short-term interest rates	+
MacDonald & Taylor (1990)	Granger causality tests with nominal money supply -growth rates	+
Artus et al. (1991)	- Granger causality tests with short-term and long-term interest rates - maximum likelihood estimation of a structural model describing the transmission of US monetary policy	+ +
Kirchgässner & Wolters (1991a)	Granger causality tests with short-term and long-term interest rates	+
Kutan (1991)	money growth rates	-
Beyer & Schmidt (1992)	co-integration tests and error correction model for interest rates	+
Herz & Röger (1992)	estimation of a neoclassical two-country model	+
Koedijk & Kool (1992)	interest and inflation rates	-
Loureiro (1992)	VAR estimations with domestic credit	+/-
García-Herrero & Thornton (1996)	co-integration and Granger causality tests with interest rates	+ /-

Honahan & McNelis (1989) test the effect of EMS realignments on the ability to forecast the exchange rate. They find no evidence for the DEM/USD rate to be affected whereas the ability to forecast the USD exchange rate against other EMS currencies is significantly affected by realignments. They conclude that the DEM serves as the dominant EMS currency.

Fratianni & von Hagen (1990) focus on the interaction of monetary policies looking at the evidence from the growth of the monetary base standardize these terms. Their tests give a strong rejection of German dominance. von Hagen & Fratianni (1990) look at the evidence from the interest rate perspective and find that Germany is a relatively strong player in the system, although its independence has diminished over time.

Karfakis & Moschos (1990) investigate, also, interest rate linkages between Germany and the other EMS countries. First, they determine if there exist long-term co-movements between German and other EMS interest rates by employing integration and cointegration techniques. Then they examine whether German interest rate changes convey information about future movements of other EMS interest rates. Their results with monthly data on short-term domestic nominal interest rates show that German interest rates heavily influence interest rate movements in other EMS countries.

MacDonald & Taylor (1990) argue that the GDH is correct when Granger causality runs from German monetary policy to the other EMS monetary policies. They use money growth rates as indicators, and test formally whether movements in the German money supply temporally precede movements in the others. The results of their Granger causality tests reveal strong evidence in favour of the GDH, ie causality runs from German money to other monies. They also find supportive evidence for the view that foreign exchange intervention to support intra-EMS parities is predominantly undertaken by non-German members, and also that interventions are sterilized in Germany more often than in other EMS countries. Overall, based on the empirical evidence, the authors suggest that the EMS has been functioning asymmetrically with Germany as the center country.

Artus et al. (1991) analyse the transmission of US monetary policy in the EMS when evaluating the asymmetry of the EMS. They construct a small structural model of interest rates and exchange rates, run causality tests and estimate the model. The causality tests show that the main forces driving the short-term interest rate in Germany are the short-term interest rate in the US and the DEM/USD exchange rate, whereas the short-term interest rate in France depends mostly on the short-term rate in Germany and on the FRF/DEM exchange rate. The estimation of the structural model confirms these findings, ie the French short-term interest rate depends mostly on the German short-term interest rate.

Kirchgässner & Wolters (1991a) pose the question whether German interest rates dominate Euromarket rates. Their methodology differs from others in that they explicitly take into account the non-stationarity of the interest-rate time series and check for the possibility that the time series is co-integrated. This approach provides the possibility to obtain information about adjustment processes and the long-term equilibrium relations between interest rates. They formulate the German dominance hypothesis in four-assumption approach of Fratianni & von Hagen (1990), ie dependence on Germany, German independence, EMS insularity and world insularity. In terms of Granger causality, dependence on Germany implies Granger causal relations between German interest rates and those of other member countries and/or instantaneous causal relations between Germany and other countries. German independence is defined as the non-existence of Granger causal relations between the interest rates of other member countries and German interest rates. EMS insularity means that besides the relations with Germany, there are no Granger causal or instantaneously causal relations between the other member countries of the EMS. Finally, world insularity implies that if German interest rates are included in the information set, there are no Granger causal or instantaneous relations between countries outside the EMS and the interest rates of other member countries. German dominance implies that all four conditions hold. For the long-term, the authors reformulate their hypotheses slightly so that dependence on Germany means that German interest rates are included in the error-correction terms of the equations of other member countries of the EMS. German independence implies that the interest rates of other member countries are not included in the error correction terms of the German equation. EMS insularity means that interest rates of third countries in the EMS are not included in the error-correction terms of the equations of other EMS member countries, and finally, world insularity is defined so that the interest rates of countries outside the EMS are not included in the error-correction terms of the equations of EMS member countries other than Germany. The true importance of Germany in Europe can be seen in the fact that its observed dominance in the long-term is not restricted to countries in the EMS. The authors note, however, that because of capital controls, their findings concerning German long-term dominance do not necessarily imply German policy dominance in the sense that other European central banks cannot follow an independent monetary policy and choose their own preferred rate of inflation. This is because the EMS allows realignments of exchange rates.[4]

Kutan (1991) looks at the evidence from the growth in the monetary base and interest rates. He assumes that central banks in the EMS peg short-term interest rates and that the leading country is Germany, which sets its money supply target independently. The rest of the EMS countries fix their exchange rates at a given level and intervene in the foreign exchange market to keep them in place. A reduced form of the model is estimated using block-exogenity tests[5]. The results suggest that monetary policies in the EMS are relatively interactive. Yet, since the EMS has not caused a greater co-movement in money demand functions between the participating countries in the "hierarchical" structure claimed by German dominance, the author rejects this hypothesis.

Beyer & Schmidt (1992) employ the interest rate parity in order to test the asymmetry of the EMS. Using three-months interest rates in their empirical test, they carefully investigate the statistical properties of the data. The authors show that the parameters are not stable over time, and that, according to cointegration tests, there is a long-run relationship between the German and other EMS interest rates. They then employ an error correction model to test for functional symmetry of the EMS. The results allow the authors to conclude that there is functional asymmetry. However, they note that their results cannot be used to draw any conclusions concerning causal relationships between interest rate links.

Koedijk & Kool (1992) assess the timing and speed of monetary convergence between the EMS countries, focusing on bilateral interest and inflation differentials. Their study differs from most of the others in that they do not use Germany as the benchmark country. Hence, if other EMS countries passively follow Germany's lead, inflation rates should converge, and given the integration of financial markets, so too should interest rates. For comparison, they select British variables, for as an outsider to the ERM, Great Britain is expected to have had more freedom in determining an independent monetary policy. Additionally,

[4] Also see the work of Kirchgässner & Wolters (1991a), which investigates interest rate linkages between the US and Europe and within the EMS between 1974–1989. The study shows a strong German influence on the development of other European countries. The authors conclude that while Germany does not dominate other countries totally, there are significant relations between EMS countries which are not influenced by Germany.

[5] A block-exogenity test has the null hypothesis that the lags of one set of variables do not enter the equations in a system for the remaining variables.

instead of VAR regressions, the authors apply a modified version of principal component analysis. Their conclusion is that the most important differences within the EMS are between Germany, the Netherlands and Great Britain on the one hand, and Belgium, France and Italy on the other. The results indicate that France and Italy may have been able to avoid part of the negative consequences of their deflationary policies because of the borrowed credibility of their exchange rate commitment, but since large differences in independent interest rate and inflation differentials with Germany have persisted, they reject the German dominance hypothesis.

Loureiro (1992) assesses monetary autonomy in EMS countries by focusing on the domestic credit. He argues that, in an asymmetric fixed exchange regime, monetary authorities in small countries cannot discretionarily use domestic credit to achieve domestic objectives. Consequently, innovations in the domestic credit should mostly be the result of innovations in exchange market variables. The degree of the use of domestic credit as a policy instrument is then assessed empirically through the forecast variance decomposition technique. The results indicate that the asymmetry of the EMS is not proven for France and Italy, whereas the GDH is accepted for the Netherlands. Denmark and Belgium remain intermediate cases.

Biltoft & Boersch (1992) test the GDH with three-month interest rates by running Granger causality tests. If the EMS has been functioning asymmetrically, causality should run unidirectionally from Germany to other EMS countries. Notably, these researchers use daily observations of interest rates, and divide the data into two sub-periods, with the break following the Basel-Nyborg Agreement of September 1987. They find that, for the first sub-period, the GDH must be rejected, but that the EMS has become asymmetric in the second period. Moreover, the asymmetry has been toward the countries with few or no capital controls. Unidirectional interest rate linkages were reported for Belgium, Denmark, France and the Netherlands, whereas Italy has consistently been isolated from German monetary policy. This could, according to the authors, be due to capital controls and a wider exchange rate band.

Herz & Röger (1992) analyse the GDH in a framework different from that commonly used. Instead of constructing a reaction function for the central bank, they construct a neoclassical two-country version of the standard Mundell-Fleming framework. They concentrate on the explanation of inflation rates under different exchange rate regimes. In their model, they have equations for the supply side of the domestic and foreign economy, and for the money market in the respective economies. They apply uncovered interest rate parity and assume perfect capital mobility within the EMS. Finally, they define a parameter determining the burden of intervention for each of the central banks. In the case of German dominance, Germany does not intervene, rather it determines monetary growth in a fixed exchange rate block. The results of their empirical tests clearly indicate German dominance in the monetary policies of other EMS countries.

García-Herrera & Thornton (1996) employ cointegration and Granger-causality techniques to investigate the existence of long-run comovements between German and other EMS members' interest rates. They also examine whether short-run changes in German interest rates convey information about future movements in other EMS interest rates. They also include US interest rates in their analysis in order to evaluate the role of the rest-of-the-world monetary policy in EMS interest rate linkages. They use one-month data and find evidence of Granger-causality stemming from German interest rates to interest rates in Belgium, France, Spain, and the UK. Bidirectional causality was found between German and Italian, German and Danish, and German and Dutch interest rates. For the interest rates in Germany and Ireland, they report no causality. The authors also find that the inclusion of US interest rates shifts the balance of the Granger causality test towards bidirectional causality. This, they say, is consistent with the level of arbitrage activity to be expected from efficient capital markets.

There is also the view of eg Bini Smaghi & Micossi (1990) and Weber (1991), that, after a short initial transitional phase, the EMS has functioned as a bipolar system with a "hard currency" option offered by the Bundesbank and a "soft currency" option supplied by the Banque de France. Even though the bipolar working was supported by empirical results, they also indicated that the French commitment towards the "hard" option has increased in the latter half of the 1980s, pulling other currencies along and making the "soft" bloc around the FRF shift towards the "hard currency" standard. At the end of the 1980s, this rendered the fixed parities more credible and prevented inflation from emerging as strongly as it did outside the system.

To date, no consensus in the literature exists about whether the EMS has been working asymmetrically or symmetrically. There are studies that find a rich structure of cross-country policy interactions, so that even though Germany exerts a significant influence on many EMS countries, it is not immune to influences from others. Further, other EMS countries are found to transmit their policy impulses to each other. This suggests an almost symmetric functioning of the EMS.

Hence, the effect of EMS membership on monetary policy-making remains, scientifically, a controversial issue. As stated in eg Bini Smaghi & Micossi (1990), Cohen & Wyplosz (1991), and Begg & Wyplosz (1993), few doubt that the EMS entails a tightening of the external constraints. This interpretation of the EMS as an asymmetric system dominated by Germany emerged due to increasingly vocal observations by policy-makers and implicitly recognized in the Basel-Nyborg agreement from September, 1987. Yet how this tightening of the external constraints actually operates is never fully elucidated. Thus, the failure to confirm the asymmetric model of coordination empirically, casts doubt on the specification and testing of the hypothesis not the hypothesis itself. Even here, the debate over the German dominance hypothesis still revolves around the effects of interdependence and the channels through which this interdependence operates.

3 Theoretical and empirical analysis of monetary policy

3.1 Central bank loss functions

The analysis of optimal monetary policy has a long tradition in economic policy research. Generally, the central bank has an objective function which involves increasing output and decreasing inflation, the latter being under the control of the monetary authority. Besides the policymaker, there is the wage setter who contracts in advance, usually for fixed periods of time. In such a framework, whenever the actual unemployment diverges from its natural rate and the policymaker is concerned with the growth of output, the optimal solution becomes time-inconsistent, as was shown by Kydland & Prescott (1977) and Calvo (1987). In such a situation, a credibility problem arises when, after announcing the monetary policy, the policymaker is tempted to introduce inflation surprises. It is simply not credible to announce a monetary policy that leaves room for surprise inflation. The game between the policymaker and the wage setters, therefore, must lead to an equilibrium solution where the expectations of wage setters are fulfilled. The only credible monetary policy then, is one which affects output growth. As long as the public is aware of the central bank's temptation to deviate from its announced monetary commitment, any government's attempt to affect output growth will fail. In the resulting, consistent, equilibrium, output will remain the same while inflation becomes unnecessarily high. The lower the weight that monetary authorities give to inflation in the utility function, the higher the consistent equilibrium inflation.

A suggestion for the removal of the inflation bias implied by the inconsistency was made in Barro & Gordon (1983). Using the traditional inflation-output trade-off in an intertemporal framework, they compared the costs from conducting discretionary monetary policy with following a rule. They showed that the best enforceable rule is a weighted average of the ideal rule and discretion, meaning that the building up of an anti-inflationary reputation by the public sector was crucial for surrounding the time-inconsistency problem. This, in turn, raised the question of central bank credibility, ie how could the reputation of an inflation-prone central bank be improved so that the public's inflation expectations would decrease?

When the credibility argument is applied to a fixed exchange rate system, the real exchange rate appreciation due to the existence of inflation differentials is taken into account in the game between the policymaker and the wage setters. Apart from taking the central bank's inflationary temptations into account, rational private agents also take into account the restrictions that a fixed exchange system imposes on the authorities' incentives. Giavazzi & Pagano (1988) provided an extension of the Barro-Gordon model, where the EMS was included in the loss function of the central bank. Their argument was that participation in the EMS helps inflation-prone countries to overcome their inefficiency stemming from the public's mistrust of the authorities and, thus, brings potentially large credibility gains to the central bank. Assuming the EMS (or any fixed exchange rate system) works asymmetrically, this gain is possible when one central bank sets monetary policy for the entire region, while another surrenders its monetary autonomy and passively pegs the exchange rate. The result is that both countries will end up with the inflation rate that would prevail in the center country if it were a closed economy. If the center country is less inflation-prone than its partner, the latter can gain by credibly pegging. The participation in the EMS, does not, however, remove the policy choices altogether. This is evidenced by the different monetary policy performance of the European countries, a fact which calls for analysing their policy preferences more closely.

3.2 Reaction function literature

Traditionally, empirical studies of monetary policy have employed a reduced-form reaction function methodology. In this framework, the measure of policy action is related to a set of potential policy targets or information variables:

Policy Instrument = f (Intermediate targets, Information variables) (1)

This relationship can be viewed formally as part of a feedback control mechanism or rule in which the policy instrument is adjusted systematically when actual values of the intermediate target differ from desired values, or if actual values of the information variables deviate from expected values.

Empirical studies using the reaction function approach differ in terms of the choice of dependent and independent variables, data frequency, and methods for evaluating the success of the model. For the dependent variable, a money or reserve aggregate, or the short-term interest rate have been used. For the independent variables, three classes of information variables have been employed: monetary aggregates, measures of real economic activity, and measures of inflation. In the next section, we make a brief survey of the reaction function literature, concentrating on methodological issues.

3.2.1 Survey of previous studies

Levy (1981) develops a money supply-reaction function and estimates it within the context of an IS-LM framework. In that study, particular emphasis is placed on measuring the responsiveness of the Federal Reserve to budget deficit and the government borrowing requirement. The author argues that only a handful of studies have estimated money supply reaction functions by including a deficit or public debt measure as an independent variable. Hence, the author constructs an IS-LM framework with an endogenous monetary sector, and then chooses the monetary base equation to be tested as the reaction function. In his reaction function equation, the monetary base is expressed as a function of variables describing the economy including indicators of fiscal policy. From a methodological point of view, the equation is transformed into a first-difference equation and then estimated using quarterly data. The empirical results show that the monetary base has been extended in response to increases in inflationary expectations and government deficits. In addition, the Federal Reserve has tended to accommodate its own previous actions rather than abruptly change policy.

Bradley & Potter (1985) investigate the responsiveness of monetary and fiscal policies to the state of the economy. They account for the possibility that monetary and fiscal policy authorities consider each others' actions when setting policy. Policymaker reaction functions are, thus, derived in their model using an optimization procedure in which a loss function is minimized with respect to the policy instrument, subject to a constraint reflecting the policymakers' view of the structure of the economy. The policymaker then selects values for the policy instrument that minimize deviations of inflation and unemployment from a prespecified target. These authors, especially, want to find out whether monetary and fiscal authorities consider each other's actions when setting policy. Their method of testing the reaction functions empirically involves running two-stage least squares estimations.

Hamada & Hayashi (1985) investigate the reaction function of the Bank of Japan. They specify the money supply rule by referring to empirical results from previous studies analysing the behaviour of the central bank in the US and in Japan. They argue that, against the previous evidence, it is reasonable to suppose that the growth of the money supply depends on the inflation rate, on changes in the industrial production, and on the stock of foreign currency reserves. In their empirical analysis, they use a lag length of eight months to capture eventual long-lasting effects of the explanatory variables on money supply. They divide their sample period into subperiods because the reaction function is not expected to remain stable over the whole period. Hence, the empirical results differ depending on the period under study.

Mastropasqua et al. (1988) construct a simple central bank reaction function that focuses the monetary coordination in the ERM. They relate monetary base creation through domestic channels to changes in the foreign component of the monetary base and to variables representing the domestic objectives of monetary policy. As domestic objectives, they select inflation and growth. They argue that, to the extent that monetary base growth is determined in the light of domestic objectives, changes in the foreign component must be offset by equal and opposite changes in the domestic component. However, there is the problem of endogenity: changes in the domestic component are liable to affect interest rates in domestic markets and, through this channel, the foreign component. The authors solve this problem by employing two-stage least-squares and seemingly unrelated regressions techniques to take full account of the possible correlations between the residuals of the estimated reaction functions.

Artus et al. (1991) analyse the transmission of interest rate changes from the US to Europe and the asymmetry of the EMS. In that context, they construct a structural model of interest rates and exchange rates. The model also comprises two equations describing the policy reactions of the (French and German) monetary authorities. The dependent variables are the respective short-term interest rates. As the authors state, a number of possible variables can appear in the interest rate equations. They choose as explanatory variables such potentially affecting the policy objectives of the authorities: capacity utilization rate, trade deficit, foreign interest rates, and exchange rate. In order to select the relevant variables for the final test of their model, the authors run causality tests between the interest rates and the explanatory variables. In their estimation of the structural model, they only introduce those variables which significantly affect (short-term) interest rates.

Since we assume Germany is the center country of the EMS here and, consequently, German variables are exogenous, we only examine the results for French short-term interest rates. The period under analysis extends from 1979 to mid-1988. The causality tests show that in the formation of the French short-term interest rate, the French long-term interest rate, inflation, German rates, US rates and exchange rates all seem to play a role. However, German variables outweigh US variables. Moreover, the authors point out that the desire of the central bank to stabilize the exchange rate has intensified over the years.

The authors then estimate the structural model using the maximum likelihood method. They treat US rates and the administratively set FRF/DEM exchange rate as exogenous. In the reaction function on the short-term interest rate, changes in financial variables are decisive, whereas real variables do not matter. The French short-term rate clearly responds to changes in the German short-term rate, as well as to inflation and the FRF/DEM exchange rate[6]. This result is interpreted as supporting the view that the EMS has functioned asymmetrically.

Hakkio & Sellon (1994) model the behaviour of the Federal Reserve. They attempt to determine which variables were influential in monetary policy decisions and whether policy responded

[6] The German short-term interest rate, by contrast, depends on the US short-term rate, the DEM/USD exchange rate and the central bank's foreign exchange reserves.

systematically to these variables. The authors adopt a traditional reduced-form reaction function. The equation is not derived from a formal model. It includes as explanatory variables monetary aggregates (M1,M2), different inflation rate indices, measures of economic activity (industrial production, unemployment), exchange rates vis-à-vis the major world currencies, and indicators of financial market activity. They find that monetary policy has depended most clearly on the inflation rate, measured by a variety of contemporaneous and leading indicators.

Neumann (1996) provides an exhaustive analysis of the reaction function of the German Bundesbank. The Bundesbank's concept of monetary targeting is an intermediate approach to securing internal value of money. Its focus is on providing the monetary frame for zero or low trend in inflation through:

- attempting to anchor the public's expectations as regards medium to long-run inflation by setting a consistent target rate for monetary growth, and
- systematic short-run deviation from the mid-point target for the purpose of counteracting unanticipated shocks to prices and the exchange rate and for accommodating shocks to money demand.

The author uses the quantity theory background of monetary targeting in constructing the reaction function of the Bundesbank. The quantity theory of money implies that providing stable money for the medium to long run requires selecting the appropriate money expansion path, for given trends of real growth and velocity. By announcing the target path to the public and by explaining its derivation the public's inflation expectations will be anchored, provided the Bank enjoys credibility. Thus, the reaction function derived on this theoretical basis implies that the Bundesbank counteracts excessive inflation, leans against the wind of real exchange rate appreciation and accommodates shocks to money demand. Empirical estimation of this equation with only four explanatory variables yields the result that adding a proxy for money demand shocks as an independent variable improves the estimation results considerably.

Ueda (1996) analyses the behaviour of the Bank of Japan by testing a reaction function adopted from reaction function literature. Thus, neither in this study is the reaction function derived formally from, say, the maximization of an objective function of the central bank. The author estimates several reaction functions and admits that those are not necessarily the best equations one can find. The set of independent variables consists of GDP and business cycle indicators, the exchange rate vis-à-vis the USD, current account balance, money growth rate, and the inflation rate. Of these, the interest rate has responded most saliently in countercyclical fashion to real GDP. The monetary authority has also paid close attention to exchange rate and current account developments.

Obviously, most of the issues of how policy should react to shocks are really questions about alternative policy rules which describe how policy makers should react to different contingencies. Summarizing the empirical results surveyed above, the US monetary authority appears to prefer nominal-income targeting or a mixture of real-GNP and inflation-rate targeting. In contrast, Germany and Japan prefer more mixed regimes - sometimes exchange rate targeting is employed, other times they use income targets. This finding may be explained by the theoretical result referred to in Bryant et al. (1993a) that money targeting or exchange-rate targeting could be the preferred regime under at least one of the following conditions:

- productivity or the supply shocks are the most prevalent disturbances to economies,
- policymakers loss functions place great weight on stabilization of the inflation rate or the price level, and place little or no weight on stabilization of output or employment, or
- policymakers' loss functions give significant weight to the stabilization of financial variables such as interest rates and exchange rates.

