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Chapter 2

EMU, Monetary Policy Interactions and Exchange Rate Stability

Summary

EMU leads to the elimination of monetary policy coordination failures within the euro area. Whether this translates into more transatlantic exchange rate stability depends on the origin of economic shocks. Martin's (1997) conclusion that EMU will lead to more stable exchange rates is shown to hold for both symmetric and asymmetric shocks in Europe, but not for shocks that originate outside Europe. The results remain valid when taking into account that the pre-EMU era was characterised by a Bundesbank-led ERM, rather than a free float. Finally, the results are checked for a future expansion of the euro area.

2.1 Introduction

This paper considers the changes in monetary policy makers' incentives as a result of economic and monetary union (EMU) and studies their possible impact on exchange rate stability between the euro and the dollar.

Most of the existing literature predicts that the exchange rate volatility of the euro will be higher than that of the German mark. See, for instance, Alosgoufis and Portes (1997), Coeuré and Pisani-Ferry (1999), Demertzis and Hughes Hallet (1998), McCauley (1997).\(^1\) These papers basically make two intuitive points that are related to the fact that the euro area is relatively closed when compared to the individual participating

\(^1\)Some other studies are inconclusive: Begg, Giavazzi and Wyplosz (1997), Cohen (1997), Masson and Turtelboom (1997).
countries. The first point is that the ECB will give priority to internal price stability over the external value of the euro. Therefore, EMU may lead to benign neglect of the exchange rate in Europe, which could lead to higher exchange rate volatility than before. The second point is that the external adjustment channel has become narrower and a larger exchange rate adjustment is required to restore internal price stability after a shock (Krugman, 1989, Hau, 2000).

A study by Martin (1997) is interesting in that it concludes that exchange rate volatility is likely to decline when compared to a situation of floating rates. Martin uses a simple two-country model with random supply shocks, which stresses that the incentive to conduct an active exchange rate policy is related to relative country size. He interprets the creation of the euro as implying a change in the relative size of the players (monetary authorities) and concludes that a more symmetric system (in terms of size) will have a more stable exchange rate. The intuition is that when one country is smaller than the other, this country will have a stronger incentive to strategically use its exchange rate to stabilise its economy (unless this country is extremely small, in which case it should try to keep its exchange rate constant at all times).

This paper differs from Martin (1997) in several respects. First, it stresses the importance of the internalisation of monetary policy spill-overs within the euro area as a result of EMU. The intuition behind this point will be discussed below. A second aspect not addressed by Martin is that EMU involves monetary cooperation between only a subset of all central banks in the world. The possible relevance of this aspect is illustrated by a classic article on the internalisation of externalities by Rogoff (1985a), who shows that cooperation between two players in a three-player game may be counterproductive (i.e. welfare-decreasing).

I extend Martin’s model to a three-country version in order to address the internalisation of externalities between two countries (Germany and France) in the presence of a third country (the United States). A three-country model also allows me to look explicitly at the impact of asymmetric shocks in the euro area on exchange rate stability. Following Martin (1997), I use a simple model with Lucas supply curves. Nominal wage are set before monetary policy is determined. Policy makers are assumed to have an output target which does not exceed the natural rate. This means that the time-inconsistency problem does not arise. Taking an output target above the natural rate

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2Rogoff proves this by giving an example where cooperation between central banks exacerbates the credibility problem of central banks vis-à-vis the private sector. In his example, international monetary cooperation raises the rate of wage inflation because wage setters recognise that a non-cooperative regime contains a built-in check on each central bank’s incentives to inflate. Cooperation may remove this disincentive to inflate, so that the central bank’s credibility deteriorates.
(thus taking the time-inconsistency problem on board) would not affect the main results of this paper.

This chapter focuses on supply shocks, because supply shocks pose a bigger dilemma for central banks in terms of the trade-off between inflation and output than demand shocks. In the case of demand shocks, a monetary policy that aims at price stability automatically dampens output fluctuations. In the case of supply shocks, prices and output are negatively correlated, so that a monetary policy geared at short-run price stability could adversely affect the output gap. The bigger monetary policy dilemma means that supply shocks are the more interesting case. Moreover, Bayoumi and Eichengreen (1993) find empirically that international spill-overs on the demand side are unimportant when compared to spill-overs on the supply side. Examples of negative supply shocks are oil price shocks, adverse weather conditions and a credit crunch. Examples of positive supply shocks include technological innovation and deregulation of product and labour markets.