3.3 The model

We construct a regression equation to be tested empirically. Referring to the empirical literature analysing the German Dominance Hypothesis (GDH), we assume that Germany is the monetary policy leader in the ERM so that German monetary policy is fixed by the Bundesbank with no constraints from the monetary policies of the other countries. Here, we are interested in the relations of the other EMS countries with Germany on a bilateral basis.[7] More specifically, we are interested in how German monetary policy affects the monetary policy of the partner countries, so we abstract from any feedback

[7] Excellent discussions of multilateral monetary relations between EMS countries have been made by Basevi & Calzolari (1984) and Schulstad & Serrat (1995).

between the countries. These assumptions do not rule out German strategic reactions to other EMS monetary policies. Nor do they rule out independence from Germany for other EMS countries (both within parity limits and through parity changes).

As the typical theoretical model in the literature sets up the monetary policy problem as the minimization of a hypothetical social loss function, we start with a general formulation of a loss function for the central bank.[8] In doing this, we want to distinguish between internal and ERM-related aspects in the monetary policy formulation:

$$\mathcal{L}=\frac{1}{2}r^2+\theta D+\lambda F \tag{1}$$

The first term on the right-hand side describes that the central bank faces a cost from operating with its instrument, r. For example, policymakers believe that changing interest rates imposes costs on private sector behaviour. More generally, as Bryant et al. (1993b) note, policymakers may believe that volatility in a variety of variables can impose costs on the economy. D is a function of domestic variables that the central bank is concerned for, and similarly, F is a set of foreign, or in this case, EMS-related variables. θ and λ are the weights that the central bank places on each group of variables. The loss function further operationalizes the assumption that the central bank is concerned about the stability of its target values. We can assume that the stability of the target variables is an intermediate economic policy target serving some ultimate longer-run policy target such as stable economic growth.

Following the standard specification of the loss function in a closed-economy context in the literature, we suppose that on the domestic side, the monetary authorities minimize the expected squared deviations of output and inflation from their target levels:

$$D=\frac{1}{2}[(y-\bar{y})^2+\sigma(\pi-\bar{\pi})^2] \tag{2}$$

where y is actual output, $\bar{y}$ is the target level for output level, π is the inflation rate and $\bar{\pi}$ is the target inflation rate. The parameter σ

[8] We assume that the central bank is the sole relevant decision-making unit in monetary policy matters, so that we abstract from issues arising from different preferences over output and inflation between the government and the central bank.

represents the relative social importance assigned to inflation: a higher σ places a greater weight on inflation deviations and a lesser weight on output. Generally $\bar{y}$ is different from equilibrium employment because of distortions in the labour market. $\bar{\pi}$ is set by the monetary authority. The central bank wants to keep π as close to $\bar{\pi}$ as possible, because inflation or inflation surprises implies a cost and is, therefore, not desirable.[9]

The foreign component in the loss function describes the role of the ERM in the domestic monetary policy conduct. In the ERM, the currencies are pegged to a central rate, and around this central rate they have a fluctuation band.

The influence of the ERM on monetary policy may reflect simply the constraint of keeping the exchange rate within the band or, alternatively, trying to shadow the monetary policy of the anchor country (Germany) even within the band. These aspects are operationalized in the following loss function.

$$F=\frac{1}{2}(\delta^2+\tau(r-r^*)^2) \tag{3}$$

Here, τ stands for the weight put on following German monetary policy, where r and r* are the domestic and foreign interest rate, respectively, and δ denotes the devaluation expectation.

The foreign component of the central bank's loss function in (3) includes, on the basis of the above discussion, devaluation expectations concerning the central rate (ie realignment expectations), and the interest rate differential vis-à-vis Germany. Of these two terms, the former is intended to capture the influence the ERM membership as such has on monetary policy. Clearly, if ERM membership has a guiding influence on monetary policy, this must imply that expected realignments are avoided. The other, stronger, dimension of ERM influence, harmonization of monetary policy with the anchor country, is captured by the interest rate differential term.

Inserting expressions (2) and (3) into the loss function in equation (1) yields

$$\mathcal{L}=\frac{1}{2}r^2+\frac{\theta}{2}\left[(y-\bar{y})^2+\sigma(\pi-\bar{\pi})^2\right]+\frac{\lambda}{2}\left[\delta^2+\tau(r-r^*)^2\right] \tag{4}$$

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[9] On the cost of inflation, see eg Gale (1982).

The task of the central bank is to choose interest rate that minimize this loss. In terms of participation in the ERM, this reflects two aspects. First, the central bank may want to minimize devaluation expectations, ie to maximize the credibility of the central rate. Second, the central bank may want to minimize exchange rate fluctuations, ie maximize exchange rate stability in a credible ERM regime. The alternative strategy in the latter case is to utilize the credibility of the central rate through allowing fluctuations of the exchange rate within the band and instead stabilizing the domestic interest rate.

In order to minimize the loss equation, we need the first-order condition. Deriving equation (4) with respect to r gives

$$\mathfrak{L}': \; r+\theta[a(y-\bar{y})+\sigma b(\pi-\bar{\pi})]+\lambda[d\delta+\tau(r-r^*)]=0 \qquad (5)$$

$-a$, $-b$ and d are the partial derivatives of $(y-\bar{y})$, $(\pi-\bar{\pi})$ and δ, respectively, with respect to the interest rate r.[10] They are all negative (a and b positive) constants indicating that an increase of the interest rate has a dampening effect on all of these variables.[11]

From the target zone theory[12] we know that in a system with fluctuation bands, any interest rate differential reflects the sum of the expected rate of depreciation of the exchange rate within the band, and the expected rate of devaluation of the central rate:

$$r-r^*=k(s-c)+\delta \qquad (k<0) \qquad (6a)$$

[10] The relation between the interest rate and output, and the interest rate and inflation, will not be specifically modeled here. These relations can be established within a standard IS-LM-AS model of open economies, as exemplified eg in chapter 3 in the present. In these models aggregate demand depends on the current account and the interest rate. Inflation depends positively on the expected rate of inflation and the output gap or demand pressure. In the simplest versions of the models inflation expectations are exogenously given; hence the demand pressure is the main determinant of inflation. Given a stable relationship between the real interest rate, or nominal interest rate under exogenously given inflation expectations, and output, inflation rate also depends on the interest rate in a stable manner. Thus, the partial derivatives a and be b in equation (5) capture the interest rate effect of aggregate demand and the combined effect of the slope of the Phillips-curve and the interes rate effect, respectively.

[11] A positive value of d is valid for a crisis situation, where an increase of the domestic interest rate increases devaluation expectations.

[12] For a survey of target zone theory, see eg Ranki (1996).

where r and r* are the domestic and foreign interest rate, respectively, s denotes the (log of the) spot exchange rate and c is the (log of the) central rate, k is a parameter reflecting the mean reversion in the spot rates, and δ denotes the devaluation expectation. This means that the expected rate of depreciation can be written as

$$\delta = r - r^* - k(s-c) \tag{6b}$$

Hence, replacing δ in equation (5) with the expression obtained in equation (6b) gives the following first-order condition

$$\mathcal{L}': \ r - \theta[a(y-\bar{y}) + \sigma b(\pi - \bar{\pi})] + \lambda[(r - r^* - k(s-c))d + \tau(r - r^*)] = 0 \tag{7a}$$

By rearranging all terms with the domestic interest rate on the left-hand side, we obtain an equation that describes the determination of the interest rate, namely

$$r + \lambda dr + \lambda \tau r = \theta[a(y-\bar{y}) + \sigma b(\pi - \bar{\pi})] + \lambda dr^* + \lambda \tau r^* + \lambda kd(s-c) \tag{7b}$$

$$\Rightarrow \ [1 + \lambda(d+\tau)]r = \theta[a(y-\bar{y}) + \sigma b(\pi - \bar{\pi})b] + [\lambda(d+\tau)]r^* + \lambda kd(s-c) \tag{7c}$$

$$\Rightarrow \ r = \frac{\theta}{1+\lambda(d+\tau)}[a(y-\bar{y}) + \sigma b(\pi - \bar{\pi})] + \frac{\lambda(d+\tau)}{1+\lambda(d+\tau)}r^* + \frac{\lambda kd}{1+\lambda(d+\tau)}(s-c) \tag{7d}$$

If $\lambda=0$ reflects that the central bank is only concerned about domestic factors, then – trivially – only the domestic variables matter, as r* and (s–c) disappear. Assuming that $|\lambda(d+\tau)| < 1$, the domestic variables y and π always have a positive effect on the domestic interest rate. If $\lambda \neq 0$ so that the foreign variables r* and s–c affect domestic monetary policy, s–c also always has a positive effect on the interest rate since k and d are both negative.

The effect, of r* depends on the relative size of d and τ. If $d > -\tau$, then the sum $d+\tau$ is negative, which makes the coefficient negative, and vice versa, if $d < -\tau$. In the special case where $d = -\tau$, the term with the German interest rate disappears. In other words, the effect of an interest rate change on devaluation expectations has to be smaller than or equal to the weight put on following German monetary policy in order to obtain sensible results.

4 Empirical analysis

We are looking for empirical evidence that the EMS has actually played a central role in the monetary policy conduct of the participating countries. Given general consensus on the development of the EMS, we should expect to observe the weight of the exchange rate restriction provided by the ERM to have increased, especially during the "hard" EMS period of 1987-1992. The approach is essentially that employed in the large reaction function literature, consisting of a large number of studies.

We now turn to an empirical application of the framework developed in the previous section, with the aim of evaluating the weights given by central banks to the various determinants of monetary policy. Most deal with the reaction function of a large economy such as the US, Japan or Germany. In these cases, the role of foreign variables has been very limited. Only a few cases include some form of the exchange rate in the reaction function. In the current study, however, we analyse the behaviour of the central bank in small, open economy. Since a small, open economy is largely affected by the continuous interaction with other countries, this evidently affects the conduct of monetary policy. Thus, we formulate the problem as a trade-off between internal targets and external constraints.

4.1 Operationalization of the model

The model is based on the theory given in the previous section. The dependent variable is the domestic short-term (one-month) interest rate.[13] Monetary policy is assumed to be conducted through either using the short-term interest rate directly, or through open market operations, which then affect the interest rate indirectly.

The set of explanatory variables consists of two kinds of variables. First, we have indicators of the domestic economy: the inflation rate and industrial production. Second, we have variables reflecting exchange rate changes: movements of the spot exchange rate, and deviations of the spot exchange rate from the central parity. As exogenous variables, we use the German and US interest rate. If Germany is the monetary leader in the system, then German interest rates should affect the interest rates of the other countries, but not vice versa. Moreover, if the primary goal of the other EMS countries is to stabilize the exchange rate (vis-à-vis the DEM), they should not care about the monetary policy of the rest of the world (here represented by the USA). In that case, the center country alone reacts to external shocks, and these are then transferred into the system via the monetary policy of the center country.

Taking this together and considering the time-series properties of the data, we obtain a regression equation such as

$$\Delta r = \alpha + \beta_1 \Delta\pi + \beta_2 \Delta y + \gamma_1 (s-c) + \gamma_2 \Delta r^* + \gamma_3 \Delta r^{**} + \varepsilon \qquad (7)$$

where

Δr = change in the domestic interest rate
$\Delta\pi$ = change in inflation
Δy = change in output
$(s-c)$ = deviation of the spot rate from the central rate

[13] Another commonly used indicator of the conduct of central bank policy has been the money base growth rate. As Taylor (1996) notes, there is a similarity between money supply rules and interest rates. If money growth is fixed then the money demand function can be viewed as a relationship between three variables: the price level or its percentage change the inflation rate, real GDP and the short term interest rate. If the interest rate is isolated as one variable, it is seen that the interest rate depends on the inflation rate and real GDP. Hence, analysing the interest rate as indicator of monetary policy is as valid as looking at the money supply.

Δr^* = change in the German interest rate
Δr^{**} = change in the US interest rate
ϵ = error term

In those cases when a currency is floating and has, thus, no central parity, we use the change of the spot exchange rate instead of the deviation of the spot rate from the central rate. In the regression, we have used in level form those variables which do not seem to have a unit root for the remaining variables, first differences have been used.

When estimating the model, we introduce dynamics by using vector autoregression (VAR). A VAR system is a reduced form of a linear dynamic simultaneous equation model in which all endogenous variables obtain an equation where the dependent variable is explained by lagged values of itself and by lagged values of all the other variables in the system. Here, we use three lags for the endogenous variables. All other variables except German and US interest rates are treated as endogenous.

For the purpose of describing the dynamic interaction of the time series, we employ the impulse-response function. In order to analyse the effects of a shock in one or more variables, we derive the moving-average presentation of the system. There, each variable is described as a function of the innovations, which are uncorrelated both across equations and over time. With the moving-average representation, one can analyse the effects of an innovation in one variable ea a policy variable in isolation. A typical shock is commonly understood as one standard error in an equation. The system's response is traced in the impulse-response functions which show the effects of an innovation in one variable on subsequent values of all variables in the model. In the current study, we have calculated the cumulative impulse response functions in order to see the effect of the innovations on the levels of the variables. However, there is one drawback with the impulse functions due to the tendency of VAR models to be over-parametrized. When confidence intervals are calculated taking into proper account VAR parameters uncertainty, very large confidence intervals around the calculated impulse responses are very usual. Here, we calculated the confidence intervals, but because of their negligible informative value, for the sake of space, they are not reported.

Since the German interest rate is exogenous in the VAR model, we do not directly obtain the impulse responses of the endogenous variables to changes in the German interest rate. The exogenous variable can, however, be treated as a deterministic part of the error term and its impact can be calculated from the usual impulse responses.

Since the German interest rate appears in all the equations in the system, the impulse response of a specific variable to a one per cent increase in the German interest rate is a weighted sum of its impulse responses to all the endogenous variables. The weights are the coefficients of the German interest rate in the respective equations.

The data under investigation spans the period from January 1980 to June 1996, which covering almost the entire existence of the EMS. We use monthly data because of the non-availability of production data at higher frequencies. The period is divided into three subperiods: January 1980 – January 1987, April 1987 – September 1992, and December 1992 – June 1996. This division reflects the changing character of the EMS. During its early years, the economies of the participating countries differed remarkably, and realignments were frequent. The second subperiod[14] represents the years of the "hard" EMS: nominal convergence of the economies was substantial and no realignments occurred. The last period starts when the GBP and the ITL were allowed to float, which was the start for the "new" EMS with the currently wider bands.[15]

The data is compiled as follows: the interest rates are those reported by the Bank for International Settlements (BIS); the central rates are those reported in the *Beihefte zu den Monatsberichten: Reihe 4, Devisenstatistik* published by the Deutsche Bundesbank; all the other variables, ie the exchange rates, industrial production, and inflation rates were collected from the International Financial Statistics published by the IMF. All other data except the interest rates have been transformed by taking logarithms.[16]

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[14] The starting dates for the second subperiod are different for the ESP and the GBP. In these cases, the starting date is the same as the date of entry of these currencies into the ERM. The ESP joined the ERM in June 1989, and the GBP in October 1990.

[15] An analysis of the history of the EMS is provided in eg Gros & Thygesen (1992).

[16] Standard tests for the properties of the data have been performed, and their results are available on request.

4.2 Results

A variety of methods can be used for evaluating the model. Here we concentrate on the relative weightings of domestic versus foreign variables. Tables 4.1 and 4.2 summarize the results obtained for the regression with equation 6. Table 4.1 displays the t statistics for the coefficients, and Table 4.2 shows the F statistics for the respective groups of the lags of each variable. The unit shock impulse response functions are plotted in Figures 4.1–4.7.

The estimated VAR fits the data relatively well. The residuals do not appear to be autocorrelated nor heteroscedastic, and the model is capable of explaining up to 88.6 % of the observed interest rate changes. The proportion explained by the estimated VAR is fairly high in other equations as well, perhaps with the exception of the inflation equations. Great Britain appears to deviate from the general pattern in that the estimated VAR accounts for most of the observed variation in the inflation rate, but the explanatory power of the interest rate equation remains modest. Overall, the estimated VAR performs generally better in the second and/or third subperiod than in the first subperiod. The reason may be the higher global interest rate volatility in the first subperiod. The impulse response functions displayed in Figures 4.1–4.7 show that in the first subperiod, the interest rate often "overshoots" its new level after an innovation in the interest rate before it again starts to converge. The estimated lag structure remains fairly stable across subperiods and indicates that, generally, the first lag is the most significant. The estimated dynamics of the deviation of the spot exchange rate from the central rate suggests a different pattern in that slightly more lagged effects occur in the second subperiod in four of the seven cases. In sections 4.3.1–4.3.7 we present the results country by country.

Table 4.1

t-values		Domestic interest rate	Domestic inflation	Domestic production	Deviation from central rate	German interest rate	US interest rate	Constant	Dummy
Belgium	I	-0.94	.34	**2.73**	**3.26**	**3.68**	**1.79**	-2.26	
		-0.61	-.42	**3.10**	**-1.84**				
		-2.24	1.69	**3.03**	1.44				
	II	0.38	-1.53	1.21	1.48	**10.16**	-.21	-1.51	
		-.36	-.26	1.17	.42				
		2.92	.49	.89	**-2.38**				
	III	**2.25**	-1.59	-.16	-1.11	-1.31	.20	-1.20	
		-1.04	-.20	-.13	1.09				
		-.54	-.17	-.38	-1.20				
Denmark	I	**-2.30**	1.28	.04	**2.24**	-0.39	.52	-0.17	
		-1.46	.14	.49	-.94				
		-1.52	**2.20**	.16	-.97				
	II	1.08	0.38	-0.32	0.76	0.76	-0.30	-0.68	**2.85**
		-0.01	**1.71**	0.93	0.39				
		0.16	-0.63	-0.08	-0.97				
	III	**3.17**	0.23	0.93	-1.09	0.67	-0.35	0.09	**11.67**
		0.86	-0.65	0.51	0.67				
		-1.08	0.14	1.27	-0.19				
France	I	-1.42	0.85	-0.383	**2.81**	1.40	0.82	0.06	**6.98**
		-0.35	-0.13	-0.60	-0.94				
		0.07	-1.31	0.08	-1.26				
	II	**1.75**	0.62	0.26	**1.73**	0.40	-1.17	0.30	**4.41**
		-0.35	**-2.08**	0.14	**-2.86**				
		-0.32	0.39	-0.08	**1.88**				
	III	**2.62**	-0.80	0.18	-1.47	1.16	-1.56	0.65	**3.01**
		-1.35	-0.25	-0.42	1.32				
		0.18	-1.01	0.84	-0.83				

Significant values (at 10 % level) are bold.
* no ERM

Table 4.1 continued

t-values		Domestic interest rate	Domestic inflation	Domestic production	Deviation from central rate	German interest rate	US interest rate	Constant	Dummy
Great Britain	I*	**2.78**	1.24	-0.24	**-1.85**	0.28	0.27	1.40	
		-0.58	-0.93	-0.13	0.24				
		-0.76	-0.80	-1.34	-0.56				
	II	0.45	0.86	**-2.28**	-0.11	1.15	**-1.92**	0.37	
		-1.63	-1.38	**-1.92**	**1.77**				
		-0.02	-0.12	**-2.28**	**-2.22**				
	III*	0.70	**1.91**	**-1.82**	-0.50	0.62	-0.35	1.03	
		0.12	-1.37	-0.90	-1.05				
		1.85	-0.28	-0.26	-1.09				
Italy	I	-1.09	**-1.74**	0.67	-0.21	-0.28	0.45	-1.06	
		1.34	0.21	**3.56**	-1.45				
		-0.46	0.23	**1.99**	0.03				
	II	**-2.44**	-0.54	-0.56	0.11	0.81	-0.36	0.60	
		0.66	0.34	-0.15	1.43				
		0.54	-0.58	0.79	**-2.33**				
	III*	1.69	0.01	-0.97	1.08	0.06	1.71	-0.89	
		1.06	-0.80	0.47	0.19				
		0.45	1.55	**2.25**	-1.08				
The Netherlands	I	**-2.63**	-0.44	0.47	**3.45**	**6.10**	0.80	-0.11	
		-0.23	0.48	0.51	-1.09				
		0.51	-1.14	0.66	-0.13				
	II	**2.79**	-1.26	0.39	1.19	**11.57**	0.92	-0.64	
		-1.26	-0.89	-0.69	1.02				
		0.46	0.74	-0.80	-1.30				
	III	0.74	0.36	0.04	0.30	**4.90**	**1.85**	-1.46	
		0.17	-0.24	1.09	-0.10				
		-0.47	0.08	0.78	-0.59				

Significant values (at 10 % level) are bold.
* no ERM

Table 4.1 continued

t-values		Domestic interest rate	Domestic inflation	Domestic production	Deviation from central rate	German interest rate	US interest rate	Constant	Dummy
Spain	I*	**-4.74**	-0.21	0.04	0.43	0.05	0.56	-1.07	**9.99**
		-4.99	-0.73	0.15	-1.24				
		-1.55	-0.73	-0.59	0.83				
	II	-0.76	-0.61	0.48	0.48	0.23	0.16	-0.40	
		-0.20	0.98	0.36	-0.77				
		-1.69	0.80	0.76	0.58				
	III	**-6.64**	-0.70	-1.46	**3.41**	0.24	-1.54	**-3.92**	
		-1.93	**-2.06**	**-2.19**	**-4.51**				
		-0.69	-0.20	-0.68	**6.38**				

I: January 1980 - January 1987
II: April 1987 - September 1992
III: December 1992 - June 1996

Significant values (at 10 % level) are bold.
* no ERM

Table 4.2

F-values		Domestic interest rate	Domestic inflation	Domestic production	Deviation from central rate	German interest rate	US interest rate
Belgium	I	1.93	0.95	**3.58**	**4.27**	**13.54**	**3.19**
	II	**2.97**	1.22	0.62	2.55	**103.31**	0.05
	III	2.47	0.91	0.19	1.97	1.81	0.03
Denmark	I	2.57	2.13	0.09	2.17	0.16	0.27
	II	0.08	0.75	0.10	1.69	1.33	0.12
	III	1.85	0.26	0.66	0.79	0.21	0.24
France	I	0.76	0.76	0.20	**3.39**	1.97	0.67
	II	1.48	1.45	0.41	**2.77**	0.16	1.38
	III	2.49	0.51	0.35	0.74	1.33	2.42
Great Britain	I*	**2.86**	1.95	0.67	1.33	0.08	0.71
	II	1.38	**6.43**	2.33	1.96	0.91	**3.98**
	III*	**3.23**	1.82	1.13	0.62	0.38	0.12
Italy	I	1.42	1.04	**5.35**	0.88	0.08	0.20
	II	**2.82**	0.21	0.60	2.03	0.65	0.13
	III*	2.76	1.20	**3.51**	1.11	0.004	**2.93**
The Netherlands	I	2.49	0.63	0.18	**4.67**	**37.23**	0.64
	II	2.65	1.04	0.54	1.23	**133.80**	0.84
	III	0.14	0.04	2.06	0.05	**22.90**	**3.60**
Spain	I*	**55.63**	**35.75**	**103.89**	**35.79**	**100.90**	**99.80**
	II	0.68	0.12	**2.80**	0.41	2.07	0.86
	III	**18.59**	2.07	**5.02**	**15.49**	0.06	2.38