The modeling framework is as follows. Firms are supposed to decide in which country production will be located based on relative real wage levels. I implicitly assume that the choice of location is not affected by other considerations, such as the availability of well-educated workers, the quality of physical infrastructure and the corporate tax level in each country. Moreover, I implicitly assume that production can be relocated at zero costs. These are arguably strong assumptions, but they stress the importance of labour costs compared to other corporate costs and they serve to keep the analysis tractable algebraically.\(^3\)

The results are as follows. Surprise inflation reduces the real wage rate and attracts jobs from abroad, which gives central bankers an incentive to inflate. They correctly anticipate that other central banks do the same, but they cannot coordinate. Therefore, inflation is overly responsive to supply shocks. EMU enables European monetary policy makers to commit to each other that they will conduct a certain policy. Full monetary policy coordination takes place by the Governing Council of the ECB, where the externalities involved in unduly fierce policy responses are internalised. The ECB will keep inflation closer to zero than the national central banks in Europe did before. The reason is not that the ECB is more inflation averse, but that the participating central banks have become able to coordinate their policies.

\(^3\)The mechanism described in the text is probably more realistic for multinational firms than for nationally operating companies. Multinationals are better able to let countries compete to be the most attractive business location. Also, labour intensive firms tend to relocate more easily than capital intensive firms. See Pennings and Sleuwaegen (2000) for an exploration of the determinants of international corporate relocation.
The more moderate response of euro area inflation to supply shocks under EMU does not necessarily lead to more transatlantic exchange rate stability. It turns out that the consequences of EMU for exchange rate stability depend on the origin of the shock. This chapter looks at four different types of supply shocks: symmetric and asymmetric shocks in Europe, shocks in the US and worldwide shocks. In response to a negative (symmetric or asymmetric) supply shock in Europe, the more moderate inflation response of the ECB leads to more exchange rate stability indeed. But the situation is different for a supply shock in the United States. In response to a negative supply shock in the US, the Federal Reserve will engage in monetary easing. Before the start of EMU, the sensitivity of the national central banks in Europe to what happened in the United States caused them to ease their policy stance as well, which helped to dampen the resulting dollar depreciation. After the start of EMU, European monetary policy is conducted by the ECB, which is less inclined to let inflation move away from zero (see above). As a result, the Federal Reserve's monetary policy response to US shocks will cause a larger divergence of monetary policy stances across the Atlantic and will generate larger dollar-euro exchange rate movements than before the start of EMU. The results for a worldwide shock are ambiguous in general: they depend on the relative size of the two blocs.

Initially, I assume that before the start of EMU, the European currencies floated freely against each other. Next, I show that the conclusions remain valid when taking into account that, in fact, Europe used to have an exchange rate mechanism (ERM). The specification of the ERM accounts for the asymmetric character of the arrangement, in the sense that the Bundesbank had a leading role, whereas the other national central banks had an exchange rate target against the German mark. I also take into account the possibility of an ERM break-down. This increases the practical relevance of the conclusions.

I also conduct a sensitivity analysis with respect to an expansion of the euro area. This is likely to become relevant, given the foreseen enlargement of the European Union and the expected future participation of the new member states in the monetary union. Most of the results do not change. However, if the euro area were to become (significantly) larger than the US, the exchange rate may become more, not less, responsive to a symmetric worldwide shock after EMU, since in that case the US would obtain stronger incentives to actively use the exchange rate as an instrument. This size effect could ultimately dominate the mitigating impact of the internalisation of externalities in Europe as a result of EMU.

The remainder of this article is organised as follows. In the next section, I will relate this paper to the earlier literature on this subject. In Section 3, I specify a three-
country model. In Section 4, I derive optimal monetary policies for the European and US monetary authorities under floating rates, ERM and EMU and evaluate the consequences for exchange rate stability. Section 5 concludes.

2.2 Literature review

Previous research suggests several possible reasons why EMU may affect the exchange rate volatility of the euro (compared to the volatility of the German mark against non-EMU currencies before the start of EMU).

One possible reason is that EMU may change the structure of the euro area economy. Krugman (1993) predicts that increased specialisation will lead to more asymmetric shocks in Europe. On the other hand, Frankel and Rose (1998) argue that increasingly synchronised business cycles will reduce the relative importance of asymmetric shocks. The incidence of shocks in the euro area could have an impact on exchange rate stability against currencies outside the euro area.

It is too early to tell on the basis of empirical evidence which of the two explanations (regional specialisation and/or further economic integration) is right. However, EMU may affect exchange rate stability against currencies outside the euro area, even if the nature, size and frequency of economic shocks stays the same. The reason is that EMU is a new institutional setting, which has changed the rules for the conduct of monetary policy. Previous authors have pointed at three consequences of EMU which may affect the trade-offs to be made by monetary policymakers.