Critical values at 10 % level: I: > 2.7, II: > 2.8, III:> 2.99.
Significant values (at 10 % level) are bold.
* no ERM
I: January 1980 - January 1987
II: April 1987 - September 1992
III: December 1992 - June 1996

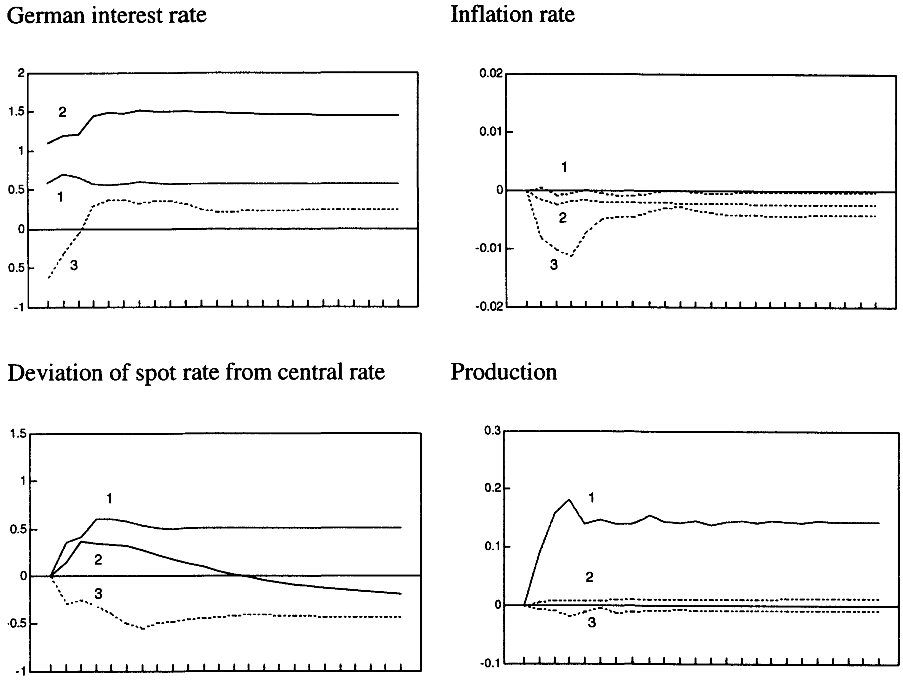
4.2.1 Belgium

In Belgium, production has been the only domestic variable affecting the domestic interest rate, and it has been of importance for the domestic interest rate changes only in the first subperiod. An increase in production has resulted in a rise in the domestic short-term interest rates indicating that the monetary authority has acted to prevent an overheating of the domestic economy. The significant coefficient for production might reflect the contradictory economic situation in Belgium: in order to dampen inflation the country had to satisfy with relatively low levels of activity. In the two later subperiods, domestic variables have not played a significant role for monetary policy making. Instead, the role of the history of the domestic interest rate itself is significant throughout all the subperiods.

Of the foreign variables, the US interest rate appears in the equation with a significant coefficient in the first subperiod. This might be explained by the fact that, as pointed out by Gros & Thygesen (1992), in the early years of the EMS, monetary policy in the US was tightened at the same time as financial flows were liberalized. This increased interest rate variability as a tool to achieve intermediate monetary policy targets. As a consequence, EMS countries faced the challenge of responding to changes in the US interest rates and the ensuing international financial shocks. As the US interest rates rose to high levels, European countries had either to accept a depreciation of their currencies or to follow US interest rate changes.

The German interest rate and the deviation of the spot exchange rate from the central rate, in turn, have gained importance during the second subperiod as compared with the first. This is particularly well illustrated in Figure 4.1 where the effect of a one per cent point rise in the German interest rate results in a larger than one-to-one permanent positive effect in the Belgian interest rate. In the first subperiod, this effect was only around half a percentage point. The exchange rate also has had a remarkable effect on the domestic interest rate during the first subperiod. At that time, Belgium aimed for a stable position near the central rate, but because of the pressure from the US monetary policy, and because Belgium was still recovering from the inflation crisis induced by the oil shock, it suffered from a persistent inflation differential vis-à-vis Germany. The currency depreciated, and interventions were needed to keep the BEF from its upper limit. It is also interesting to note that in the third subperiod, we do not find significant effects of either of the German interest rate or the deviation of the spot rate from the central rate.

Figure 4.1 **Cumulative impulse response functions of the Belgian short-term interest rate to innovations in domestic and foreign variables**



1 Period I
2 Period II
3 Period III

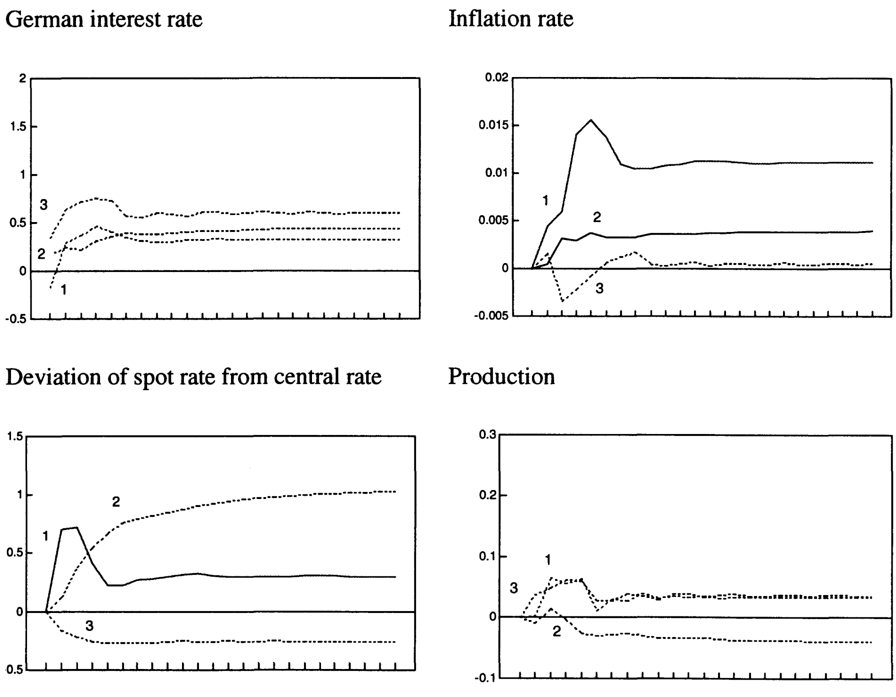
Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

4.2.2 Denmark

In Denmark, we observe that the inflation rate has been the significant domestic variable affecting monetary policy, whereas production has not been decisive for domestic interest rate changes. A rise in inflation has led to a rise of the domestic interest rate, which indicates that the monetary authority has tried to control inflation. This link was less pronounced in the second subperiod and disappears in the third subperiod. Denmark's story here is very similar to that of Belgium's: in the first subperiod, Denmark suffered from the inflation shock induced by the oil price hike. Monetary policy was not effective in depressing inflation, and, as described in Gros & Thygesen (1992), Denmark requested realignments in order to maintain competitiveness. The level of economic activity remained relatively low. The domestic interest rate itself affects future interest rate changes in the first subperiod, and then again in the third subperiod. The third subperiod also includes a dummy in order to capture turbulence during the exchange rate crisis in August 1993.

On the foreign side, the deviation of the spot exchange rate from the central rate has a significant coefficient only in the first subperiod. As Figure 4.2 illustrates, the effect of the German interest rate seems to increase over time so that the permanent positive effect is about twice as large in the third subperiod as in the first subperiod. However, the coefficient for the German interest rate is not statistically significant in any of the subperiods.

Figure 4.2 **Cumulative impulse response functions of the Danish short-term interest rate to innovations in domestic and foreign variables**



1 Period I
2 Period II
3 Period III

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

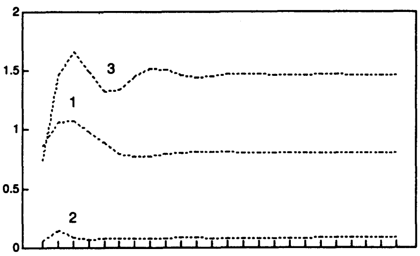
4.2.3 France

In France, we find no significant coefficients for the domestic variables. Only the inflation rate gets a significant coefficient during the second subperiod. It has a perverse negative sign indicating that the monetary authority reacts by lowering the interest rate when the inflation rate increases. The impulse response of the interest rate to inflation innovations, as displayed in Figure 4.3, however, is very close to zero. The negative effect might be explained by the change in the course of the French monetary policy from 1983. Since then France has pursued a tough monetary policy. To bring about convergence of inflation with the anchor country, the money supply in France was tightened more than in Germany so that by 1990 the two countries' inflation rates were the same. This change of regime most certainly affected inflation expectations. The VAR methodology, based on lagged values of a variable, cannot capture such a change in expectations. Hence, since we are facing a problem of simultanity, we can question the direction of causality between the interest rate and the inflation rate. The significance of the past values of the domestic interest rate itself, in turn, increases towards the third subperiod.

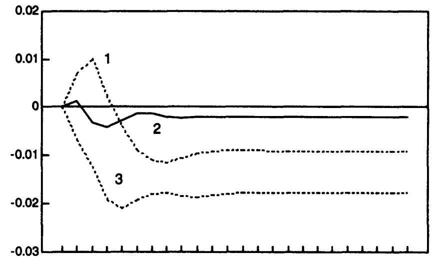
From the foreign variables, deviation of the spot exchange rate from the central rate was a significant determinant of the monetary policy during the first and second subperiods. In the first subperiod, the FRF was unstable because of the divergence between the domestic and the German economies. As Gros &Thygesen (1992) report, the consequent tensions in the foreign exchange markets had to be controlled by interventions. These are mostly sterilized interventions, as found in eg Mastropasqua et al. (1988) or Loureiro (1992), so the effect of the spot exchange rate on the domestic interest rate has been only temporary during the first subperiod. The coefficient for the German interest rate is not significant, but as Figure 4.3 illustrates, the influence of the German interest rate seems to have been the least during the "hard" EMS period, ie the second subperiod. In the first subperiod, the response of the French interest rate to changes in the German interest rate were close to one, and are larger than one in the third subperiod. However, because the insignificance of the coefficient, we may not conclude with any certainty that the role of the German interest rate for the French monetary policy would have increased.

Figure 4.3 **Cumulative impulse response functions of the French short-term interest rate to innovations in domestic and foreign variables**

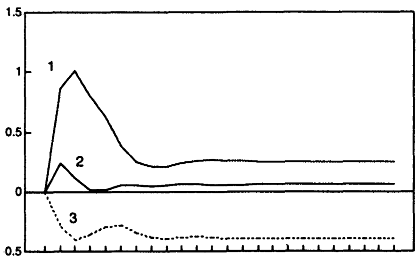
German interest rate



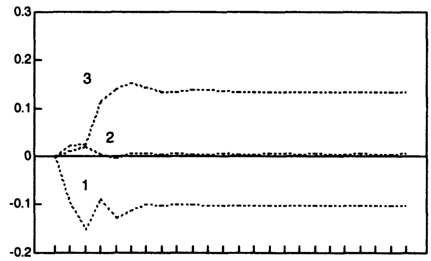
Inflation rate



Deviation of spot rate from central rate



Production



1 Period I
2 Period II
3 Period III

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

4.2.4 Great Britain

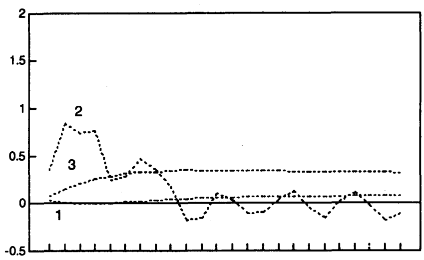
The periods for Great Britain are divided according to the exchange rate regime of the GBP. The first and third subperiods represent British monetary policy under a floating GBP, whereas the second subperiod includes GBP's very brief participation in the ERM. Due to the lack of observations, therefore, the empirical results for the second subperiod cannot be interpreted reliably. The impulse responses in Figure 4.4 illustrate clearly the odd response of the interest rate to all variables.

In the British case, the domestic variables gain significance over time. Both the inflation rate and production get significant coefficients in the second and third subperiods. The role of the domestic interest rate itself disappears in the second subperiod, but is crucial again in the third subperiod.

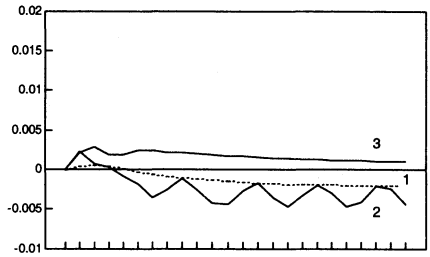
Of the foreign variables, the change of the (floating) exchange rate had a significant negative effect on the domestic interest rate, meaning that a depreciation of the GBP vis-à-vis the DEM resulted in a decrease in the domestic interest rate. This might reflect the relative importance of the GBP/USD exchange rate, so that in times of a strong DEM, the USD has been relatively weak. During such periods, capital flows have been such that the Bank of England has preferred to lower interest rates. The fact that Great Britain is, financially, more closely related to the US than to Germany, is perhaps reflected in the fact that in the second subperiod, US interest rates become a significant coefficient. We know from elsewhere, as eg Gros & Thygesen (1992) have claimed, that during the ERM period, movements of the GBP vis-à-vis the DEM constrained British monetary policy at times. Unfortunately the shortness of the period prevents us from making any conclusions on that issue.

Figure 4.4 **Cumulative impulse response functions of the British short-term interest rate to innovations in domestic and foreign variables**

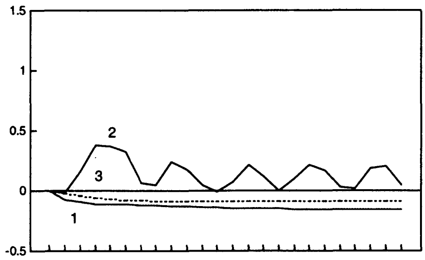
German interest rate



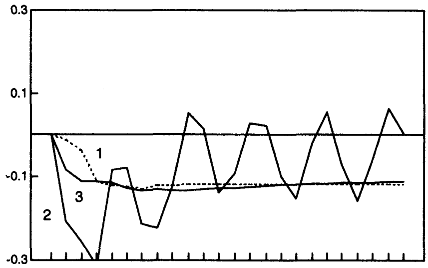
Inflation rate



Deviation of spot rate from central rate



Production



1 Period I
2 Period II
3 Period III

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

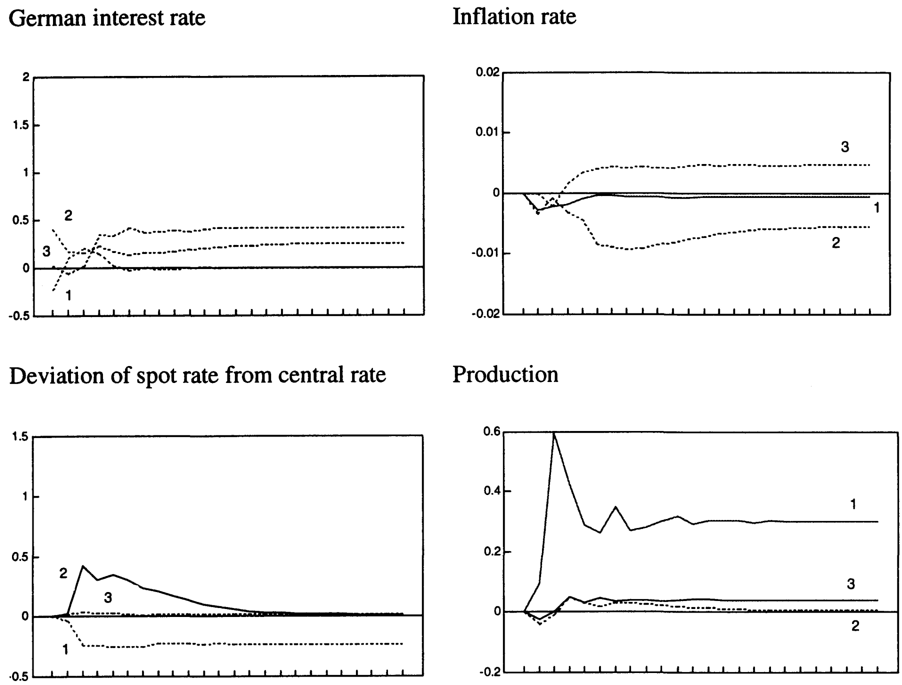
4.2.5 Italy

In the case of Italy, we also have one subperiod, namely the third, with a floating exchange rate. Hence, we could expect to see a difference in the reaction pattern of the domestic interest rate in the third subperiod as compared to the two prior subperiods with the ITL participating in the ERM.

First, we can observe that the domestic variables have both a significant coefficient in the first subperiod. This is not surprising since we know that Italy has pursued monetary policy that has systematically and substantially generated more inflation than in Germany. The growing inflation differential was compensated for with realignments rather than depressed with domestic monetary policy actions. This is seen in Figure 4.5. Domestic inflation affects domestic short-term interest rates only temporarily, and the magnitude of the effect is negligible. Because of the very small magnitude of the effect, we can ignore the negative sign of the impulse response function. In the second subperiod, the domestic variables loose their power to explain changes in the domestic interest rate. In the third subperiod, again, production has an influence on the domestic interest rate, but it is only slightly different from zero. The history of the domestic interest rate, in contrast, gains explanatory power towards the end of the period.

On the foreign side, we observe that the deviation of the spot exchange rate from the central rate has a significant coefficient only during the "hard" EMS subperiod. The German interest rate remains insignificant throughout the entire period, but the impulse response shows that its influence increased from practically zero to almost half a percentage point towards the third subperiod.

Figure 4.5 **Cumulative impulse response functions of the Italian short-term interest rate to innovations in domestic and foreign variables**



1 Period I
2 Period II
3 Period III

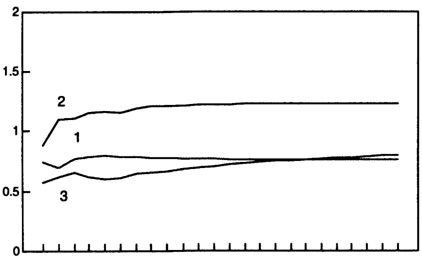
Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

4.2.6 The Netherlands

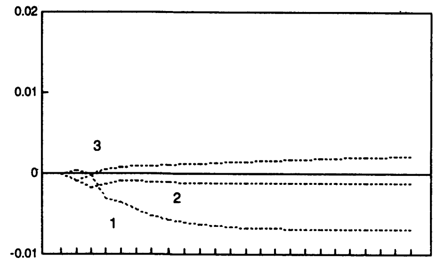
The Dutch case is the most clear of all. The role of Germany is fully evident throughout the entire period. The domestic variables play no role in monetary policy making. Only the foreign variables matter so that the role of the German interest rate, in particular, has been strong. Its effect was most pronounced in the second subperiod. The deviation of the spot rate from the central rate, in turn, is decisive only in the first subperiod. In contrast to all other countries, the history of the domestic interest rate itself loses meaning for the Netherlands as we move to the third subperiod. This reflects the fact that, in terms of equation (4), all weight has been put on τ, ie on following German monetary policy.

Figure 4.6 **Cumulative impulse response functions of the Dutch short-term interest rate to innovations in domestic and foreign variables**

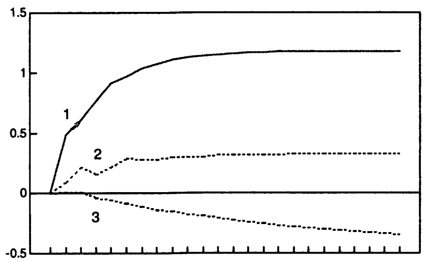
German interest rate



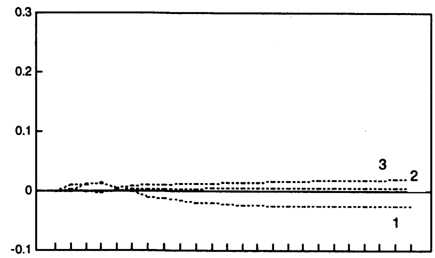
Inflation rate



Deviation of spot rate from central rate



Production



1 Period I
2 Period II
3 Period III

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

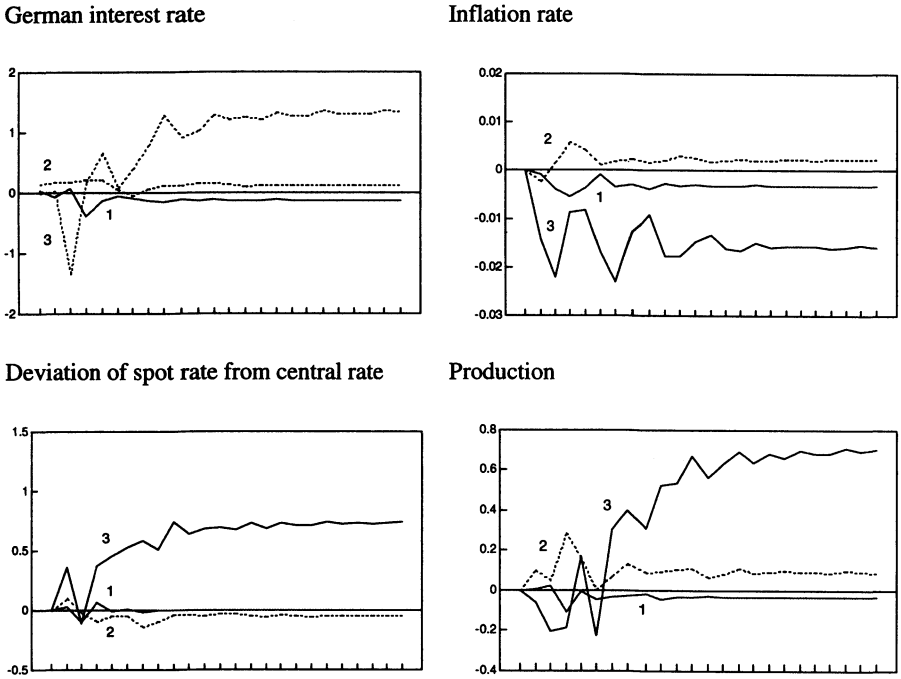
4.2.7 Spain

In the Spanish case, the subperiods are divided so that the first covers the time when the ESP was floating, and the second and third subperiods represent the participation of the ESP in the ERM. The third subperiod ends at December 1994, because of the January 1995 shift in monetary policy when the Banco de España announced a direct inflation target for the medium term and, shortly thereafter, raised its key interest rate in three steps. This happened at a time when the ESP was weak, and there was confusion in the markets over the new policy. Due to this abrupt shift in regime, we prefer to cut the subperiod for Spain before this event.

Domestic variables have been significant determinants of Spanish monetary policy during the first and third subperiods. The impact of both inflation and production are more pronounced in the third subperiod than in the first. The negative effect of the inflation rate on the interest rate may be explained by the instability in the Spanish financial markets in 1993-1994. As reported in the EMI 1994 Annual Report, cross-border capital flows were liberalized in early 1992, resulting in the introduction of new financial instruments as well as frequent portfolio switching by the public. This made it difficult for the central bank to control monetary conditions.

On the foreign side, the German interest rate has a significant coefficient throughout the entire period, while the exchange rate has been decisive only during the first and third subperiods. In the first subperiod, this means that the change of the (floating) exchange rate has had a slightly positive effect on the domestic interest rate, ie monetary policy has reacted to weakening of the ESP with an interest rate hike. In the third subperiod, this positive effect is much more pronounced. When the ESP has deviated from its central rate, monetary authorities have reacted by raising the interest rate in case of a positive deviation, and vice versa in the case of a negative deviation. It might be surprising that the deviation of the spot rate from the central rate does not show in the second subperiod, although the ESP entered the ERM at a central rate that was considered ambitious given Spain's competitiveness, external position and underlying inflation rate. It is also apparent that the Spanish authorities had difficulties keeping the ESP within the band. The high interest rates required to dampen strong domestic demand also caused capital inflows. The extent to which domestic production dominated monetary policy decisions can also be seen in the impulse response functions displayed in Figure 4.7.

Figure 4.7 **Cumulative impulse response functions of the Spanish short-term interest rate to innovations in domestic and foreign variables**



1 Period I
2 Period II
3 Period III

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

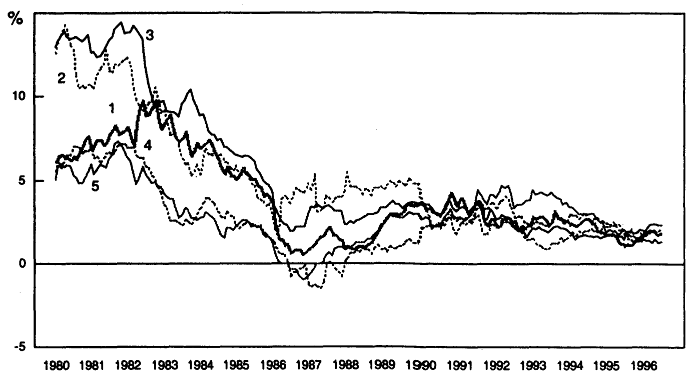
5 Summary of the results

5.1 Domestic variables

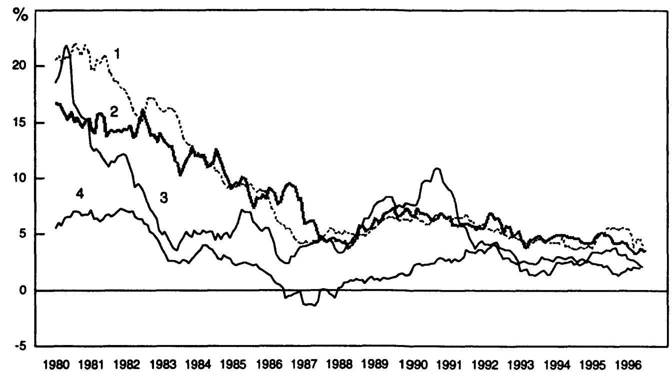
Taking the country-by-country results together, we can make the overall observation that the inflation rate has had surprisingly little effect on domestic monetary policy during the first subperiod. At that time, Europe suffered from the inflation shock induced by the oil shock, so one might expect more anti-inflationary monetary policies. On the other hand, at that time inflation was counteracted by actions other than monetary policy such as modifying wage-indexation, and further that inflation differentials were often compensated for, at least partly, with devaluations. In any case, the role of monetary policy in controlling inflation gains in importance only after the mid-1980s. This is seen especially in the increased inflation convergence towards the low level of the anchor country, Germany, as displayed in Figure 5.1, and in the consequently diminished need to adjust the exchange rates. But despite of the change in the orientation of monetary policy, the role of the inflation rate has decreased in the third subperiod. This can probably be explained by the fact that, in the 1990s, inflation rates in the ERM countries have strongly converged, as Figure 5.1 illustrates. We see that the range of domestic inflation rates narrowed and virtually disappeared, when the German inflation rate crept up after the unification. The convergence together with the fact that the level of the inflation rates has stabilized has diminished the need of monetary policy to react. Production, in turn, loses of significance for monetary policy in the second subperiod. This, again, can be explained by the fact that during the second subperiod, especially in the end of the 1980s, the business cycles in the ERM countries were both synchronized and favourable for growth. Therefore, as long as there was no danger of overheating, there was no pressure for monetary policy to react. Taking this together would conform with the conclusion that the role of the domestic variables for monetary policy making has been about the same throughout the entire period.

One observation is the persistence of interest rates. Interest rates have been influenced by their own history clearly throughout the period, but the pattern of the dynamic response to domestic interest rate innovations seems to have undergone a change towards the third subperiod. In general, the estimated impulse response function suggests that the interest rates converges to the new level within six months after the innovation in the first and second subperiod. The estimated reaction is also monotonous. In the third subperiod, however, there is some "overshooting" right after the initial shock in interest rates in Belgium, Denmark and France. In these cases, it also takes longer than six months before the interest rate finds its new level. In the other countries, on the contrary, there is no "overshooting" and the interest rate settles at the new level within a few months.

Figure 5.1 **Inflation rate in ERM countries**



1 Belgium
2 Denmark
3 France
4 The Netherlands
5 Germany



1 Italy
2 Spain
3 Great Britain
4 Germany

5.2 Foreign variables

On the foreign side, the German interest rate has a significant coefficient only in two countries, Belgium and the Netherlands. In the other countries, the deviation of the exchange rate from the central rate has been the significant determinant of monetary policy. This indicates that all countries, with the exception of Great Britain and Spain, have tried to follow German monetary policy at the same time as they have tried to minimize devaluation expectations. In all these cases, the effect of depreciation of the spot exchange rate on the domestic interest rate is positive. If German monetary policy had no influence, then the effect should be negative, because in equation (7d), as λ grows, the coefficient for the exchange rate term approaches k, a negative constant. Thus, the countries have followed Germany directly to some extent during the first and second subperiods. The absence of the German interest rate in the empirical results indicates that the effect of domestic interest changes on devaluation expectations has been of the same size as the weight put on following Germany.[17] If we look at the impulse response functions for the first subperiod in Figures 4.1–4.7 we note that in all other countries except the Netherlands and Belgium, the effect of the exchange rate on the interest rate is only temporary. This is in accordance with Loureiro's 1992 finding that, during the period, the Netherlands was the only ERM country where the management of interest rates was a feasible instrument for counteracting exchange rate movements. Other countries followed a sterilized intervention policy which was unable to counter depreciation trends. In Figures 4.1–4.7, this can be seen as a temporary increase of the interest rate resulting from a depreciation of the exchange rate. Such behaviour, in turn, indicates that during the first subperiod, the EMS would not have been as asymmetric as has often been claimed.

In the third subperiod, the foreign variables show up only for the Netherlands and Spain. In the Netherlands, the German interest rate is the only decisive variable, which is reflected in the fact that θ is zero in the Netherlands, but all weight is on stabilizing the participation in the ERM. Moreover, there are practically no devaluation expectations, ie $\delta = 0$, and τ has a large value indicating that German monetary policy has been strictly followed. In Spain, by contrast, the exchange rate has a positive influence on the domestic interest rate. It seems that the reaction function in Spain works in the third subperiod in the fashion

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[17] In terms of equation (7d), in these cases $|d| = |\tau|$.

that was characteristic for the other countries during the first or second subperiods. Because of the late entrance of the ESP into the ERM, this makes sense.

The other cases where neither the German interest rate nor the exchange rate shows a significant effect on the domestic interest rate, this might reflect two completely different situations. One explanation could be that $\lambda=0$, ie that only domestic factors matter. However, none of the domestic variables show up, either. Thus, it seems more likely that we have a situation where devaluation expectations are so small that the term disappears. At the same time, German monetary policy is not strictly followed by the other countries. This indicates that the EMS has become even more symmetric over time. During the existence of the wide fluctuation margins, either the amount of sterilized intervention has increased, or deviations of the exchange rate from its central rate have been allowed more generously than before, or both. In any case, the exchange rate restriction originally provided by the ERM seems to have lost constraining power on domestic monetary policy making. Interest rate policies have converged, but not because of "strait-jacket" effects but because of similar domestic preferences.

Interestingly, the overall role of the foreign variables has clearly decreased over time. In the first subperiod, the effect was clear, while in the third subperiod it seems to be very small. Of course, the fluctuation bands of the ERM have been wider in the third subperiod than in the first two. and clearly margins of 15 per cent give more room for monetary policy than narrow bands.

6 The changing role of the ERM

The EMS is a supplement to domestic monetary systems. How it has worked has depended on the countries involved and changes in their policy preferences over time. The results of this study show three features:

- the relatively stable role of the domestic variables,
- the declining importance of the foreign variables, and that
- the history of the domestic interest rate itself has become more decisive for monetary policy decisions.

6.1 The disinflation process

The first part of the interpretation of the empirical results concerns the weighting of domestic targets. The results indicate that there has been a stabilization process going on in Denmark and France in the 1980s, and then also in Great Britain and Spain in the 1990s. Belgian and Dutch monetary policies have not reacted to changes in the domestic inflation rate. In the Netherlands' case, this is explained by the fact that the NLG has long been a currency that retains its value. In Belgium, in turn, the central bank has controlled inflation through dampening any overheating of the economy. In the traditionally inflation-prone countries (Great Britain, Italy and Spain), the monetary policy trade-off has been more a question of balancing the two domestic factors than domestic and foreign components of the loss function.[18]

The reason for the disinflation process might be found, as suggested in other studies, in the monetary cooperation practiced within the EMS. For example, Fratianni & vonHagen (1990) show that the conditional variance of inflation, as well as its trend, has fallen in EMS countries. This fall is matched in non-EMS countries, but between the EMS countries they find greater covariance than outside the EMS, suggesting policy coordination within the EMS countries. Also Bell (1995) notes that the main benefit of the ERM of lowering the inflation rates in the participating countries is not due to the (quasi-) fixity of the exchange rates, but to the monetary policy conducted in the individual countries as participants in the system.

A further finding of close monetary policy coordination between the EMS countries is presented in Hughes-Hallet et al. (1993). They argue that the joint challenges to EMS members posed by the system's potential instability seem to have forced their central banks to abandon independence and to cooperate to a degree never originally foreseen. Hence, all EMS countries have adopted the target of the anchor country, namely monetary stability. In that sense, it could be argued that the domestic targets have not been independent of the existence of the EMS. - On the other hand, the willingness to participate in the EMS may be interpreted as evidence of the convergence of internal targets of the countries in question.

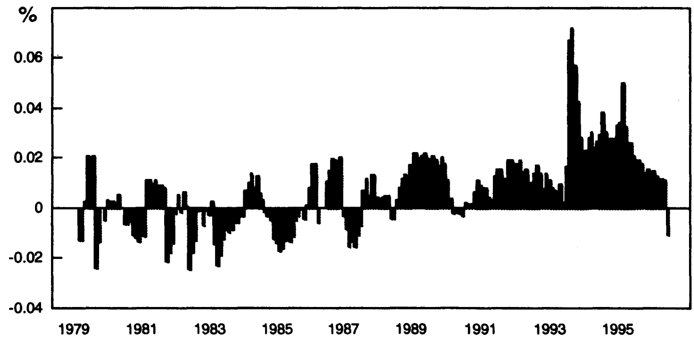
[18] See also Gros & Thygesen (1992) for an analysis of the disinflation in the EMS.

6.2 Lesser external constraint

The second part of the interpretation concerns the role of the ERM. In earlier research, eg Loureiro (1992) has analysed the symmetry of the EMS using VAR estimations on domestic credit. His results showed that especially France and Italy enjoyed relatively large monetary independence during the first subperiod. Only the Netherlands followed strictly German monetary policy, whereas Denmark and Belgium were "intermediate cases". Similar results are presented in Bini Smaghi & Micossi (1990), who have analysed a period corresponding the second subperiod of this study. They found evidence for that especially after 1987, monetary policies in ERM countries responded more readily to the requirements of exchange rate stability in the traditionally inflation-prone countries. The impulse response functions obtained in this study give a similar indication – the exchange rate variable has the strongest effect during the second subperiod in Italy. Its coefficient is significant also for France and Belgium, but the impulse response functions show that the effect is smaller during the second subperiod, than the first. In the Netherlands, the exchange rate has no effect on monetary policy after the first subperiod.

Page 35 of the 1994 Annual Report of the European Monetary Institute (EMI) states, "After the widening of the fluctuation bands in the ERM... the central banks of the participating countries had in principle the opportunity to use the increased room for manoeuvre to set monetary policies with less emphasis on the exchange rate. ...The solution of downgrading the exchange rate as a nominal anchor was, however, not generally pursued, thereby confirming that the ERM continued to function as a coordinating framework for national monetary policies... What has not changed is the final objective of monetary policy, namely price stability..." The following year, EMI writes on page 16 of its 1995 Annual Report, "... monetary policy responses to exchange rate tensions followed two broad strategies: the majority of ERM countries continued to give priority to stable nominal exchange rates vis-à-vis the strongest ERM currencies in their formulation of monetary policy; other countries found it more appropriate to allow more exchange rate flexibility, as evidenced by the increased use of the +/– 15 % fluctuation bands within the ERM." Apparently, the deviations of the spot exchange rate from the central rate have diminished and are, therefore, so negligible that they do not affect domestic monetary policy. This should not be surprising considering that during the first subperiod, and even more so during the

Fig. 5.2 continued **Deviation of spot rate from central rate (upper panel) and interest rate variability (lower panel) in Denmark**



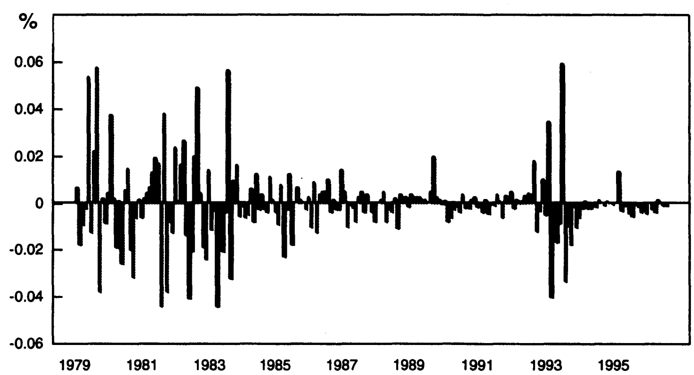


Fig. 5.2 continued **Deviation of spot rate from central rate (upper panel) and interest rate variability (lower panel) in France**

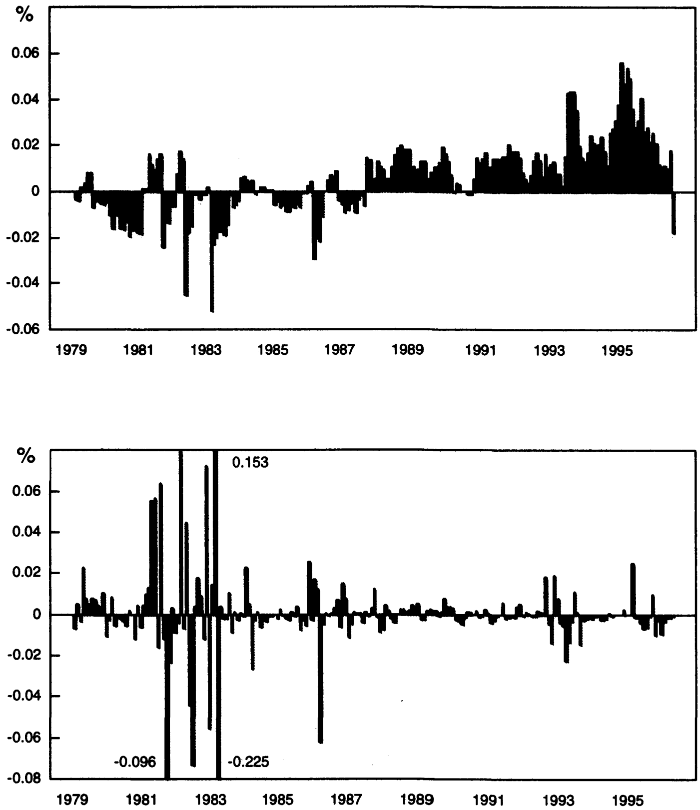
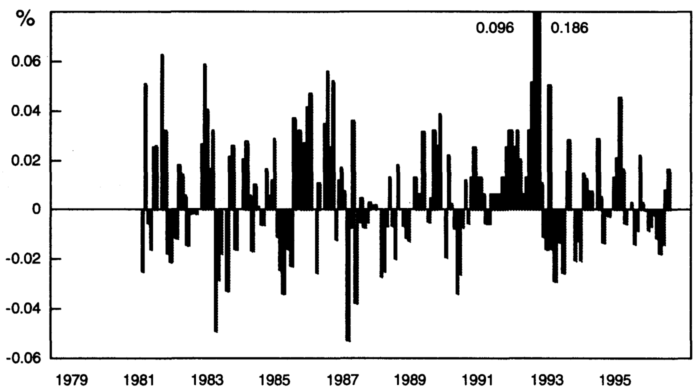


Fig. 5.2 continued **Deviation of spot rate from central rate (upper panel) and interest rate variability (lower panel) in Great Britain**



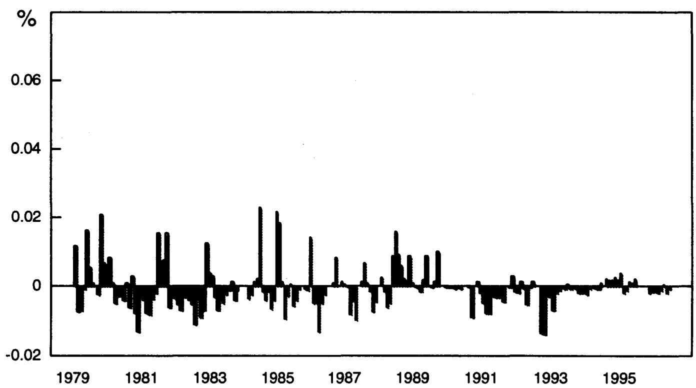
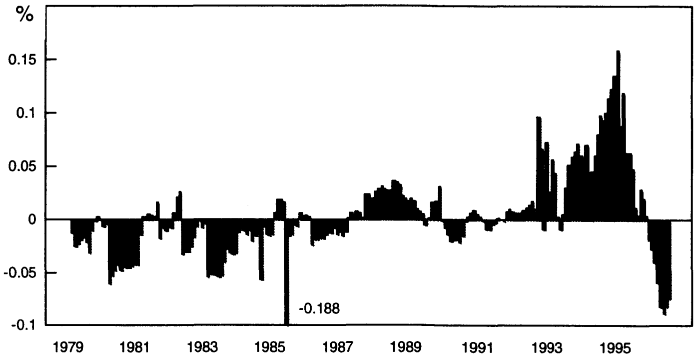


Fig. 5.2 continued **Deviation of spot rate from central rate (upper panel) and interest rate variability (lower panel) in Italy**



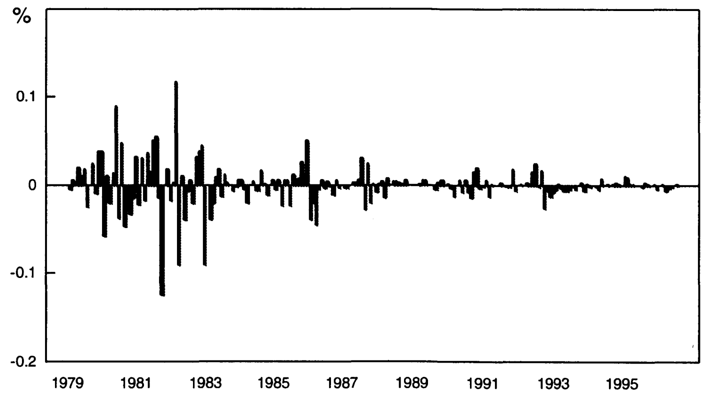
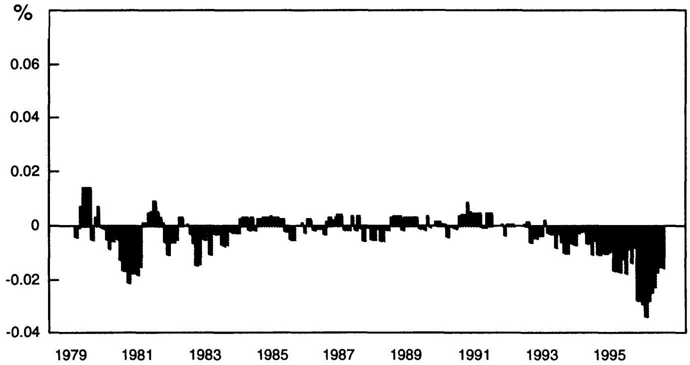


Fig. 5.2 continued **Deviation of spot rate from central rate (upper panel) and interest rate variability (lower panel) in The Netherlands**