In the first place, as discussed in the introduction, the centralisation of monetary policy decision-making may contribute to the elimination of coordination failures within Europe. For instance, when a negative symmetric supply shock occurs in a floating exchange rate regime, monetary policy makers who care about employment have an incentive to increase the inflation rate in order to alleviate the output consequences of the shock (Canzoneri and Henderson, 1991). The action of each policy maker has a negative externality on the other countries, as a more accommodative policy stance aggravates the consequences of the initial shock in the other country. Theory predicts that monetary policy will overreact, leading to suboptimal outcomes in the absence of coordination.

Secondly, EMU reduces the number of players, as central bankers from the participating Member States now collectively determine monetary policy for the euro area in the Governing Council of the European Central Bank (ECB), which acts as a single entity. The European Commission (1997) argues that the smaller number of players will
facilitate policy coordination between the ECB and other major central banks, leading to more stable exchange rates. On the other hand, Aloskoufis and Portes (1997) and Begg et al. (1997) predict a move from a unipolar dollar-oriented world towards a bipolar system around the dollar and the euro and conclude that the emergence of a more symmetric international monetary system will lead to more instability.

A third consequence of EMU which may be of relevance for the conduct of monetary policy is that the policy domain of the ECB is the entire euro area, whereas the German Bundesbank used to be responsible for German price stability only. The Bundesbank was of course aware of the consequences of its policy in other countries that participated in the Exchange Rate Mechanism of the European Monetary System (ERM), but it is only natural that German national interests dominated in the end. The difference in policy domain is most important in the case of asymmetric shocks. Kenen (1997) argues that the ECB policies will usually mitigate asymmetric shocks, not aggravate them, as the Bundesbank sometimes did. The implication, although not stated explicitly by Kenen, seems to be that a larger policy domain leads to more exchange rate stability against the currencies of third countries.

My paper differs from the rest of the literature in a number of ways. First, it explicitly accounts for the fact that countries compete for economic activity and it incorporates the relative size of Europe and the US into the model. Ghironi and Giavazzi (1998) focus on country size in a similar manner, but they study a different question than I do. Moreover, their model is too complex to be solved analytically. Second, it studies the impact of European and non-European supply shocks. Bénassy-Quéré et al. (1997) present a three-country model which is much more richly specified than mine. They analyse the consequences of both supply and demand shocks in Europe, but they do not study the impact of foreign (i.e. non-European) shocks, as I do. Bénassy-Quéré et al. find that real exchange rate volatility vis-a-vis the dollar is likely to increase as a result of EMU. However, their results become less clear-cut when comparing ERM and EMU, rather than floating rates and EMU. They find that the impact of EMU on nominal exchange rate volatility is ambiguous. In the current paper, purchasing power parity is assumed to hold, rendering the model unsuitable for studying the real exchange rate. However, I find unambiguous results for nominal exchange rates, not only when comparing floating rates and EMU, but also when comparing ERM and EMU.

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4 They explore the issue of the optimal size of a currency area.
5 Bénassy-Quéré et al. find that lower exchange rate volatility may result when output stabilisation is included in the loss function of the monetary authorities, but argue that having exchange rate stabilisation in the loss function is a more appropriate description of the behaviour of the ECB.
2.3  The model

I will employ a static, single-period three-country model, in which strategic interaction among all central banks is explicitly modeled, following the Canzoneri and Henderson (1991) approach.

The model is analogous to Martin (1997). The world consists of three countries (Germany, France, United States, to be represented by country indices G, F and S, respectively). Each country produces a single good. Germany and France are of equal size (normalised to unity) and the United States has size $\alpha$, which is larger than 1. Size refers to the population of a country. Applying the size argument consistently would argue for making Germany more sensitive to US than to French real wage developments. I choose equal weights for reasons of algebraic simplicity. This amounts to assuming that each of the European countries is influenced as much by real wage changes in the US as by real wage changes in the other European country.\footnote{Other countries are not considered here. In practice, the non-participating EU countries (Denmark, Sweden, United Kingdom) may affect dollar-euro exchange rate stability and so may Japan (or other countries). Eichengreen and Ghironi (1999) focus on the relationship between the ‘core’ and ‘peripheral’ EU countries. Kawai (1997) discusses the international role of the Japanese yen. The most important possible future events would be the UK joining the monetary union and the EU accession and EMU participation of another large country, such as Poland. The impact of a possible future expansion of the monetary union is discussed in subsection 2.4.6.} Output per capita in the three countries is a function of the real wage levels at home and abroad. See Appendix A.