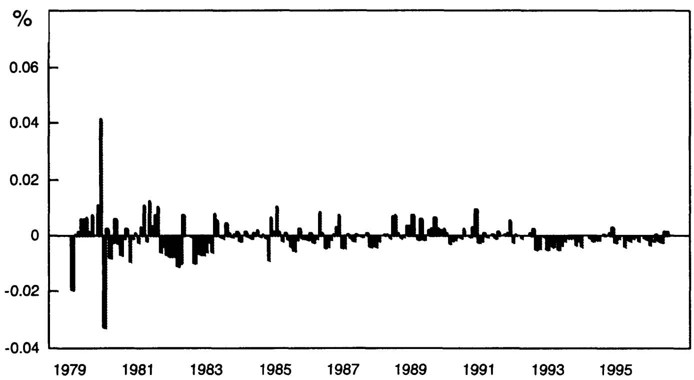
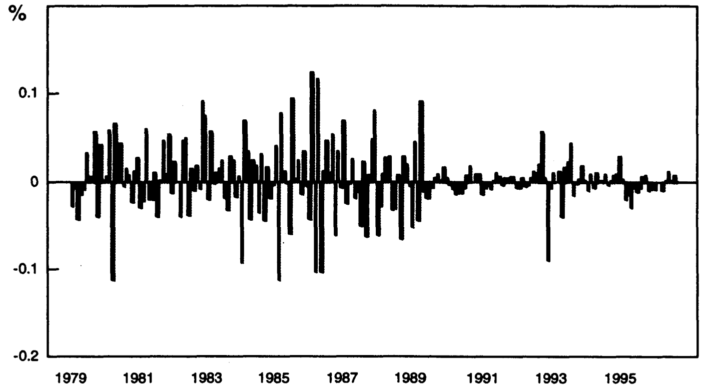
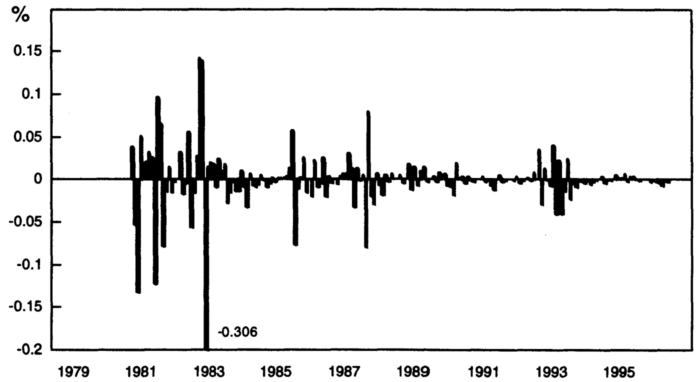
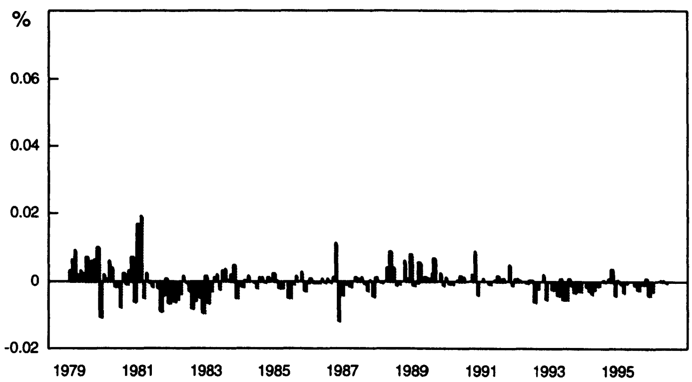


Fig. 5.2 continued **Deviation of spot rate from central rate (upper panel) and interest rate variability (lower panel) in Spain**





Interest rate variability in Germany



It was empirically shown also in Hughes-Hallet et al. (1993) that the EMS induces system instability for participating countries when agents anticipate parity changes.[22] The authors argue that this potential instability has forced not only greater rigidity in parities but also greater cooperation and the abandonment of monetary independence. They also found empirical evidence that an EMS with no parity change and fixed money supplies exhibited reasonable stability. In an earlier paper (Ranki, 1996), we also found that "core" countries do not suffer from persisting realignment expectations. The results showed that during the period 1987-1992, which is identical to the second subperiod in this study, the BEF/DEM and NLG/DEM exchange rates had the smallest devaluation expectations, ie they were practically negligible. The DKK/DEM and FRF/DEM exchange rates gained credibility throughout the period. The remaining currencies GBP/DEM, ITL/DEM and ESP/DEM, in contrast, suffered from relatively poor credibility. Thus, utilizing these results we can conclude that, as the theory says, if the central rate is credible, then the domestic monetary authority can delegate the adjustment burden to the exchange rate. This is what has happened to an extent in the third period of our analysis in the case of the "core" countries who have enjoyed exchange rate credibility. This has also been suggested in the EMI 1994 Annual Report. According to the report some EU central banks have gained credibility in financial markets from their determination to maintain an anti-inflationary policy stance.[23]

6.3 Consensus on monetary policy targets

The third part of the interpretation concerns the phenomenon that the interest rate depends, to an increasing extent, on its own past. However, any such discussion should be prefaced by stating that there has been a change in the way monetary policy is conducted in Europe. As Driffill (1988) notes, the only reason for countries not to want to maintain fixed exchange rates is a difference in preferred inflation

[22] One early empirical contribution in the discussion of the trade-off between interest and exchange rate variability in the context of the EMS is the study of Artis & Taylor (1988). They found evidence for a reduction in the volatility of interest rates for ERM members. The authors attributed this reduction to the enhanced credibility of the exchange-rate policies of the respective countries.

[23] They point out the synchronized nature of the economic upswing also has played a favorable role in this regard.

rates. Looking at the history of the EMS, we get the impression that preferences concerning the inflation rate have converged over time. In the early years, some ERM countries were inflation prone, while others conducted anti-inflationary monetary policy. In particular, Germany became the leading country because of its superior price stability record. However, as the prominent position of the DEM as the nominal anchor was to a large extent eroded after the German unification and inflation in Germany picked up, the relations between the EMS currencies became more symmetric. Moreover, there is today an agreement among the EU central banks that the final target of monetary policy is the achievement and maintenance of monetary stability. The strategies to achieve these targets can vary[24], but there is a strong consensus on the final target. The EMI 1995 Annual Report notes (p. 3), "Overall, monetary policies geared towards the primary objective of price stability have contributed to a general decline in inflation."

Evidence for this change in the preferences is the convergence of the inflation rates. This, of course, improves the sustainability of fixed exchange rates between the ERM countries. Moreover, since the inflation rates in most ERM countries have stabilized at low levels, emphasis can now be put on stabilizing interest rates. Indeed, since the turbulence on the foreign exchange markets in autumn 1993 and early 1995, official and key interest rates have been lowered on several occasions. As stated in the EMI 1994 and 1995 Annual Reports, ERM countries have continued their policies of gradually lowering official or key interest rates, thus allowing short-term market interest rates to decline. The conduct of monetary policy seems to have changed so that today, a reputation for consistency in monetary policy has become a key element in achieving monetary stability.

Alternatively, one could interpret the development of the role of the EMS so that it gradually came to be regarded as an implicit coordination mechanism through which countries could improve their performance by coordinating their economic policies. Hence, the EMS seems to have become more symmetric in the 1990s, and to function more as it was originally intended. Since the widening of the fluctuation bands, or should we say, since the liberalization of the capital markets, there has been a strengthening consensus that monetary policy should provide a credible anchor for nominal stability. In terms of this study, as the target values of $\bar{y}$ and $\bar{\pi}$ as well as the

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[24] See the Annual Report 1994 of the *European Monetary Institute* for s survey of the monetary policy strategies of the EU central banks.

weight σ given for the inflation target (see equation 4) have converged in the individual countries, the role of the ERM-related variables as a restrictive guiding line for domestic monetary policy has diminished. The restoration of domestic monetary stability, then, also implies stability within the ERM. In terms of equation 4, since δ and the interest rate differential $r-r^*$ have decreased, their effect on domestic monetary policy has, automatically, decreased even if the value of λ would not have become smaller. In the words of the EMI 1994 Annual Report (p. 45), "As the convergence of inflation towards low levels makes further progress, ensuring that competitive positions do not get sharply out of line, this will be the best guarantee of limiting exchange rate tensions in the future." The interest rate policies can thus become more smooth than was the case in the unstability-prone past of the EMS.

7 Conclusion

In this study, we have derived a monetary policy rule, the interest rate rule, from a minimization problem faced by the central bank. The loss function trades off costs of interest rate instability against benefits from succesful demand management and a stable exchange rate in the ERM. ERM-related considerations, particularly, exogenous effects from German interest rates as well as deviations from the ERM-central rates, were introduced into the analysis through the latter channel. In the empirical section of the paper, we quantified the significance of the effects of the various factors on the domestic interest rate of an ERM-country by performing regression analysis with the domestic interest rate as the dependent variable. The evidence suggests that the countries can be divided into two groups. In the first group (Belgium, Denmark, France and the Netherlands) the trade-off of monetary policy was a choice between domestic and external targets in the early years of the EMS. The second subperiod was a period of convergence and tight exchange rate stabilization. As a result of the convergence, in the third subperiod, the exchange rate has deviated *more* from the central rate since the widening of the fluctuation bands than it has done before. At the same time, the effects of the German interest rate have diminished, while the significance of the lags of the domestic interest rate has remained high or even increased. In the traditionally more inflation prone countries (Great Britain, Italy and Spain) the trade-off of monetary policy has been rather a question between the two domestic factors than between the domestic and foreign components of the loss function.

These results seem to be consistent with the interpretation that the EMS has become more symmetric, especially as regards the "core" countries. Or, one could interpret the development of the role of the EMS so that it gradually came to be regarded as an implicit coordination mechanism through which countries could improve their interest rate convergence by coordinating their economic policies. It has evolved into a group of countries with mutually consistent targets, being still of an external constraint for countries with diverging economies, but a transparent indicator of the success of economic policies in the countries with a high degree of convergence.

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Monetary Policy in a Bipolar International Monetary System

Contents

1 Introduction

Countries differ in size and monetary significance. The resulting asymmetry of the international monetary system confers a broad array of benefits and problems on countries that issue leading currencies. These few special currencies have strategic importance for others, so how those others behave reflects on the issuer country.

Since the Great Depression, most European currencies have not been used as key currencies in the international monetary system because, as individual currencies, their relative importance in the world economy was too small to back up developments in international markets with sufficient supply. European Economic and Monetary Union (EMU) may change this aspect of European life quite dramatically. Implementation of the Maastricht Treaty imposes a single currency throughout the EMU area, creating at a stroke one of largest monetary blocs in the world economy. As transition to the single currency is effected, we could expect an irresistible structural shift in the international monetary system. That shift has huge potential to destabilize exchange rate regimes; it will very likely to be a major concern of monetary policysetters in the EMU area.

This study seeks to identify possible ways that Europe's planned single currency, the euro, could influence foreign exchange markets, and thereby anticipate monetary policy issues that could eventually face the European Central Bank (ECB). The discussion mainly concerns the international dimension of ECB monetary policy and the case for careful coordination of monetary and exchange rate policies.

The discussion is premised on two assumptions: the euro (EUR) will replace the Deutschmark (DEM) as the number two currency after the US dollar (USD) in the international monetary system, and use of the EUR will be more widespread than the DEM because it inherits the currencies of several EU member states. Judging from history, we can further assume that the ascendance of a new key currency in the international monetary system holds broad implications.

Article 2 of the Constitution of the ESCB (European System of Central Banks) states that the primary objective of ECB policy will be to maintain price stability. It won't be their only objective, though. The ECB's leaders will clearly have to confront exchange rate issues as well. Indeed, the EUR exchange rate could become volatile precisely because it gains extensive use as an international asset. With such status, its price could be determined by spurious expectations rather than macroeconomic fundamentals. Excessive volatility, in turn, would make it difficult for officials to set policy or for private agents to make plans. A serious long-running misalignment could have economic consequences quite independent of Europe's macroeconomic fundamentals. We think the ECB has strong motives to work for stabilization of exchange rate movements.

Exchange rate management of an international currency is a non-trivial task. The price of such currency is largely determined by demand, which, in turn, is largely affected by the expectations of international investors and other actors. A policy action intended to compensate for the effects of an inflationary shock could quite unintentionally destabilize the exchange rate. To illustrate this dilemma, we construct a simple two-country model with an IS-LM-AS framework. We then hit our model economy with different types of shocks: demand shocks, supply shocks, money supply shocks, money demand shocks and exchange rate shocks. The qualitative effects of these shocks on interest rates, inflation, output and the exchange rate are explored. The proposed framework indicates that the likelihood of conflict between inflation stabilization and exchange rate stabilization depends on the type of shock. In the model, a demand shock always drives the value of the domestic currency in opposite directions in the goods market and the foreign exchange market. Other shocks may, of course, be less problematic for the policysetter, but nevertheless the results argue strongly that the exchange rate problem needs to be assessed empirically.

Having established that there may be situations where that force a trade-off between price stability and exchange rate stability, we then briefly discuss the prospects for international monetary cooperation. It appears that a certain amount of monetary coordination is needed to avoid excessive exchange rate volatility or, in the longer run, misalignments (especially if the currency blocs are heavily integrated).

The study is constructed as follows. Chapter 2 briefly describes the roles of an international currency and the possibilities of the EUR to attain wide use in the international monetary system.

To consider how a domestic monetary target can be achieved without harming the desired degree of exchange rate flexibility, Chapter 3 reviews earlier discourses on exchange rate flexibility and economic shocks. Using an IS-LM-AS framework, we subject a theoretical model of two economies with key currencies to various shocks (demand, supply, monetary, all-domestic, foreign, and exchange-rate shocks). The analysis seeks to uncover which types of shocks, or combinations thereof, bring monetary actions to maintain price stability into conflict with actions to promote exchange rate stability. We next apply the model empirically using US and German data to portray a world with two large economies and two main currencies. We contrast the effects on the US-German model with effects on the theoretical model with VAR methodology that isolates predominant sources of volatility.

Chapter 5 provides an interpretation of the results and discusses their consequences in terms of conduct of the monetary policy and exchange rate management. Chapter 6 concludes.

2 The euro in the international monetary system

An international currency can be defined as a currency that performs all monetary roles. When an international currency is used on a global scale it can be considered a key currency. Thanks to its universal acceptability, a key currency may act as a vehicle currency in situations where the indirect exchange costs of using it are lower than the direct exchange costs between two less popular currencies.[1] Vehicle currencies can be highly useful; for example, in invoicing or holding liquid balances.[2]

2.1 The roles of an international currency

A key attribute of money is its general acceptability in the settlement of debt. As a means of international payment, a currency is used either in direct exchange or as a vehicle of indirect exchange between two other currencies.

[1] Here, strict distinction between key currency and vehicle currency is unnecessary. The terms are basically interchangeable within this discussion.

[2] The issue of the characteristics of an international currency is handled in more detail in the study of the ECU institute (1995), Ranki (1995), Bénassy-Quéré (1996) or Prem (1997). Thorough theoretical presentations of the properties of international currencies are Cohen (1971), Klump (1989), Tavlas (1991) and Van het dack (1992).

When serving as a unit of account, the currency is the common denominator by which goods and services are valued and debts expressed. A currency can be used to invoice merchandise trade and denominate financial transactions.

When used as a store of value, the currency becomes a means of hold wealth. An international store of value is involved whenever held assets are denominated in a currency other than that of the country of the holder.

International currencies have demonstrated an ability to maintain their value over time. Confidence in the stability of a currency is determined mainly by its inflation record. Therefore, the safest currency for all investors regardless of their country is the currency of the country with the lowest and most predictable inflation.

Whether a currency becomes an international currency may also be contingent on the structure of the financial markets in its home country. Obviously, investors prefer assets from countries with the best-organized, most-efficient financial institutions and markets. They require markets that are open, broad and deep enough to provide economies of scale and a wide variety of instruments. This precondition is largely self-fulfilling: as use of a currency increases, a market develops thereby making it even more convenient to use that currency. When money markets for the currency are sufficiently liquid and deep, the currency assumes the role of the major international currency – a preferred medium of exchange.

The transaction domain of an international currency depends mainly on world trade patterns. The need to switch between currencies and, consequently, the ensuing transaction costs can be substantially diminished, when actors adapt their own currency mixes to that of most other actors and hold the most widely used currencies as international exchange media. Quite naturally, the choice of currency tends to concentrate on the international exchange media of those countries most predominant in international trade.

2.2 The euro as an international currency

To consider the factors affecting the euro's potential to become an international currency, we draw upon some real-world observations. Previous experiences with other internationally used currencies (USD, GBP, DEM and JPY) reveal three joint developments that auger growing acceptance as an international currency. First, the importance of a currency increases as it continues to exhibit stable inflation performance and be backed by a credible monetary policy. Second, a wide menu of financial instruments and lifting of capital controls based on the currency are developed. Finally, the extent to which the currency is used in world trade increases.

Agents are normally want to manage the risk that the value of a currency they hold may change. They further understand that a currency may lose purchasing power due to changes in domestic price levels, nominal exchange rates, or both. Thus, the degree to which the EUR competes with the USD as a key currency in the long run, is likely to depend on the stability of the purchasing power demonstrated by each of these two currencies. Initially, the EUR will be hard to judge against the USD, since the ECB has yet to establish any sort of track record for EUR inflation or credible monetary policy.

Nor is time alone all the ECB needs to establish credibility in implementing its policy commitments. The stability characteristics of the EUR will have to be designed in from the start through creation of an institutional framework with all preconditions to conduct a credible anti-inflationary monetary policy. The monetary constitution embodied in the Maastricht Treaty lays the foundations for such credibility by setting price stability as the primary objective of ECB monetary policy of the. The treaty also guarantees the ECB and its affiliate national central banks an independent position in monetary policy decisionmaking. In principle, an ECB that successfully continues to meet its price stability objective would lay a basis for the EUR to supplant the USD, at least partly, as the preferred key currency.[3]

Although the market for the EUR will clearly be deeper than the market for any EU currency at present, the EUR will also have to be made more fully usable as a means for international payments if it is to play an important role as an international reserve asset. For both the interbank market and the non-bank private sector, reluctance to use the EUR will persist until banking in the EUR is as cheap, or cheaper than, the alternatives. This depends on the success of further financial deregulation in bringing down the cost of banking in the EU.

The transaction domain for the EUR within the EU will be inherited from current EU currencies. As the second most important currency in foreign exchange markets, the EUR market will be deeper than the market for any of the individual EU currencies. Economies of

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[3] When discussing stability, political risk should also be considered. Political risk measures the probability of a borrower being forced to default because of the imposition of exchange or other controls by a political authority. Hence, the conditions for the EUR to become an international currency can be improved by strengthening political stability in the EMU area, which for its part makes the commitment to liberalized financial markets credible.

scale should rapidly benefit the international use of the EUR, making it an efficient medium of exchange.

The EUR could also gain from changes in invoicing patterns. EU trade invoiced in EUR would feed the growth of the currency's use as a means of payment in international transactions.[4]

The above said, there is little reason to imagine that the EUR will dethrone the USD as the world's preferred international currency. The size of the market and scale advantages for the USD are now so large that it can withstand tremendous pressures. Incidents in isolation (eg increased inflation risk, worsening of the US current account, or diminishing importance of the USD in world trade) do little to shake people's abiding faith in the USD. In fact, in times of global currency disturbances, the demonstrated flexibility of US financial markets and confidence in the country's long record of political and economic stability make the USD a haven currency.

Further, the USD's continued retention of its prime position in the international monetary system could continue simply because the switch to a different key currency involves substantial hysteresis. For example, Cooney (1987) has argued that it is actually in the interests of the rest of the world to support US deficits and maintain the dollar as the key currency.[5] After all, most traders would consider a rapid or severe correction in the US current account as harmful to the interests of non-US exporters. Investors, too, might be averse to the idea of having to find new places to invest the present surpluses of their major trading partners.

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[4] It should be noted that the change of invoicing currency in *intra*-EU trade does not have any direct *external* effects on the use of the EUR. There is, however, an important indirect effect. If intra-EU trade increases, the domestic financial markets for the EUR will develop and, thus, promote the preconditions for international use of the EUR.

[5] It should be noted that a reduction of the trade deficit of the US would necessitate stronger growth performance in other major economies. For a further discussion on the trade deficit problem of the US, see eg Cooney (1987).

2.3 Costs and benefits of an international euro for EMU

The effects of EUR's international roll on EMU have been widely considered.[6,7] Here, we restrict our focus to three issues related to aspects of monetary and exchange rate policy of the ECB.[8] We first consider the cost of loss of control over the money supply when the EUR serves as an international currency. Next, we examine the potential costs and benefits accruing through exchange rate management, and consider the merits of a development path towards making the relative positions of the USD and the EUR more symmetric. We close this section of discussion by speculating on consequences of a more symmetric international monetary system in global exchange rate developments. The discussion assumes that integration and liberalization on a global level will progress, or at least remain at the current level.

2.3.1 Losing control over the money supply

The international importance of a central bank is not solely determined by size or degree of its country's trade participation; the bank's tone, reputation for stability, sophistication, and sureness of touch in financial matters are all essential to winning respect in international monetary affairs. The ECB must demonstrate a good understanding of its strengths and vulnerabilities, and it must be allowed to develop in a convincing fashion.

Inaccurate accounting is an example of a possible impediment to the ECB's task of promoting the credibility of European economic policies and stability of the EUR. Because flows of EUR abroad can only be measured imprecisely, assessment of money growth becomes more difficult. In the event of an offshore disequilibrium, the excess

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[6] This question is addressed in *Commission of the European Communities* (1990). Goodhart (1993) provides a discussion of the results of the Commission study.

[7] The costs and benefits for EMU from the international use of the EUR depend, first of all, on the position of the EUR in the international monetary system. In a tripolar system where the USD dominates, both the EUR and the JPY would remain international, but not key, currencies. The effects from the EUR are thus less than if it assumes a key currency position.

[8] Further issues are discussed in Ranki (1995), Bénassy-Quéré (1996) and Funke & Kennedy (1997).

supply of EUR offshore might cause the EUR exchange rate to depreciate. This, in turn, improves the current account, and offshore EUR becomes onshore EUR. However, the rate of growth of domestic EUR balances also increases, so some of the offshore EUR inflation is swept onshore. The ECB, in turn, would find it harder to pursue effective anti-inflationary policies.

2.3.2 Exchange rate management

An EUR foreign exchange market of sufficient depth to dampen volatility will also be harder to control by official intervention. Assuming that EMU participants are no more vulnerable to exchange rate fluctuations than the US, exchange rate management could become a focal issue for the ECB, independent of the formal USD-EUR exchange rate regime.