Workers choose the nominal wage. They do not observe either the general price level or country-specific shocks before setting wages. Workers attempt to minimise the expected square deviation of the real wage from the wage target, which is equal to zero. Substituting the optimal wage rule $(w_i = \pi_i^*)$ into the supply per capita functions yields\footnote{Using the weights which follow from country size only, that is using the equations derived in Appendix A, does not materially change the conclusions that I present further on in this article. My conclusion that exchange rate volatility after a worldwide shock under EMU is likely to be smaller than before, becomes somewhat stronger, in the sense that it holds for all $\alpha > 1$.}

\begin{align*}
  y_G &= \alpha (\pi_G - \pi_G^*) - \frac{\alpha}{2} (\pi_F - \pi_F^*) - \frac{\alpha}{2} (\pi_S - \pi_S^*) + \varepsilon_G, \\
  y_F &= -\frac{\alpha}{2} (\pi_G - \pi_G^*) + \alpha (\pi_F - \pi_F^*) - \frac{\alpha}{2} (\pi_S - \pi_S^*) + \varepsilon_F, \\
  y_S &= -\frac{1}{2} (\pi_G - \pi_G^*) - \frac{1}{2} (\pi_F - \pi_F^*) + (\pi_S - \pi_S^*) + \varepsilon_S.
\end{align*}

where $y_i$ is (the natural logarithm of) per capita output, $\pi_i$ is the inflation rate, $\pi_i^*$
is the inflation rate expected by workers at the time of wage formation, \( \varepsilon_i \) is a country-specific random supply shock and \( i \) is a country index.

Several observations can be made with respect to equations (2.1)-(2.3). In the first place, the amount of production in a country depends on unexpected inflation. Surprise inflation leads to more production. Secondly, relative country size (represented by the parameter \( \alpha \)) features in the equations, since supply per capita in small countries is more sensitive to surprise inflation abroad than supply per capita in large countries. If a firm decides to relocate production from a large country to a small one, the large country loses as much supply (in absolute terms) as the small country gains. Clearly, though, the relocation has a relatively large impact for the small country, which is reflected in the above equations for supply per capita.\(^9\)

Notice that the supply curve of an individual country has a positive slope. However, the slope of the world aggregate supply curve, given by \( y_G + y_F + \alpha y_S \), is actually vertical. It does not depend on the inflation rates. This characteristic is not too restrictive for our purposes, since I focus on the impact of monetary policy on the choice of location of production and not on the possibility that surprise inflation increases total world output. In a more general setting, the world aggregate supply curve would not be vertical, but it would still be steeper than the national supply curves. The intuition is that, when countries compete for employment, local surprise inflation in, say, Germany raises supply in Germany but reduces supply in France and the United States. The fact that the world supply curve in this model is vertical simplifies the algebra and does not qualitatively affect my results.

Monetary policy makers try to steer the economy so as to keep both inflation and the output gap close to zero. Their loss function is given by:

\[
L_i = \frac{1}{2} \left[ \pi_i^2 + \beta y_i^2 \right], \quad i = G, F, S, \tag{2.4}
\]

with \( y_i \) and \( \pi_i \) as above. More precisely, \( \pi_i \) is the deviation of the increase in the general price level from the target value, which we normalise to zero, and \( y_i \) is the deviation of per capita output from the socially optimal level, which we normalise to zero as well.\(^10\)

Note that there is no time-inconsistency problem in this model, because the output

\(^9\)One may notice that if \( \alpha \) goes to infinity, the impact of relative wages on output in the largest country \( (y_G) \) does not go to zero. However, it becomes negligible in relative terms \( (\frac{y_G}{y_F} \to 0) \), in line with what one would intuitively expect.

\(^10\)The loss function comes close to the trade-off which the Federal Reserve is supposed to make. It can also be interpreted as the trade-off for the ECB between sticking to the goal of price stability as defined in the EU Treaty and giving in to more short-term oriented goals that politicians may press for.
target of policy makers is not above its natural rate. The parameter $\beta > 0$ represents the relative weight attached to the output objective by the policy maker. Clarida et al. (1998) empirically find that the monetary policy reaction functions for the US, Japan and the largest European countries are quite similar. This suggests that it is not unreasonable to assume that $\beta$ is equal for all the central banks in this model.\footnote{This conclusion cannot be transposed directly to the ECB, since the Lucas critique may apply in the case of such a fundamental regime change as EMU. The ECB may be either more or less conservative (have another value of $\beta$) than the participating national central banks used to be. However, the fact that the EU Treaty (and the ECB statutes) was negotiated by the governments of the participating member states and that the governor of each national central bank has one vote in the ECB governing council supports our assumption that the ECB's conservativeness should be the average of the participating countries and that a different monetary policy behaviour should be explained by changes in the interaction between the players (central banks), as analysed in this paper.}

Central banks set policy in a discretionary manner. Each central bank chooses the price level in its own country, over which it has full control. Central banks know the supply per capita functions and observe wages and country-specific supply shocks before setting monetary policy. They can use the price level as an instrument to influence the real wage level, which in turn affects the level of output.

Thus, in all cases, the timing of events and actions is as follows. First, private inflation expectations are formed. Secondly, wages are set by the unions, which endeavour to stabilise expected real wages. Third, supply shocks occur. Fourth, inflation is set by the central banks, which minimise their expected loss. Finally, output is set by firms which choose production locations in order to maximise profits.

### 2.4 Monetary policy and the exchange rate

In this section, I will explore the response of the exchange rate to several types of shocks. I will discuss the outcome of the model in three different situations (floating rates, ERM, EMU). These situations only differ in the degree of coordination between European national central banks. In all cases, there is no monetary coordination between Europe and the US. Under floating rates, all central banks play Nash. Under ERM, the Bundesbank (Buba) and the Federal Reserve (simultaneously) move first and are followed by the Banque de France. Both the Buba and the Fed act as a Stackelberg leader versus the Banque de France, while they play Nash against each other. Under EMU, both central banks in Europe act as one decision maker (ECB), which again plays Nash against the Federal Reserve.

First, I will compare the outcomes under floating rates and EMU. Then I will compare...
ERM and EMU. The first comparison is the simpler one; the second comparison allows me to see if the conclusions with respect to the impact of the start of EMU on exchange rate stability between Germany/Europe and the United States can be maintained under a more realistic scenario.

I make the simplifying assumption that purchasing power parity (PPP) holds. In practice, sizeable and long-lasting deviations from PPP occur due, for instance, to the presence of non-tradable goods and the fact that the short-run effects of monetary expansion tend to be dominated by the reaction of financial markets (i.e. arbitrage in financial assets) rather than by goods market arbitrage. A more realistic approach would be to distinguish between tradable and non-tradable goods and/or between short-run and long-run effects of monetary policy. However, this would complicate the analysis considerably.

I will initially assume that the euro area is not larger than the United States ($\alpha \geq 2$). Later on, in subsection 2.4.6, I will consider the possibility that the euro area is larger than the US ($\alpha < 2$). This may become relevant when new countries join EMU after expansion of the European Union towards the East. Throughout the paper I will maintain the assumption that the US is larger than any of the two regions forming the euro area (i.e. $\alpha > 1$).

### 2.4.1 Floating rates

In the absence of an exchange rate arrangement or a monetary union, all central banks play Nash, i.e. they optimise policy without being able to make any commitments. Minimising the loss function (2.4) subject to the supply curve restrictions (2.1)-(2.3), taking the monetary strategies of the other countries as given, yields the following first-order conditions:

\[
\pi_G = -\alpha \beta y_G, \\
\pi_F = -\alpha \beta y_F, \\
\pi_S = -\beta y_S.
\]

In response to a negative shock, all central banks must make a trade-off between output loss and inflation. For the Bundesbank and the Banque de France, the optimal ratio of output loss and inflation is $\frac{1}{\alpha \beta}$, which reflects both the steepness of the supply curve (proportional to country size $\alpha$) and the central banks' preferences $\beta$. The Federal Reserve will divide a negative shock over output loss and inflation in a ratio $\frac{1}{\beta}$. As
2.4. Monetary policy and the exchange rate

$\alpha \geq 2$, it is clear that the Federal Reserve, the central bank of the large country in our model, will choose a higher output loss and lower inflation. It does this not because central banks’ preferences differ. In fact, the preferences are assumed to be identical. Each central bank has an incentive to create surprise inflation in order to shift the burden of adjustment to other countries. However, the relatively small size of Germany and France implies that a given amount of output (say: the location choice of a factory) is more important to these countries than to the US. Therefore, Germany and France are willing to accept a higher amount of inflation in order to prevent the loss of this amount of output.

Combining the first-order conditions with the above supply curve equations yields the response functions of the central banks under floating rates:\textsuperscript{12}

\[
\pi_G^* = \left( -\frac{2\alpha\beta}{2 + 3\alpha^2\beta} \right) \varepsilon_G + \frac{-\alpha^2\beta^2}{2 + 2\beta + \alpha^2\beta} \left[ \frac{\alpha(2 + 3\beta)}{2 + 3\alpha^2\beta} (\varepsilon_G + \varepsilon_F) + \varepsilon_S \right] \tag{2.8}
\]

\[
\pi_F^* = \left( -\frac{2\alpha\beta}{2 + 3\alpha^2\beta} \right) \varepsilon_F + \frac{-\alpha^2\beta^2}{2 + 2\beta + \alpha^2\beta} \left[ \frac{\alpha(2 + 3\beta)}{2 + 3\alpha^2\beta} (\varepsilon_G + \varepsilon_F) + \varepsilon_S \right] \tag{2.9}
\]

\[
\pi_S^* = \frac{-\beta}{2 + 2\beta + \alpha^2\beta} \left[ \alpha\beta (\varepsilon_G + \varepsilon_F) + (2 + \alpha^2\beta) \varepsilon_S \right]. \tag{2.10}
\]