Large-scale substitution of the EUR for the USD could cause strong EUR appreciation against the USD, so transitional arrangements should be designed to prevent any shift from USD to EUR from having seriously disruptive consequences on the exchange rate and trade. In any case, extensive substitution would take a while to accomplish: the USD is presently used in over 80 % of world foreign exchange transactions and makes up over 60 % of world foreign exchange reserves. What reason could be so compelling as to cause public or private sector agents to switch currencies by suddenly selling off a large part of their holdings and incurring huge capital losses? Kenen (1993) argues, rather that rapid asset switching, it is far more likely that growth in EUR holdings will take place gradually through accumulation.

The popularity of the EUR will depend in part on the stability of its exchange rate against other international currencies. The inflation record of the EUR relative to the USD and the JPY will, in the long term, affect the exchange rate development between these currencies. If inflation in EMU area is assumed to be lower than in the US or Japan, it would probably contribute to EUR strength.

Like the USD, the EUR could be strong even if the EMU area runs a current account deficit. The deficit would, of course, have to be the result of excess investment over saving, so that it would be difficult for EMU participants to reduce the deficit through a depreciation of the currency. Market agents might even be quite willing to hold EUR-denominated assets. In such case, the exchange rate would not reflect the balance-of-payments situation of EMU and no depreciation would occur. On the other hand, if EMU shows a current account surplus, the EUR would also be a rather scarce international currency unless some mechanism is invoked to assure a continuous capital outflow from the EMU area.

2.3.3 Does symmetry confer stability or instability?

There are quite opposite views on how the introduction of the EUR will affect the symmetry of the international monetary system. One view holds that the international monetary system would become more stable with the EUR as major international currency because it increases symmetry in the system. The EMU area would constitute an economic power on a par with the US, which would mean that EU and US bargaining power match.[9] Highly mobile capital, currency diversification and direct investment all drive the system towards greater symmetry, even if trade between the currency blocs never expands to any considerable extent.[10] A multicurrency reserve system might even have certain advantages over one based on a single national currency, because competition between currencies would restrain authorities within the system from practising anything but fiscally virtuous policies. In such a world, flexible exchange rates would encompass a continuous process of adjustment, and it would be easier to let exchange rates move than harmonize domestic policies within the currency blocs. Thus, flexible exchange rates would give relatively greater room for domestic economic policy actions than fixed exchange rates.

The other line of argument holds that a symmetric system would prove more unstable than an asymmetric system, because the actual degree of autonomy in domestic economic policy is less than what is theoretically indicated. Garritsen de Vries (1987) note the experience with greater exchange rate flexibility after 1973 shows that while floating was helpful to balance-of-payments adjustment insofar as exchange rate movements prevented current account imbalances from widening caused by divergent rates of inflation, exchange rate changes

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[9] The opposite view is that EMU will not cause a qualitative switch from an asymmetric to a symmetric international monetary system. The proponents of this view argue that US leadership has already been eroded by Germany and Japan.

[10] For a discussion on EMU's effect on the symmetry of the international monetary system, see eg Padoa-Schioppa (1988), Giavazzi & Giovannini (1989), Alogoskoufis & Portes (1990), Jaquet (1991), Currie (1993), Goodhart (1993) or Kenen (1993).

did nothing to help reduce chronic current account imbalances. In addition, even where national policy independence is quite minimal, there is still a danger that some officials may abuse what they perceive as room to manoeuvre. Such danger becomes pronounced in situations where the cyclical positions of the issuer countries of the major international currencies differ.

Indeed, cyclical changes could be quite problematic for ECB policymakers unless there is consensus on national-level economic policy measures. For example, there could be a deflationary bias if all EMU countries simultaneously try to reduce inflation by letting the nominal exchange rate appreciate. Obviously, the exchange rate cannot appreciate for everybody, so some countries will be frustrated. There could also be the situation where everybody simultaneously conducts over-restrictive monetary policy, thereby imposing unnecessarily high unemployment levels. Countries could unilaterally try to achieve full employment through depreciation of the nominal exchange rate without coordinating their domestic policies, only to cause an inflationary bias. Across-the-board monetary expansion in the EMU area could even result in higher world inflation, and cause prolonged misalignments instead of desired smooth adjustments. The cost arising from spillovers of economic policies directed to meet domestic targets will only stay small as long as the proportion of trade between the currency blocs remained low.

3 Economic shocks, exchange rate stabilization and monetary policy

There is wide consensus among economists that price stability provides a meaningful policy target. Many studies[11] have concluded that price stability has positive macroeconomic implications: it raises the efficiency of the monetary system, reduces uncertainty about the future, confers higher long-term growth rates, increases cyclical stability, etc. Thus, our questions mainly concern whether the central bank should be concerned about the exchange rate, and if so, to what extent.

There is an extensive body of literature seeking to determine the amount of exchange rate flexibility appropriate to given situations. In

[11] See eg Taylor (1996) for arguments for monetary stability.

these discussions, flexibility to set exchange rates is usually seen as a supplemental tool of monetary policy to be used, for example, when compensating for imperfect capital mobility.[12] Floating, the "hands-free" approach to exchange rate management, can allow excessive exchange rate variability that sends false or confusing signals to policymakers and private agents.

3.1 Arguments for exchange rate stability

Most central banks have a formal mandate to stabilize domestic prices, and use the classical approach of targeting the supply of money. The transmission of monetary policy is thought to take place mainly through interest rates.

However, especially when an economy is very open, the exchange rate can affect prices through at least two channels. First, the price of imports affects domestic prices. Second, central bank interventions in foreign exchange markets, unless sterilized, affect domestic liquidity. Both aspects make exchange rate a substantial consideration for macroeconomic policy. The need for exchange rate stabilization is also argued for as a means to reduce excessive exchange rate fluctuations disturb financial flows, or, in the medium-term, long swings that may disturb trade flows.

There is no satisfactory way to reduce exchange rate expectations to fundamentals – exchange rates simply do not behave as any existing theoretical models for exchange rate determination predict.[13] Certain kinds of volatility, for example, cannot be traced to any specific source. Further, the mere expectation of an exchange rate change can lead to an immediate change in the exchange rate and, through that channel, causes output to change in the two respective countries. Krugman (1989) argues that unstable exchange rates make firms cautious, unwilling to change their production and pricing decisions in response to the exchange rate; the delinking of exchange rates from real variables allows the exchange rates to become still more unstable; and so on. Hence, changes in the expected rate of change of the exchange rate are a potentially important source of disturbance to the world economy and a potentially important channel through which other

[12] See Mussa (1979) for a discussion.

[13] See MacDonald & Taylor (1992) or MacDonald (1995) for surveys of exchange rate economics.

disturbances may be transmitted from one economy to another. To avoid output changes that are due to exchange rate volatility not linked to real economy, the central bank may want to stabilize exchange rate movements and, consequently, expectations of exchange rate movements. These short-run movements can be affected through intervention on the foreign exchange markets.

A fixed exchange rate system[14] may lower exchange rate volatility, and as a result risk to international traders is lowered, simplifying their profit-maximizing calculations. Competition between producers located in different countries is also facilitated, encouraging further integration of economies. Thus, overall such a system can have a beneficial effect on growth. The argument for fixed exchange rates is quickly dispelled, however, if there are frequent changes in the fixed rates. Frequent changes increase uncertainty in foreign trade and in the financial markets, so the benefit of fixed rates in promoting international trade and effective allocation of capital is eroded. Depending on the structure of the economy, exchange rate stabilization may also cause a loss or weakening in the ability to gear monetary policy to domestic targets.

No matter what the exchange rate system, misalignments may arise. The prevention of misalignments requires international coordination of economic policies. Three factors increase the need for coordination as economies become more interdependent. First, the increased number and magnitude of disturbances to which each country's balance of payments are subjected directs national policy instruments towards the restoration of external balances. Second, greater interdependence impedes the process by which policy authorities reach their domestic objectives. Third, greater integration can provide perverse incentives for a community of nations to engage in counterproductive behaviour that ultimately leaves all participants worse off than they need be.[15]

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[14] Eg Levačić & Rebmann (1982) compare the advantages and disadvantages of fixed versus flexible exchange rate systems. Krugman (1989) describes the experience with floating exchange rates.

[15] Hamada (1979) provides an excellent discussion of international interaction and the consequent need for policy coordination.

3.2 The model

In order to analyse the interaction of the monetary policies in two large economies, the US and the anticipated EMU area, we construct a traditional Mundell-Fleming (MF) symmetric two-country open economy macromodel.[16] Generally, some transmission of various disturbances to the home country can be shown to occur if desired expenditure in the home country is affected by the terms of trade, or if import prices affect the demand for money, or if import prices directly affect the cost of domestic output. In the version of the MF model constructed here, we have three markets in both of the countries: a domestic goods market (the IS curve), a money market (the LM curve), and resources or the labour market (the AS curve). Conventionally, we have four assets: domestic and foreign money; domestic and foreign bonds. Domestic and foreign money are held only by local residents, whereas bonds can be traded across borders. The model assumes perfect capital mobility so that uncovered interest rate parity holds, thereby making domestic and foreign bonds perfect substitutes. Both countries are large and each country's interest rate is linked to the interest rate of the other country via interest rate parity. Each country can affect the common interest rate through its domestic policies. Exchange rate expectations, however, can also induce differentials between interest rates.

For the home country, we write the following equations

$$y = \theta(s + p^* - p) - \sigma r + \gamma y^* + \epsilon_d \qquad \text{IS function}$$
$$m - p = y - \lambda r + \epsilon_m \qquad \text{LM function}$$
$$p = \pi y + \epsilon_s \qquad \text{AS function}$$

Symmetry means that the structural parameter vector $(\theta, \sigma, \gamma, \lambda, \pi)'$ is the same at home and abroad. Otherwise, foreign variables are denoted by an asterisk (*). Hence, we write for the foreign country

$$y^* = -\theta(s + p^* - p) - \sigma r^* + \gamma y + \epsilon^*_d \qquad \text{IS function}$$
$$m^* - p^* = y^* - \lambda r^* + \epsilon^*_m \qquad \text{LM function}$$
$$p^* = \pi y^* + \epsilon^*_s \qquad \text{AS function}$$

Inflation expectations, as is standard in such short-run (one-period) analyses, are static (and exogenous). To simplify, we let real and

[16] For a description of the standard Mundell-Fleming model, see Steveson et al. (1988), Copeland (1989), or Pentacost (1993).

nominal interest rates be equal. The model will be solved first under the assumption that the domestic and foreign interest rates will be equal (as determined by the money markets); an exogenous "peso shock" ϵ_E, will be added to the model without introducing any additional complexities. The shock is linked to the interest rates as

$$r^* = r + \epsilon_E$$

so that it drives a wedge between the domestic and foreign interest rates. Exchange rate expectations can easily incorporated by substituting the interest rate parity condition for the domestic interest rate in the model. In the thus modified model, domestic goods and money market disturbances should be interpreted as composites, ie $\epsilon_d - \sigma\epsilon_E$ and $\epsilon_m - \lambda\epsilon_E$.

We derive the reduced form solution for the common interest rate r, eliminating the terms of trade term, $s + p^* - p$, from the two IS equations to arrive at

$$(1-\gamma)(y+y^*)=-2\sigma r^*+\epsilon_d+\epsilon_d^* \tag{1}$$

The LM and AS equations, give us

$$(m+m^*)-(p+p^*)=(y+y^*)-2\lambda r^*+(\epsilon_m+\epsilon_m^*) \tag{2}$$

and

$$(p+p^*)=\pi(y+y^*)+(\epsilon_s+\epsilon_s^*) \tag{3}$$

so from these two equations we have, by eliminating $(p+p^*)$,

$$(1+\pi)(y+y^*)=(m+m^*)+2\lambda r^*-(\epsilon_m+\epsilon_m^*)-(\epsilon_s+\epsilon_s^*) \tag{4}$$

Substituting this into equation (1) gives us

$$(1-\gamma)[(m+m^*)+2\lambda r^*-(\epsilon_m+\epsilon_m^*)-(\epsilon_s+\epsilon_s^*)]= (1+\pi)[-2\sigma r^*+(\epsilon_d+\epsilon_d^*)] \tag{5a}$$

or

$$r^*=\chi^{-1}\left[(\epsilon_m+\epsilon_m^*)+(\epsilon_s+\epsilon_s^*)-(m+m^*)+\left(\frac{1+\pi}{1-\gamma}\right)(\epsilon_d+\epsilon_d^*)\right] \tag{5b}$$

where $\chi = 2\ (\lambda + \sigma(1+\pi)/(1-\gamma)) > 0$, assuming that $\gamma < 1$; the interest rate solution has the usual structure in the sense that positive money and aggregate demand shocks as well as adverse supply shocks will increase the interest rate, while money supply shocks will reduce it.[17]

To solve for terms of trade, we use the IS equations to derive the following equation

$$(1+\gamma)(y-y^*)=2\theta q+(\epsilon_d-\epsilon_d^*); \tag{6}$$

where $q = s + p^* - p$.

The LM and AS equations once again give

$$(m-m^*)-(p-p^*)=(y-y^*)+(\epsilon_m-\epsilon_m^*) \tag{7}$$

and

$$(p-p^*)=\pi(y-y^*)+(\epsilon_s-\epsilon_s^*) \tag{8}$$

so

$$(1+\pi)(y-y^*)=(m-m^*)-(\epsilon_m-\epsilon_m^*)-(\epsilon_s-\epsilon_s^*) \tag{9}$$

which, after substituting into equation (6) produces

[17] Note that symmetry here is reflected in the form various disturbances affect the interest rate.

$$q=(s+p^*-p)=\left[\frac{1+\gamma}{2\theta(1+\pi)}\right][(m-m^*)-(\epsilon_m-\epsilon_m^*)-(\epsilon_s-\epsilon_s^*)] - \left(\frac{1}{2\theta}\right)(\epsilon_d-\epsilon_d^*) \tag{10}$$

This leaves four (4) endogenous variables to be determined; y, y^*, p and p^*. The nominal exchange rate will thereafter be determined by the identity $s = q + (p - p^*)$.

Let ξ and ψ be the two composite random variables on the r.h.s of equations (5) and (10), respectively.

$$\xi=\chi^{-1}\left[(\epsilon_m+\epsilon_m^*)+(\epsilon_s+\epsilon_s^*)-(m+m^*)+\left(\frac{1+\pi}{1-\gamma}\right)(\epsilon_d+\epsilon_d^*)\right] \tag{11}$$

$$\psi=\left[\frac{1+\gamma}{2\theta(1+\pi)}\right][(m-m^*)-(\epsilon_m-\epsilon_m^*)-(\epsilon_s-\epsilon_s^*)]-\left(\frac{1}{2\theta}\right)(\epsilon_d-\epsilon_d^*) \tag{12}$$

Thus, we can write the 4-dimensional system consisting of outputs and price levels as

$$\begin{aligned} y-\gamma y^* &= \theta\psi-\sigma\xi+\epsilon_d \\ -\gamma y+y^* &= -\theta\psi-\sigma\xi+\epsilon_d^* \\ \pi y-p &= -\epsilon_s \\ \pi y^*-p^* &= -\epsilon_s^* \end{aligned} \tag{13}$$

This system can written in a compact form using matrix notation

$$\mathbf{Az} = \mathbf{B}\omega \tag{13'}$$

where $\mathbf{z} = (y, y^*, p, p^*)'$, $\omega = (\epsilon_s, \epsilon_d, \epsilon_m, m, \epsilon_s^*, \epsilon_d^*, \epsilon_m^*, m^*)'$ and where the matrices **A** and **B** are given by

$$
\mathbf{A}=\begin{pmatrix} 1 & -\gamma & 0 & 0 \\ -\gamma & 1 & 0 & 0 \\ \pi & 0 & -1 & 0 \\ 0 & \pi & 0 & -1 \end{pmatrix};
$$

$$
\mathbf{B}=\begin{pmatrix} -\beta_s & \beta_d & -\beta_s & \beta_s & \beta_s^* & \beta_d^* & \beta_s^* & -\beta_s^* \\ \beta_s^* & \beta_d^* & \beta_s^* & -\beta_s^* & -\beta_s & \beta_d & -\beta_s & \beta_s \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \end{pmatrix} \tag{14}
$$

where

$$
\beta_s=\left(\frac{\lambda(1+\gamma)+\left[\frac{2\sigma(1+\pi)}{1-\gamma}\right]}{(1+\pi)\chi}\right)>0;\ \beta_d=\lambda\chi^{-1}>0;
$$

$$
\beta_s^*=\left(\frac{\lambda(1+\gamma)+\left[\frac{2\sigma\gamma(1+\pi)}{1-\gamma}\right]}{(1+\pi)\chi}\right)>0;\ \beta_d^*=\frac{1}{2}-\frac{\sigma(1+\pi)}{\chi(1-\gamma)}>0
$$

The solution to equation (13') is given by

$$
\mathbf{z}=\mathbf{A}^{-1}\mathbf{B}\boldsymbol{\omega} \tag{15}
$$

where $\mathbf{A}^{-1}$ denotes the inverse matrix of **A** (it exists, since the determinant of **A** is $1-\gamma^2$, which is less than one for bounded cross-country income effects $\gamma < 1$). The inverse is given by

$$
\mathbf{A}^{-1}=[\det(\mathbf{A})]^{-1}\mathrm{adj}(\mathbf{A})=(1-\gamma^2)^{-1}\,\mathrm{adj}(\mathbf{A})
$$

where adj(**A**) denotes the adjoint of **A**. If α_{ij} denotes the ij[th] element of the product matrix $\mathbf{A}^{-1}\mathbf{B}$, ie $\alpha_{ij} = [\mathbf{A}^{-1}\mathbf{B}]_{ij}$, we have

$$\alpha_{11}=\frac{[\gamma\beta_s^*-\beta_s]}{(1-\gamma^2)}<0; \quad \alpha_{12}=\frac{[\beta_d+\gamma\beta_d^*]}{(1-\gamma^2)}>0; \quad \alpha_{13}=\alpha_{11}<0;$$

$$\alpha_{14}=\frac{[\beta_s-\gamma\beta_s^*]}{(1-\gamma^2)}>0; \quad \alpha_{15}=\frac{[\beta_s^*-\gamma\beta_2]}{(1-\gamma^2)}>0; \quad \alpha_{16}=\frac{[\beta_d^*+\gamma\beta_d]}{(1-\gamma^2)}>0;$$

$$\alpha_{17}=\alpha_{15}>0; \quad \alpha_{18}=-\alpha_{15}<0; \quad \alpha_{21}=\alpha_{15}>0; \quad \alpha_{22}=\alpha_{16}>0; \quad \alpha_{23}=\alpha_{15}>0;$$

$$\alpha_{24}=-\alpha_{15}<0; \quad \alpha_{25}=\alpha_{11}<0; \quad \alpha_{26}=\alpha_{12}>0; \quad \alpha_{27}=\alpha_{11}<0; \quad \alpha_{28}=-\alpha_{11}>0;$$

$$\alpha_{31}=-\pi\alpha_{11}+1>0; \quad \alpha_{32}=\pi\alpha_{12}>0; \quad \alpha_{33}=\pi\alpha_{11}<0; \quad \alpha_{34}=-\pi\alpha_{11}>0;$$

$$\alpha_{35}=\pi\alpha_{15}>0; \quad \alpha_{36}=\pi\alpha_{16}>0; \quad \alpha_{37}=\pi\alpha_{15}>0; \quad \alpha_{38}=-\pi\alpha_{15}<0;$$

$$\alpha_{41}=\pi\alpha_{15}>0; \quad \alpha_{42}=\pi\alpha_{16}>0; \quad \alpha_{43}=\pi\alpha_{15}>0; \quad \alpha_{44}=-\pi\alpha_{15}<0;$$

$$\alpha_{45}=\pi\alpha_{11}+1>0; \quad \alpha_{46}=\pi\alpha_{12}>0; \quad \alpha_{47}=\pi\alpha_{11}<0; \quad \alpha_{48}=-\pi\alpha_{11}.$$

Given the solution to the model above, we derive the reduced form solution for the nominal exchange rate. By definition $s = q + (p - p^*)$, so that

$$q=(s+p^*-p)=\left[\frac{1+\gamma}{2\theta(1+\pi)}\right][(m-m^*)-(\epsilon_m-\epsilon_m^*)-(\epsilon_s-\epsilon_s^*)] - \left(\frac{1}{2\theta}\right)(\epsilon_d-\epsilon_d^*) \tag{10'}$$

and

$$p-p^*=[1-\pi(\alpha_{11}+\alpha_{15})]\epsilon_s+\pi(\alpha_{12}-\alpha_{16})\epsilon_d+\pi(\alpha_{11}-\alpha_{15})\epsilon_m - \pi(\alpha_{11}-\alpha_{15})m-[1+\pi(\alpha_{11}-\alpha_{15})]\epsilon_s^*+\pi(\alpha_{16}-\alpha_{12})\epsilon_d^* + \pi(\alpha_{15}-\alpha_{11})\epsilon_m^*-\pi(\alpha_{15}-\alpha_{11})m^* \tag{16}$$

where

$$1-\pi(\alpha_{11}+\alpha_{15})=1-\frac{2\sigma}{\chi(1-\gamma)}>0; \quad \pi(\alpha_{12}-\alpha_{16})=0;$$
$$\pi(\alpha_{11}-\alpha_{15})=-\frac{2\pi}{\chi(1+\pi)}\left[\lambda+\frac{\sigma(1+\pi)}{(1-\gamma)}\right]<0 \tag{17}$$

Previously, we have assumed static exchange rate expectations. However, at any point in time, the exchange rate in a floating rate regime with high capital mobility depends both on current variables and expectations about future exchange rates. Fundamentals matter in the long run, but often the prospects for the fundamentals are unclear, so that expectations are dominated by uncertainty. Thus, short-run fluctuations in exchange rates can be explained to a great extent by fluctuations in expectations. To account for this, we introduce exchange rate expectations into the model.

We thus calculate the effects of the "peso shock" on domestic and foreign output-price level combination. The notation here is identical to the one in the matrix solution to the output-price level combination in domestic and foreign economy presented in equation (14), ie α_{ij} refers to the ij^{th}-element of the product matrix $\mathbf{A}^{-1}\mathbf{B}$. Thus

$$\frac{\partial y}{\partial \epsilon_E}=-[\sigma\alpha_{12}+\lambda\alpha_{13}]=\frac{\lambda}{\chi(1+\pi)}\left[\lambda+\frac{\sigma(1+\pi)}{1-\gamma}\right]=\frac{\lambda}{2(1+\pi)} > 0 \tag{18}$$

$$\frac{\partial y^*}{\partial \epsilon_E}=-[\sigma\alpha_{22}+\lambda\alpha_{23}]=-\frac{\lambda}{\chi(1+\pi)}\left[\lambda+\frac{\sigma(1+\pi)}{1-\gamma}\right]=-\frac{\lambda}{2(1+\pi)} < 0 \tag{19}$$

$$\frac{\partial p}{\partial \epsilon_E}=-\pi[\sigma\alpha_{12}+\lambda\alpha_{11}]=\frac{\partial y}{\partial \epsilon_E} > 0 \tag{20}$$

$$\frac{\partial p^*}{\partial \epsilon_E}=-\pi[\sigma\alpha_{16}+\lambda\alpha_{15}]=\frac{\partial y^*}{\partial \epsilon_E} < 0 \tag{21}$$

From equations (18) and (19) we see that aggregate output (y + y*) is not affected by the "peso shock", only the distribution of the aggregate output across countries.

Table 3.1 summarizes the qualitative effects of the different shocks on domestic and foreign production and inflation, and the exchange rate. Most of the effects of the various shocks are conventional. Moreover, the effects of all but two can be controlled by monetary policy. An effect either increases inflation and depreciates the currency, or vice versa.

Table 3.1 **The qualitative effects of the structural disturbances on macroeconomic variables**

Effect of on	ϵ_E	ϵ_s	ϵ_d	ϵ_m	m	ϵ_s^*	ϵ_d^*	ϵ_m^*	m^*
r	+	+	+	+	–	+	+	+	–
p	+	+	+	–	+	+	+	+	–
y	+	–	+	–	+	+	+	+	–
e	+	+/–	–	–	+	+/–	–	+	–
r^*	+	+	+	+	–	+	+	+	–
p^*	–	+	+	+	–	+	+	–	+
y^*	–	+	+	+	–	–	+	–	+

Consider how shocks change *exchange rate expectations*. A positive shock in exchange rate expectations, ie the expectation the domestic currency will depreciate strongly (a "peso shock"), makes holding of foreign assets more attractive than the holding of domestic assets. This induces a capital flow from the home country to the foreign country. The capital flow forces up the value of foreign money relative to the money of the home country. This appreciation of the foreign currency shifts demand towards domestic output, leading to an expansion of output at home and a reduction of output abroad. When asset holders can take positions in foreign assets, expectations of future exchange rates play a vital role in determining the current exchange rate and other macroeconomic variables. An asset holder who has choice about the currency denomination of his assets will not hold his assets in a currency that he expects to depreciate, unless he is compensated by a nominal interest rate differential in favour of such assets. At home, at least, the increase in output is dampened by a rise of the interest rate.

A *monetary shock* can occur either as a change in the supply of money or a change in the demand for money. Money supply changes are the result of a change in central bank strategy. Money demand changes may, for example, due to a change in the velocity of money or preferences for financial instruments.

Assume now that a positive domestic monetary shock pushes down the world interest rate. The fall in the interest rate, however, is not enough to restore overall balance of payments equilibrium at the prevailing exchange rate, as in our model the world interest rate is determined jointly across the two countries. Therefore, the initially expansionary country will experience a balance-of-payments deficit. The foreign country, in turn, will experience the increase in the expansionary country's income as an increase the partner country's exports, so that income in the partner country also rises. The fall in world interest rate, however, generates a balance of payments surplus, so the exchange rate must be adjusted. The currency of the expansionary country depreciates vis-à-vis the currency of the other country. Depreciation in the expansionary country further increases output, while appreciation in the other country dampens output.

If we look at demand and monetary disturbances, we see that each effect is distinct. This is because each of these shocks affects the interest rate differently. A demand shock from the real side has no direct effect on either nation's interest rates, nor on the world interest rate. But as output changes, the demand for money also changes, affecting the interest rate. Exchange rate changes then adjust to keep output levels at equilibrium with the world interest rate.

A monetary shock, by contrast, has a direct effect on the interest rate of the country where the disturbance occurs. Under perfect capital mobility, it induces capital flows between high-interest rate countries and low-interest rate countries. This, in turn, calls for further exchange rate changes. The exchange rate change affects output in both countries.

The three types of shocks (ie exchange rate, money demand and money supply shocks) all have qualitatively the same effect on the monetary policy target variables. A positive shock from any of these accelerates inflation and depreciates the domestic currency. The monetary policy response intended to stabilize as target variable (say, the exchange rate) would also hopefully stabilize the other target variable (inflation). However, from Table 3.1 we can see situations where the target variable's inflation rate and exchange rate call for quite contradictory monetary policy actions. This is clearly the case for demand shock, and possible for a foreign supply shock.

Typically, supply shocks involve exogenous changes in energy prices or the terms of trade, productivity shocks, or tax and wage shocks. Adverse supply shocks include the exogenous increase in factors of production. When commodity prices increase faster than goods prices, producers face increased production costs. When producers pass higher intermediate goods prices on to their own prices, inflation is higher no matter what the level of output. Hence, the economy faces a combination of declining real growth and rising inflation.

The qualitative effect of the supply shock on the exchange rate depends on whether $\pi(\alpha_{11} + \alpha_{15})$ in (16) is greater or smaller than one. This term reflects the relative sizes of the two effects. The supply shock, by reducing the supply of output, increases the price level. This diminishes the real stock of money, so the interest rate increases. Since the interest rate is higher than the equilibrium world interest rate, this leads into an inflow of capital that tends to appreciate the domestic currency. However, an increase in the price level diminishes output, because the foreign demand component of demand diminished due to the deteriorated competitiveness of domestic products in international markets. To restore this equilibrium, the exchange rate has to depreciate. Thus, the final effect of a supply shock on the exchange rate depends on which of these two effects dominates.

Demand shocks can also be problematic for monetary policymakers. Demand shocks might also be thought of as government spending shocks or shifts in investment and consumption functions. Generally, while aggregate demand shocks have only temporary effects on the level of output, they effect prices over the long term so that a positive shock leads to a higher price level.

Internationally, a demand shock from the real side of the economy in the foreign country is likely to be transmitted with greater force to the home economy under a flexible exchange rate regime. Say an increase in domestic expenditure increases the country's demand both for its own goods and the goods of the foreign country. The increase in the home country's demand for imports implies that the foreign country experiences a trade surplus. The interest rate in the home country is higher (and the interest rate in the foreign country lower) than the equilibrium world interest rate. When capital is internationally mobile, an inflow of capital follows in the home country, and an outflow in the foreign country. The domestic currency, hence, appreciates, and the foreign currency depreciates. This dampens the initial shock in the home country and strengthens the spill-over effect in the foreign country.

Thus, the demand shock increases domestic inflation, but appreciates the currency, because the shock raises inflation rates in both countries. This implies there is no trade effect through prices. To restore equilibrium, the exchange rate has to adjust. The central bank can either control inflation by tightening monetary policy and accepting an appreciation of the currency, or it can let inflation rise and prevent the currency from appreciating.

4 Model results and discussion

Having constructed a theoretical model to capture the qualitative effects of various shocks on interest rates, inflation, output and the exchange rate in a two-country world, we now estimate a VAR system to examine the relative importance of the underlying structural shocks as implied by the model. Since monetary policy target variables are dependent on policy decisions, they create simultaneous equation bias when a policy variable is regressed on targets. To alleviate this, we use a VAR procedure whereby, in the system we include the "domestic" variables interest rate r, inflation rate π and output y. The complete two-country model also includes the domestic variables of the "foreign" country.[18] For foreign variables, we use the foreign interest rate, r^*, the foreign inflation rate π^* and foreign output y^*. Finally, we include exchange rate s. In the VAR system, all variables are endogenous. One particularly useful interpretation of the VAR here is that it incorporates a monetary policy rule or a reaction function in the form of an interest rate rule, whereby US interest rates respond to changes in the other variables in the VAR. Since the VAR residuals are (linear) combinations of underlying structural shocks of the type present in the theoretical model introduced earlier, US interest rates (as well as all other VAR variables) basically respond to these underlying shocks. Thus, the VAR system to be estimated takes the form

$$X_t = a + \sum_{i=1}^{3} B_i X_{t-i} + u_t \tag{22}$$

where X_t is a 7x1 vector including the variables listed above, a is the constant vector of constants of order 7x1, B_i is a 7x7 coefficient matrix for the lagged values of X_t, and u_t is the error term vector of order 7x1. All variables are logarithmic differences except the interest rates, which are differences, but not logarithms. We test the period 1980–1996 using monthly data and defining the lag structure for three

[18] For a similar test, see Galí (1992).

months. Aside from the interest rates taken from the BIS, the data are taken from IFS tapes provided by the IMF. The interest rates are one-month inter-bank offer rates,[19] inflation rates are calculated from CPI data and output is represented by industrial production series. The exchange rate is the monthly average for the DEM/USD spot rate. Standard tests were done on the time series properties of the data; the results are reported in the Appendix.

4.1 Results

The results are reported in Tables 4.1 and 4.2. Table 4.1 displays t-values for the individual lags of the variables, and Table 4.2 reports F-statistics for the groups of lags for each variable. Figures 4.1–4.7 show the impulse response functions[20] for each of the variables. Tables presenting the variance decompositions are found in the appendix. The results are summarized and contrasted with the theoretical results from Chapter 3 in Table 4.3. Tables displaying the decomposition of variance also appear in the appendix. Sections 4.1.1 through 4.1.4 present the results verbally.

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[19] Conceptually, the ideal interest rate to use as a measure of the stance of monetary policy would be the official interest rate at which marginal financing is provided to the banking system. Unfortunately, it is impractical to pursue this approach for several reasons. As Gerlach & Smets (1995) point out, central banks typically provide financing using a number of different interest rates, which makes it difficult to choose "the" representative rate. Further, the exact interest rate that is relevant has changed over time in many countries in response to major developments in central bank monetary operating techniques. Central banks may also alter the stance of monetary policy without changing official interest rates, for instance by varying the availability of credit at official rates. Cochrane (1994), for example, has tested the one-month Treasury Bill rate as well as the Federal Funds rate and come to the conclusion that the results are almost identical. Thus, since market-determined interest rates typically respond very quickly to changes in monetary irrespective of whether they are expressed by a change in an official interest rate or by a change in the availability of credit, we use one-month interest rates as measures of the stance of the policy.

[20] Hamilton (1994) provides a lively discussion of the mathematics of impulse response functions.

Table 4.1 **t-values of VAR coefficients (equation 22)**

t-values	US interest rate	US inflation	US production	Exchange rate DEM/USD	German interest rate	German inflation	German production
INTUS	**3.32**	1.78	1.08	**1.95**	**-2.25**	0.26	0.29
	-1.16	0.06	**2.56**	0.16	0.63	0.93	0.50
	0.66	0.08	0.31	0.92	-1.04	**-1.92**	0.87
INFUS	**2.69**	**4.66**	**2.24**	1.09	**3.43**	1.45	0.77
	-0.69	**-1.81**	-1.05	**-1.96**	-0.19	-1.06	-0.64
	0.82	-1.28	-0.36	1.33	1.62	**1.91**	0.05
PRODUS	0.88	1.33	1.22	**3.18**	-0.62	-0.03	1.21
	0.32	-1.54	1.24	-0.20	-1.52	0.40	-0.05
	-0.79	-0.47	**2.25**	0.72	-0.91	-0.74	0.72
EXR	**-1.84**	-1.02	**-2.27**	**4.60**	-0.63	-0.63	**3.48**
	0.63	**2.02**	0.88	-0.08	-0.96	0.21	0.75
	-0.48	-0.65	0.66	1.17	-1.58	1.03	-1.04
INTG	0.49	-0.96	-0.25	1.34	-1.23	0.15	1.26
	-1.14	**2.77**	0.69	**2.31**	**2.77**	0.97	1.02
	1.06	0.55	-0.15	-1.41	1.33	-1.41	0.03
INFG	1.58	0.12	0.45	**2.04**	**1.80**	**2.67**	-0.20
	-0.10	-1.15	0.61	0.09	0.58	0.03	-1.23
	-0.94	-0.45	-0.55	0.26	0.69	1.69	-1.11
PRODG	-0.69	-0.17	-0.19	0.37	1.42	-0.36	**-5.94**
	-0.26	1.68	0.23	-0.74	0.58	-1.43	-1.46
	0.62	-0.30	0.02	0.21	-1.54	0.98	-0.02

Significant values (at 10 % level) are bold.

Table 4.2

F-statistics for VAR variables (equation 22)

t-values	US interest rate	US inflation	US production	Exchange rate DEM/USD	German interest rate	German inflation	German production
INTUS	3.72*	1.21	3.06*	1.67	2.60*	1.34	0.72
INFUS	2.57*	8.75*	1.89	1.62	5.77*	2.04	0.66
PRODUS	0.55	1.48	3.45*	4.04*	1.26	0.20	0.91
EXR	1.15	1.41	1.92	8.92*	1.46	0.50	4.85*
INTG	0.62	3.67*	0.17	3.59*	3.62*	0.83	0.68
INFG	1.22	0.82	0.20	1.71	1.54	3.91*	0.67
PRODG	0.34	1.09	0.26	0.19	1.31	0.96	12.3*

Significant values (at 10 % level) are bold.

Table 4.3 **Comparison of empirical results with theoretical model**

The effect of (↓) on (→)	US interest rate	US inflation rate	US production	DEM/USD exchange rate	German interest rate	German inflation rate	German production
Empirical effect of US interest rate	*	+	(–)	+	(0)	(0)	(0)
Theoretical effect of ϵ_s	+	+	–	+/–	+	+	+
Empirical effect of US inflation rate	(+)	*	(–)	–	+	–	(+)
Theoretical effect of ϵ_s	+	+	–	+/–	+	+	+
Empirical effect of US production	+	+	*	+	(–)	(–)	(0)
Theoretical effect of ϵ_E	+	+	+	–	+	–	–
Theoretical effect of ϵ_m^*	+	+	+	–	+	–	–
Empirical effect of DEM/USD exchange rate	–	–	–	*	+	+	(–)
Theoretical effect of ϵ_E	+	–	–	+	+	+	+
Theoretical effect of m	–	–	–	+	–	+	+
Empirical effect of German interest rate	–	+	(–)	(–)	*	+	(+)
Theoretical effect of ϵ_s^*	+	+	–	+/–	+	+	+
Empirical effect of German inflation	–	+	(0)	(+)	–	*	(–)
Theoretical effect of ϵ_s	+	+	+	+/–	+	+	–
Theoretical effect of ϵ_s^*	+	+	–	+/–	+	+	+
Theoretical effect of (ϵ_d^*)	+	+	+	–	+	+	+
Empirical effect of German production	(+)	(+)	(+)	+	(+)	(–)	*
Theoretical effect of ϵ_d	+	+	+	+	+	+	+

4.1.1 Analysing exchange rate changes

The decomposition of variance shows that 94.8 % of exchange rate variability is explained by innovations the exchange rate itself. Within a year, the share falls to 82 %. The second most important component in explaining variation in the exchange rate is German production, with its share rising to 6.7 %. The roles of the interest rates are such that the US interest rate explains 2.7 % and the German interest rate 1.4 % of the variation in the exchange rate. For the inflation rates, in turn, the variance decomposition yields a share of 1.9 % for the US inflation rate and of 1 % for the German inflation rate. Hence, we see that volatility of the exchange rate is linked to the underlying fundamentals only weakly. Instead, exchange rate movements seem to be largely autonomous, which leaves room even for self-validating bubbles etc.

If we analyse the nature of exchange rate changes by their effects on other variables, we see (at least in Table 4.3) that they resemble "peso" or expectation shocks. The empirically obtained effects are qualitatively closest to the theoretically derived effects of an exchange rate expectation disturbance. In particular, we see that a positive exchange rate innovation, ie an appreciation of the USD, or a depreciation of the DEM, tends to slow inflation in the US and to increase inflation in Germany.

Like all financial markets, foreign exchange markets are sensitive to collective opinions. The report of the ECU Institute (1995) argues that prices on foreign exchange markets not only reflect average opinion, they are also important sources of information that shape opinion. Thus the processes at work are self-validating; prices are both starting points and outcomes that shape expectations. In other words, mimesis could be more influential than exogenous factors. This already makes argues strongly for exchange rate stabilization that can be achieved without causing problems in other variables.

On the other hand, the exchange rate must be seen to react rationally to changes in other variables. If we look at the effects of interest rate innovations, for instance, we see that an increase in the US interest rate tends to appreciate the USD, while a German interest rate increase appreciates the DEM. Moreover, an increase in the US inflation rate is associated with a depreciating USD, and an increase in the German inflation rate results in depreciation of the DEM. All these results are in accordance with the theoretical model.

Empirical evidence pointing to the same direction has been presented in Eichenbaum & Evans (1995). They have investigated the effects of shocks to US monetary policy on exchange rates. They found substantial evidence of a link between monetary policy and exchange rates: a contractionary shock to US monetary policy leads to a persistent and significant appreciation in the nominal exchange rate of the USD. Moreover, the maximal effect of such a monetary policy shock (ie an increase in the US interest rates) on the exchange rate is not contemporaneous; instead the USD continues to appreciate for a substantial period of time.

As to the real side of the economy, a positive production shock in the US tends to appreciate the USD, while a positive production shock in Germany depreciates the DEM. These results seem to suggest that the production shocks in the two countries are different from each other by nature.

4.1.2 Analysing inflation rate changes

In the US, shocks to the inflation rate itself mainly explain changes in inflation. As the decomposition of variance shows, 97.2 % of the variance is due to the inflation rate itself in the first month after the shock, and 77.9 % a year after the shock. The second most important factor is the German interest rate which, after a year from the shock, explains 7 % of the US inflation innovations. The US interest rate explains 4.3 % of changes in US inflation. The role of the exchange rate is explaining 3.4 % of US inflation. German inflation affects US inflation with a share of 2.7 %.

By comparing the empirical results with the theoretically derived effects of the various structural disturbances, we observe that US inflation shocks resemble or seem to be dominated by domestic (US) supply shocks. This conclusion mainly considers effects on the exchange rate and domestic production; it would be inconsistent with other sources, in particular demand shocks. Please recall that supply shocks were written in the model as autonomous changes in inflation expectations. Thus inflation shocks in the US tend to increase the inflation rate at home, and diminish it in Germany. The effect of supply shocks on the exchange rate is ambiguous from the standpoint of theory, but here we can see that a positive inflation shock in the US causes the USD to depreciate and the DEM to appreciate. Such a result would seem to rule out demand shocks as the primary mover of inflation, and instead imply that, in principle, the need for anti-inflationary policy should generally coincide with a weak currency.

The volatility in the German inflation rate is explained mainly by its own innovations: up to 94.6 % of the variance immediately after the shock and up to 83 % after a year from the shock. The second most important factor affecting the German inflation is the exchange rate with a share of 5.7 % a year after the shock. The variance decomposition further yields a share of 1 % for the US inflation rate, and 2 % and 2.8 % for the German and US interest rates, respectively.

Judging from the effects on the exchange rate and domestic output, German inflation shocks also resemble domestic supply shocks. However, the empirical results are such that it is difficult to identify a single type of shock that could unambiguously be identified with the German inflation impulses. An increase in the German inflation tends to appreciate the USD and to depreciate the DEM. This also has a weak, dampening effect on economic activity. The conclusions with regard to policy conflicts are thus similar to the US case.

4.1.3 Analysing interest rate changes

In both countries, up to 71.4 % of interest rate changes are explained by innovations in the interest rate itself. In the US, the second most important factor affecting the interest rate is production. Its share is 9.3 %. The share of the inflation rate is 2.8 % and that of the exchange rate 4.0 %. In Germany, the second most important factor is the US inflation rate; it explains 5.3 % of the innovations in the German interest rate. The shares of the exchange rate and the domestic inflation rate are 5.3 % and 2.8 %, respectively.

Strangely enough, an increase in the US interest rate tends to accelerate both the US inflation rate and the German inflation rate. The result that a rise of the domestic interest rate causes an increase of the inflation rate comes out significantly both in the US and in Germany. This anomalous outcome has also been obtained in other (empirical) studies. Eichenbaum (1992), Sims (1992) and Cochrane (1994), for example, obtain the result that the price level rises for over two years after a contractionary monetary policy shock.[21] The positive correlation between the interest rate and the inflation rate is known as a price puzzle, a phenomenon of prices tending to increase temporarily after a contractionary monetary policy shock. This finding is typically explained as a reaction to the central bank's raising of interest rates in response to inflation expectations.

[21] Sims & Zhou (1994) and Christiano et al. (1996) avoid this in their studies by assuming that the monetary authority responds to commodity prices in setting monetary policy.

4.1.4 Factors affecting the real side of the economy

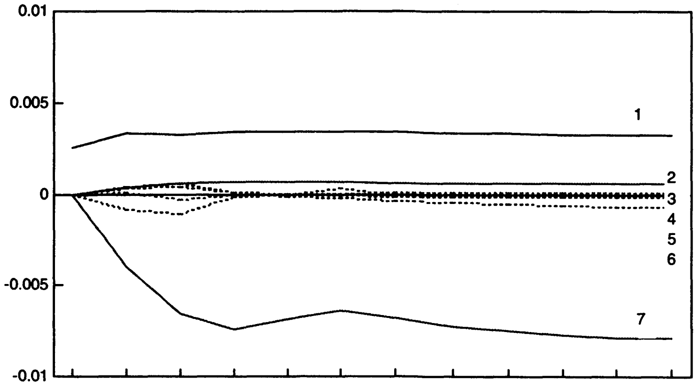
In the US, production shocks are mostly due to innovations in production itself. After the first month, 92.8 % are explained by past values of the production. The share then falls to 75.5 % a year after the shock. In Germany, the share of the production itself in explaining changes in the German production is 91.5 % after the first month after the shock, and still 84.2 % a year after the shock. The second most important component is the German inflation rate with a share reaching up to 2.5 % a year after the shock.

In the US, the real side of the economy seems to be mainly affected by exchange rate shocks, and possibly by foreign money demand shocks. In Germany, innovations in production resemble domestic demand shocks. Both kinds of shocks either appreciate the domestic currency and slow domestic inflation, or vice versa. Thus , both can be easily controlled through monetary policy, the effects of which are even stabilizing on the foreign country.

Other studies offer a rich blend of explanations. Blanchard & Quah (1989), for example, attribute virtually all short-term output variability in the US to demand shocks, while Galí (1992) finds that supply shocks dominate over all horizons. Gerlach & Smets (1995) note that aggregate demand shocks play a critical role in accounting for changes in output.