Several things can be seen from (2.8)-(2.10). First, in the case of symmetric shocks in Europe ($\varepsilon_G = \varepsilon_F$), the monetary policies of the Bundesbank and the Banque de France will be identical. This follows from the symmetry of these countries in our model. Second, in the case of perfectly asymmetric shocks in Europe ($\varepsilon_G = -\varepsilon_F$), the monetary policy of the Federal Reserve will solely be determined by US shocks, as $\varepsilon_G + \varepsilon_F = 0$. Third, in case of negative supply shocks, the equilibrium inflation rates will be above target. The intuition is that central banks generate some surprise inflation in order to mitigate the output consequences of an adverse supply shock. Put differently, they endeavour to buffer the output consequences by depreciating their own currency.\textsuperscript{13} Each central bank is aware of the fact that the other central banks will also ease their policy. However, central banks are unable to commit to a policy in the absence of formal exchange rate agreements or monetary union. As a result, all central banks let inflation increase too

\textsuperscript{12}Combine the first-order conditions with the supply curve equations, in order to obtain a system of three equations in $\pi_i$, $\pi_i^*$, $\varepsilon_i$, $i = 1, 2, 3$. Take expectations on both sides and assume that expectations of wage setters are rational. This yields three non-singular equations in $\pi_i^*$, $i = 1, 2, 3$, which implies $\pi_1^* = \pi_2^* = \pi_3^* = 0$. This simplifies the original system of equations, which can be solved for inflation to obtain equations (2.8)-(2.10).

\textsuperscript{13}Since purchasing power parity is assumed to hold, the change in the nominal exchange rate is equal to the difference in the inflation rates.
much after a negative supply shock: the behaviour of each central is optimal given the
behaviour of the other central banks, but policy coordination would allow them to achieve
the same output loss with a lower inflation rate in each country. This is a familiar result
in the literature on policy coordination (see Persson and Tabellini, 1995).

2.4.2 EMU

The start of EMU goes hand in hand with the establishment of the ECB, which is
assumed to have euro area variables in its loss function only. As the inflation rate is
chosen by the single monetary authority, it follows directly that \( \pi_E = \pi_G = \pi_F \). As
Germany and France are assumed to be of equal size, the increase in euro area output
per capita is a simple average of per capita output growth in both countries

\[ y_E = \frac{1}{2} (y_G + y_F). \]

Substituting equations (2.1) and (2.2) into this equation gives the supply curve for the
euro area

\[ y_E = \frac{\alpha}{2} (\pi_E - \pi_E^*) - \frac{\alpha}{2} (\pi_S - \pi_S^*) + \frac{1}{2} (\varepsilon_G + \varepsilon_F). \]  (2.11)

The loss function of the ECB is\(^{14}\)

\[ L_E = \frac{1}{2} [\pi_E^2 + \beta y_E^2]. \]

The supply curve for the United States and the loss function of the Federal Reserve are
unchanged.

Solving the new optimisation problem yields the following first-order conditions:

\[ \pi_E = -\frac{\alpha \beta}{2} y_E; \]  \hspace{1cm} (2.12)

\[ \pi_S = -\beta y_S. \]  \hspace{1cm} (2.13)

As before, these conditions give the choice between inflation and output made by each
central bank. The European Central Bank will divide a negative shock over output loss
and inflation in a ratio \( \frac{2}{\alpha \beta} \). It has less of an incentive to shift the burden of adjustment
on to other countries than the Bundesbank and the Banque de France under floating
rates. The creation of EMU implies that the central banks in Europe operate as one

\(^{14}\)Alternatively, one could have assumed the ECB to minimise \( L_E = \frac{1}{2} (L_1 + L_2) \). This does not affect
the resulting policy rules. See Bénassy-Quéré et al. (1997, p. 164) for a proof.
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Institution. EMU enables them to internalise the intra-European externalities. They no longer endeavour to shift the burden of falling employment onto another European country. However, they still try to use the exchange rate to shift the burden on the United States.

For $\alpha \geq 2$, the ECB is at least as 'activist' as the Fed. The reason is that if the United States is larger than the euro area, the ECB is better able than the Fed to shift the burden of unemployment abroad ('size effect'). For $\alpha < 2$, the reverse would be true.

Combining the conditions (2.12)-(2.13) with the supply curve equations (2.3) and (2.11) yields the response functions of the central banks under EMU:15

$$
\pi^*_E = \left(\frac{-\alpha \beta}{4 + 4 \beta + \alpha^2 \beta}\right) \left[(1 + \beta)(\varepsilon_G + \varepsilon_F) + \alpha \beta \varepsilon_S\right], \quad (2.14)
$$

$$
\pi^*_S = \left(\frac{-\beta}{4 + 4 \beta + \alpha^2 \beta}\right) \left[\alpha \beta (\varepsilon_G + \varepsilon_F) + (4 + \alpha^2 \beta) \varepsilon_S\right]. \quad (2.15)
$$

The response functions (2.14)-(2.15) provide several insights. First, neither the ECB’s nor the Federal Reserve’s monetary policy stance is affected by asymmetric shocks in Europe (i.e. when $\varepsilon_G + \varepsilon_F = 0$). Second, the ECB is less responsive to US shocks than the national central banks in Europe used to be before the start of EMU (i.e. $\partial \pi_E/\partial \varepsilon_S < \partial \pi_G/\partial \varepsilon_S$).16 Third, the Federal Reserve’s response function has been affected by the altered trade-off for European policy makers. The ECB’s inclination to keep inflation closer to zero implies that, in equilibrium, there is less need for the Fed to inflate under EMU than under floating rates.17

2.4.3 Comparison of floating rates and EMU

In the following, I will compare dollar-deutschmark (under floating rates) with dollar-euro exchange rates (under EMU). I am interested in the impact of supply shocks on the exchange rate. Since I have assumed purchasing power parity to hold, this impact is equal to the difference between the impact of supply shocks on US inflation and their impact on euro area (German) inflation, which have been derived in subsections 2.4.1

\footnote{Again, taking expectations on both sides and assuming that expectations of wage setters are rational yields three non-singular equations in $\pi^*_i, i = 1, 2, 3$, which implies $\pi^*_1 = \pi^*_2 = \pi^*_3 = 0$.}

\footnote{This can be seen by comparing equations (2.8) and (2.14).}

\footnote{The fact that the response function (2.15) is affected by the changed behaviour of European policy makers follows from the fact that (2.15) differs from (2.10), even though the Federal Reserve faces the same domestic trade-off as before. The latter can be seen by comparing first-order conditions (2.7) and (2.13).}
and 2.4.2. The special cases of a symmetric shock in Europe, an asymmetric shock in Europe, a US shock and a symmetric worldwide shock are shown in Table 1.

Table 1  Exchange rate response to different types of shocks

<table>
<thead>
<tr>
<th>Case</th>
<th>Floating rates (dollar-mark)*</th>
<th>EMU (dollar-euro)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asymmetric shock in EU</td>
<td>$\frac{2\alpha\beta}{2+3\alpha^2\beta}$</td>
<td>0</td>
</tr>
<tr>
<td>$(\varepsilon_G = -1; \varepsilon_F = 1; \varepsilon_S = 0)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Symmetric shock in EU</td>
<td>$\frac{2\alpha\beta}{2+2\beta+\alpha^2\beta}$</td>
<td>$\frac{2\alpha^3}{4+4\beta+\alpha^2\beta}$</td>
</tr>
<tr>
<td>$(\varepsilon_G = \varepsilon_F = -1; \varepsilon_S = 0)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Shock in US</td>
<td>$\frac{-2\beta}{2+2\beta+\alpha^2\beta}$</td>
<td>$\frac{-4\beta}{4+4\beta+\alpha^2\beta}$</td>
</tr>
<tr>
<td>$(\varepsilon_G = \varepsilon_F = 0; \varepsilon_S = -1)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Worldwide shock</td>
<td>$\frac{2\beta(\alpha-1)}{2+2\beta+\alpha^2\beta}$</td>
<td>$\frac{2\beta(\alpha-2)}{4+4\beta+\alpha^2\beta}$</td>
</tr>
<tr>
<td>$(\varepsilon_G = \varepsilon_F = \varepsilon_S = -1)$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*A positive (negative) entry in the Table indicates an appreciation (depreciation) of the dollar.