In other empirical studies, domestic supply shocks have been found to dominate in Germany. Mélitz and Weber (1996) tested the effects of demand versus supply shocks on output, inflation and the current account in Germany. They found; first, that supply shocks account for virtually all the variability of output in the long run; and second, that money supply shocks exert no significant impact on either inflation or output. They argue that this is due Germany's steady and predictable conduct of monetary policy. Gerlach & Smets (1995) also found in their empirical study of the monetary transmission mechanism that discretionary shifts in German monetary policy play only a very limited role in determining recent output and price developments.

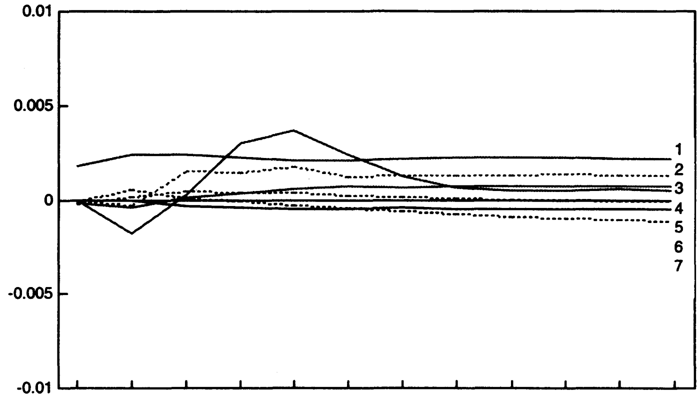
Figure 4.1 **The effects of the US interest rate shock**



1 US interest rate
2 US inflation rate
3 German interest rate
4 German production
5 German inflation rate
6 US production
7 Exchange rate (USD/DEM)

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

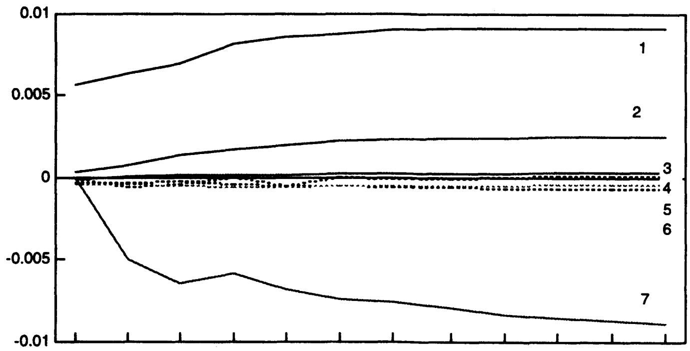
Figure 4.2 **The effects of US inflation shock**



1 US inflation rate
2 German production
3 German interest rate
4 Exchange rate (USD/DEM)
5 US interest rate
6 German inflation rate
7 US production

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

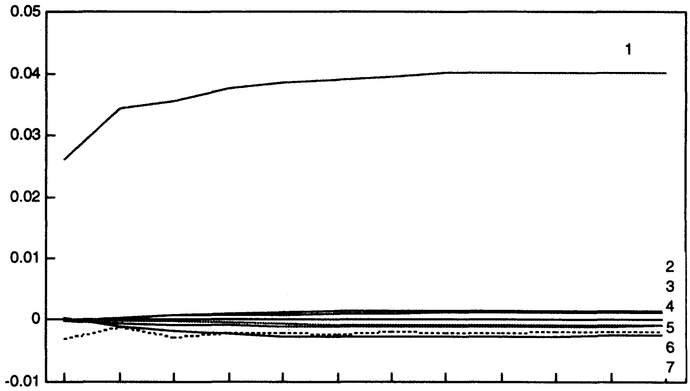
Figure 4.3 **The effects of US production shock**



1 US production
2 US interest rate
3 US inflation rate
4 German production
5 German interest rate
6 German inflation rate
7 Exchange rate (USD/DEM)

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

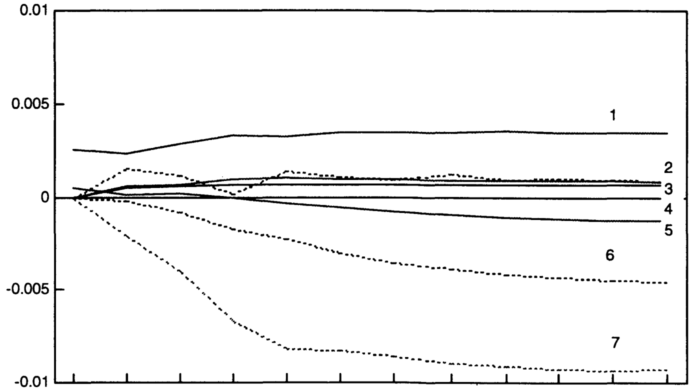
Figure 4.4 **The effects of the exchange rate shock (DEM/USD)**



1 Exchange rate (DEM/USD)
2 German inflation rate
3 German interest rate
4 US inflation rate
5 US interest rate
6 German production
7 US production

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

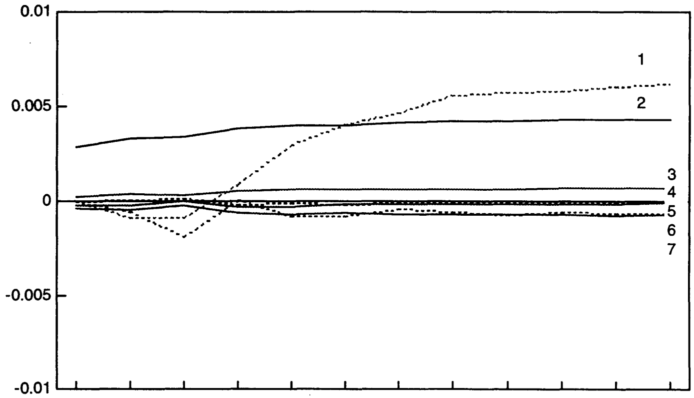
Figure 4.5 **The effects of German interest rate shock**



1 German interest rate
2 German production
3 US inflation rate
4 German inflation rate
5 US interest rate
6 US production
7 Exchange rate (DEM/USD)

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

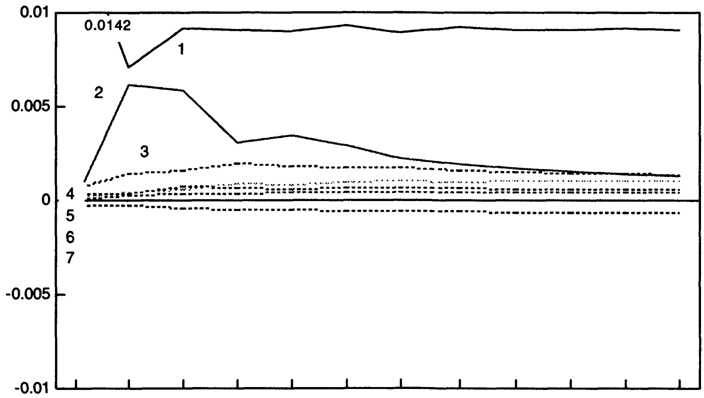
Figure 4.6 **The effects of German inflation rate shock**



1 Exchange rate (DEM/USD)
2 German inflation rate
3 US inflation rate
4 US production
5 German interest rate
6 German production
7 US interest rate

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

Figure 4.7 **The effects of German production**



1 German production
2 Exchange rate (DEM/USD)
3 US production
4 US interest rate
5 German interest rate
6 US inflation rate
7 German inflation rate

Continuous lines indicate cases where the variable in question has a significant (at 10 % level) coefficient.

4.2 Policy discussion

In the empirical analysis presented above, we have seen that supply shocks seem to dominate in explaining changes in inflation. Managing a supply shock by means of monetary policy is a potential source of tensions, because the effect on the exchange rate is ambiguous. Here, the empirical results indicate that the domestic currency depreciates and the inflation rate rises as a consequence of a supply shock. There is no trade-off for the central bank in stabilizing both the inflation rate and the exchange rate. This empirical result is valid both for the US and Germany. From the theoretical model, we know that supply shocks depreciate the domestic currency. This is further confirmed empirically, implying that a monetary policy aimed at stabilizing the inflation rate, simultaneously stabilizes the exchange rate. A tightening monetary policy action raises the interest rate. A capital inflow arises and the exchange rate appreciates. That, in turn, diminishes inflationary pressures in the domestic economy.

This behaviour is contingent on the assumption that exchange rate movements are induced by inflation shocks. However, as the empirical results show, exchange rate volatility stems almost totally from the foreign exchange markets. Thus, the only way for the central bank to stabilize the exchange rate is to concentrate monetary policy on following the exchange rate and intervening in the foreign exchange markets. However, if the *only* way to achieve exchange rate stability is to concentrate totally on the exchange rate, then there is the possibility that the cost of exchange rate stability is domestic price instability. The explanatory power of demand shocks in determining inflation and exchange rate developments seems to be very weak. Instead, the dominating factors, ie supply shocks and exchange rate shocks, produce qualitatively similar effects on the exchange rate and inflation. If, despite exchange rate stabilization, exchange rate expectations continue to be volatile, this can be transmitted through interest rates into the domestic economy. On the other hand, the fact that exchange rate stability is a policy target can diminish the volatility of expectations if a successful policy increases the certainty that the spot exchange rate deviates from the target rate only little, rarely, and randomly.

This leaves us with the question of exchange rate management.[22] Once EMU is established, there will be two large economies as in the theoretical model in the present study. The empirical findings could be expected to appear in a more pronounced manner than here, where only German and not EU-wide data are applied. If the main source behind variations in the inflation rate continue to be supply shocks, the country where the inflation variation originally stems from can try to stabilize both domestic inflation and the exchange rate. The other country, on the other hand, face the situation of an appreciating currency and rising domestic prices. Given that a domestic demand shock or, alternatively, a supply shock occurring in the US, may be the source of a monetary policy conflict in Germany, monetary policy coordination could be in Germany's interest. From the German point of view, it may be wise to let the US tackle exchange rate stabilization while Germany concentrates on controlling domestic prices. The next question is whether the US would have any special reasons itself to participate a coordinated exchange policy.

Clearly, achieving long-term exchange rate stability, or avoiding major long-run swings between the USD and the DEM would require

[22] An excellent non-technical discussion on the possible future exchange rate arrangements is provided in Corden (1994). The prospects with special regard to EMU have been analyzed carefully in the report of the ECU Institute (1995).

that monetary policy objectives and the policies to achieve these targets were broadly similar. Considering that the exchange rate reacts to changes in money supplies, monetary policy cooperation would probably be more fruitful than unilateral attempts by one of the central banks to influence the exchange rate. An expansion in one country could be followed by an expansion in the other country, so that the effect on the exchange rate would be zero (as an expectation at least). Since shifts in expectations could, in principle, be counteracted with well defined optimal monetary policy coordination, exchange rate volatility could also be expected to diminish. Considering the empirical result obtained in Gerlach & Smets (1995) that showed that the effects of a standardized monetary policy tightening on output and inflation are very similar in Germany and the US, we can infer that long-run exchange rate stability is possible. Indeed, the US has participated in coordinated interventions on occasion, but no interest in more formal monetary policy cooperation has ever been shown.[23] Corden (1994) notes that, although at times the US has decided to play in concert, the US authorities have felt completely free to manage monetary policy in the light of domestic conditions as they perceived them without seeing much need to consider possible exchange rate effects. For two-way monetary cooperation to be feasible, US policymakers should feel they have some self-interest in exchange rate stabilization.

Even given a mutual willingness to cooperate, cross-border exchange rate management may prove difficult. The major part of the variation of the exchange rate is autonomous – over 90 % of the exchange rate variation is explained by shocks to itself. As argued in the report of the ECU Institute (1995), full financial liberalization increases the substitutability between currencies, so it follows that exchange rates, given market perceptions on future policy, may become increasingly unstable as they become increasingly dependent on the interplay of expectations, policy and fundamentals. One can even envision a situation where the exchange rate is less dependent on economic fundamentals – the basis of traditional models of exchange rate determination – than policy.

What do these results possibly indicate for the future European Central Bank (ECB)? Certainly, conclusions about past or present experience do not necessarily apply in the future. The rise of EMU will most certainly involve structural changes that invalidate our present models. Still, here we can speculate about the interaction between the US and EMU area from the current results. Assuming that US supply

[23] See eg Corden (1994) for an overview on US monetary policy.

shocks result in a monetary policy conflict on the European side, the ECB has reason to avoid international exchange rate cooperation. In response, the ECB could leave the job of stabilizing the exchange rate to the US, and concentrate on stabilizing inflation within EMU.[24] Thus, we see that because of the n-1 problem, simultaneous attempts to stabilize the exchange rate and the domestic inflation rate is not possible. The solution will involve either an asymmetric international monetary system where one country dominates or monetary policy coordination.

5 Summary

This study examines stabilization aspects of monetary policy in the case of two large economies both issuing a major international currency. We start from an assumption that once EMU is established, the international monetary system will become strongly bipolar with the USD and the EUR as the major currencies. First, we review the characteristics of an international currency and briefly discuss the possibilities of the EUR to become a key currency. Next we present arguments as to why a central bank might be interested in stabilizing both inflation and the exchange rate. Excessive exchange rate volatility, when not a reflection of actual underlying problems, might give false signals to policymakers and private agents, and thereby encourage them to take inappropriate measures. Given a motivation to control exchange rate movements, we then ask whether actions to reach such a goal conflict with actions done in the pursuit of price stability, and if so, are such conflicts related to the type of shock hitting the economy.

An IS-LM-AS model is constructed to analyse the international transmission of various shocks. Certain situations are identified where the central bank faces a trade-off in its pursuit of internal or external target. These typically occur where domestic demand shocks dominate, and may occur when supply shocks dominate with the money market effect dominating over the trade effect, so that the exchange rate

[24] This is in accordance with the argument that since the ECB's primary objective is price stability it will concentrate on domestic issues. The report of the ECU Institute (1995) argues than due to this, the ECB will be reluctant to engage in any initiative to stabilize exchange rates. The ECB will instinctively aim for a minimum of commitments vis-à-vis third countries, particularly in the early years of its existence as it tries to build up its reputation for independence and for achieving low inflation.

appreciates under inflationary impulses from other shocks. The latter seems to be less worrisome as it has the same qualitative effect on prices and the domestic currency.

To identify the potential trade-off situations for monetary policy of the current major-currency central banks for the period 1983–1996, we estimate a VAR system to find out what disturbances may dominate observed changes in interest rates, inflation rates and output in both countries, as well as changes in the exchange rate.

The results indicate that the inflation rate seems to be driven by domestic supply shocks in both countries. Theoretically, the effect of a supply shock on the exchange rate is ambiguous. The empirical results suggest that US output shocks, most likely supply shocks, tend to increase the price level and to depreciate the USD. Since the price level also increases in Germany, it implies that Germany could face a combination of higher inflation and an appreciating currency. Conversely, in the US it is irrelevant whether monetary policy is directed to stabilize inflation or the exchange rate, because domestically any policy action directed to stabilize one target variable, also stabilizes the other. From the German (European) point of view, however, the exchange rate is destabilized. Hence, if the initial source of the disturbance is a US supply shock, the European side can stabilize the exchange rate only through sacrificing domestic price stability. Alternatively, the European side has to accept the destabilizing effect on the exchange rate while maintaining domestic price stability.

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Appendix

Table A.1 **Variance decomposition of US interest rate**

Month	INTUS	INFUS	PRODUS	EXR	INTG	INFG	PRODG
1	90.32	0.38	1.64	0.65	3.23	2.13	1.66
2	84.01	1.98	3.11	3.25	4.29	1.89	1.47
3	77.49	2.60	7.11	4.17	4.07	2.32	2.24
4	74.81	2.51	8.25	4.02	4.63	3.58	2.20
5	73.40	2.48	8.87	3.97	5.49	3.58	2.20
6	72.55	2.61	9.19	3.97	5.89	3.59	2.20
7	72.05	2.71	9.23	3.94	6.25	3.63	2.19
8	71.75	2.73	9.27	3.93	6.51	3.63	2.19
9	71.57	2.74	9.26	3.92	6.70	3.62	2.19
10	71.49	2.75	9.26	3.93	6.78	3.61	2.19
11	71.43	2.76	9.25	3.94	6.82	3.61	2.19
12	71.41	2.76	9.25	3.95	6.84	3.61	2.19

Table A.2 **Variance decomposition of US inflation**

Month	INTUS	INFUS	PRODUS	EXR	INTG	INFG	PRODG
1	0	97.98	0.56	0.01	0	1.37	0.09
2	3.66	82.73	1.83	0.73	7.89	1.78	1.37
3	4.50	81.59	1.81	0.84	7.97	1.91	1.37
4	4.32	78.47	1.75	1.91	9.35	2.90	1.30
5	4.29	77.70	1.74	2.88	9.22	2.89	1.29
6	4.29	77.25	1.74	3.41	9.17	2.87	1.28
7	4.31	77.16	1.75	3.48	9.15	2.87	1.28
8	4.30	77.10	1.76	3.49	9.20	2.86	1.28
9	4.30	77.07	1.76	3.50	9.21	2.87	1.28
10	4.30	77.06	1.76	3.50	9.21	2.88	1.28
11	4.30	77.05	1.76	3.51	9.22	2.88	1.28
12	4.30	77.04	1.76	3.51	9.22	2.88	1.28

Table A.3 **Variance decomposition of US production**

Month	INTUS	INFUS	PRODUS	EXR	INTG	INFG	PRODG
1	0	0	98.20	0	0	0	1.80
2	0.47	1.01	90.21	6.10	0.13	0	2.09
3	0.54	1.58	87.58	7.15	1.09	0.05	2.00
4	1.04	1.52	84.88	7.17	2.86	0.38	2.15
5	1.12	1.57	83.58	7.40	3.61	0.40	2.33
6	1.13	1.62	82.44	7.29	4.83	0.39	2.30
7	1.16	1.66	81.85	7.23	5.42	0.40	2.28
8	1.19	1.71	81.55	7.20	5.65	0.40	2.31
9	1.20	1.76	81.30	7.19	5.84	0.40	2.31
10	1.21	1.79	81.18	7.19	5.92	0.40	2.32
11	1.21	1.80	81.13	7.20	5.94	0.40	2.32
12	1.22	1.80	81.09	7.20	5.96	0.40	2.32

Table A.4 **Variance decomposition of DEM/US exchange rate**

Month	INTUS	INFUS	PRODUS	EXR	INTG	INFG	PRODG
1	0	0	0.02	95.75	0	0	4.23
2	1.83	0.38	3.17	88.31	0.52	0.09	5.69
3	2.61	0.89	3.37	86.52	0.92	0.09	5.61
4	2.60	1.68	3.30	83.72	1.73	0.43	6.55
5	2.61	1.71	3.37	82.95	1.95	0.93	6.49
6	2.63	1.89	3.40	82.61	1.95	1.04	6.49
7	2.64	2.02	3.39	82.37	1.95	1.09	6.55
8	2.65	2.05	3.40	82.21	1.96	1.17	6.55
9	2.66	2.06	3.42	82.18	1.96	1.17	6.56
10	2.66	2.06	3.42	82.16	1.97	1.17	6.56
11	2.67	2.06	3.42	82.15	1.97	1.18	6.56
12	2.67	2.06	3.43	82.15	1.97	1.18	6.56

Table A.5 **Variance decomposition of German interest rate**

Month	INTUS	INFUS	PRODUS	EXR	INTG	INFG	PRODG
1	0	0.50	1.91	0.02	95.59	1.15	0.84
2	0.16	0.98	1.85	1.17	93.39	1.12	1.34
3	1.59	4.37	1.80	5.06	84.41	1.58	1.19
4	2.10	4.62	1.75	4.80	82.17	2.49	2.09
5	2.10	5.23	1.76	4.84	81.45	2.46	2.16
6	2.07	5.32	1.74	5.09	80.84	2.76	2.17
7	2.25	5.32	1.73	5.13	80.56	2.78	2.22
8	2.25	5.32	1.74	5.22	80.45	2.78	2.24
9	2.25	5.31	1.74	5.27	80.38	2.81	2.24
10	2.25	5.31	1.74	5.29	80.36	2.81	2.24
11	2.25	5.31	1.75	5.29	80.35	2.81	2.24
12	2.25	5.31	1.75	5.29	80.35	2.81	2.24

Table A.6 **Variance decomposition of German inflation**

Month	INTUS	INFUS	PRODUS	EXR	INTG	INFG	PRODG
1	0	0	0.69	0.45	0	98.38	0.49
2	1.50	0.01	0.67	2.74	2.66	91.86	0.55
3	1.59	0.96	0.75	4.48	2.71	88.50	1.01
4	2.62	1.01	0.98	5.16	2.61	86.23	1.40
5	2.69	1.05	1.00	5.44	2.60	85.83	1.39
6	2.72	1.05	1.01	5.56	2.62	85.58	1.46
7	2.77	1.06	1.05	5.59	2.62	85.44	1.48
8	2.77	1.06	1.07	5.59	2.61	85.42	1.48
9	2.77	1.06	1.08	5.60	2.61	85.40	1.49
10	2.77	1.06	1.09	5.60	2.62	85.38	1.49
11	2.77	1.06	1.09	5.60	2.62	85.37	1.49
12	2.77	1.06	1.10	5.60	2.62	85.37	1.49

Table A.7 **Variance decomposition of US interest rate**

Month	INTUS	INFUS	PRODUS	EXR	INTG	INFG	PRODG
1	0	0	0	0	0	0	100
2	0.25	0.03	0.10	0.06	0.88	0.10	98.57
3	0.26	1.26	0.11	0.44	0.89	0.75	96.28
4	0.61	1.23	0.18	0.54	1.22	2.07	94.16
5	0.60	1.25	0.27	0.53	1.71	2.32	93.31
6	0.66	1.35	0.36	0.54	1.73	2.31	93.06
7	0.70	1.35	0.36	0.58	1.74	2.35	92.92
8	0.70	1.35	0.36	0.58	1.76	2.36	92.89
9	0.70	1.35	0.37	0.58	1.78	2.36	92.85
10	0.71	1.35	0.37	0.58	1.78	2.37	92.84
11	0.71	1.35	0.37	0.58	1.78	2.37	92.84
12	0.71	1.35	0.37	0.58	1.79	2.37	92.83

Table A.8 **Criterion for lags**

lags	1	2	3	4	5	6	7
Schwarz-Bayes criterion	-70.2	-69.3	-68.4	-67.4	-66.6	-65.7	-65.0

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