Consider some limiting cases first. First, let Europe be infinitely small compared to the US ($\alpha \to \infty$). In this case, all exchange rate response coefficients in Table 1 become zero. Intuitively, for infinitely small European countries, any difference between domestic (German or French) inflation and US inflation will cause a cross-border shift in output which, given the size of the US, would be more costly to them than any domestic shock. Therefore, it is optimal for the central banks in Europe to exactly match the US inflation rate at all times. In other words, for an extremely small Europe, it is optimal to keep the currency pegged in all circumstances. Next, notice that all exchange rate response coefficients in Table 1 become zero if $\beta$ goes to zero. The intuition is simple. Remember that central banks fully control the inflation rate. Therefore, if all central

18Let $X_{ij}$ denote the change in the exchange rate of country $j$ expressed in the currency of country $i$. Absolute purchasing power parity is assumed to hold. Therefore, nominal exchange rate changes must correspond to inflation differentials (i.e. relative purchasing power parity also holds): $X_{ij} = \pi_i - \pi_j$.

19For instance, in response to a US shock, the Fed will let inflation increase by $\beta$ times the size of the shock. This inflation increase will be exactly matched by the central banks in Europe, even when there is no shock in Europe, in order to prevent an international shift in output. Next, consider a European shock. In this case, the Fed will not respond, since the European economy is so small that it has a negligible impact on the US economy. The central banks in Europe will not respond to European shocks either, because any divergence between US and European inflation rates would cause a international shift in output which is much larger (and therefore more costly) than a domestic shock.
banks only care about price stability, they will set inflation equal to zero in all countries. PPP ensures exchange rate stability in this case.

EMU tends to mitigate the expansionary reaction of central banks to economic shocks, since the externalities that cause the unduly fierce policy responses under floating rates are largely internalised under EMU. The mitigating impact is larger in Europe, which is more directly affected by the monetary union.

The more moderate response of euro area inflation to supply shocks does not necessarily lead to lower transatlantic exchange rate stability. The consequences of EMU for exchange rate stability depend on the origin of the shock. It is easy to see from Table 1 that (the absolute size of) the exchange rate response to a shock in Europe is smaller under EMU than under floating rates. This is true for both symmetric and asymmetric shocks. Conversely, the exchange rate response to a US shock is larger under EMU than under floating rates, as will be explained below.

Intuitively, one can think of the four special cases listed in Table 1 as follows:

1. An asymmetric shock in Europe: Neither the ECB nor the Federal Reserve will allow inflation to differ from zero in response to an asymmetric shock in Europe, implying that the exchange rate will remain unchanged after an asymmetric shock under EMU. Under floating rates, however, there will be a non-trivial dollar-mark exchange rate response after an asymmetric shock in Europe. The reason is that the Bundesbank’s policy domain is the national economy, rather than the euro area (the Bundesbank’s loss function contains German, rather than European variables). It follows directly that EMU results in smaller dollar-euro exchange rate responses to asymmetric shocks in Europe.

2. Symmetric shock in Europe: Under floating rates, the Bundesbank and the Banque de France relax their policy in case of a negative symmetric shock in Europe. In response, the Fed reacts by relaxing policy as well, but to a lesser extent. The result is dollar appreciation. Under EMU, monetary policy in Europe is coordinated. Euro area inflation will increase more moderately after European shocks than German and French inflation did before. The Fed realises that the ECB will accommodate less aggressively than the Bundesbank did and reacts more moderately as well. The impact of EMU is to mitigate all central banks’ reactions to the shock, but more so in Europe than elsewhere. The difference between the ECB’s policy reaction and the Fed’s policy reaction becomes smaller, which implies a more moderate exchange rate response.

3. Shock in the US: In response to a negative economic shock in the United States, the Federal Reserve eases its policy. The Bundesbank and the Banque de France react by easing policy as well, but to a lesser extent, which results in a dollar depreciation. German and French inflation are overly responsive under floating rates, but this has a mitigating impact on the dollar-euro exchange rate response to US shocks. Under EMU,
the ECB will be less responsive to US shocks than the individual national central banks in Europe used to be before EMU, as intra-European spillovers are internalised in the ECB Council. The Federal Reserve’s response will be mitigated as well, but to a smaller extent. Therefore, the policy stance of the ECB and the Fed will diverge more strongly than before, with adverse implications for exchange rate stability: the exchange rate response to economic shocks in the US increases.

4. World supply shock: A worldwide shock is defined as simultaneous symmetric shocks of equal size in Europe and in the US. In this case, relative country size plays a role. Under floating rates, the dollar-mark exchange rate will remain stable when \( \alpha = 1 \), that is when the three countries are of equal size. Under EMU, the dollar-euro exchange rate will remain stable when \( \alpha = 2 \), that is when the US and the euro area are of the same size. If there is no symmetry in size, then the central bank of the smallest country will have a larger incentive than the other to generate a depreciation of its own currency and will succeed in doing so. In reality, the euro area is of roughly the same size as the US (i.e. \( \alpha \approx 2 \)), which implies that the exchange rate response to a world supply shock will be smaller under EMU than under floating rates. Thus, under the assumption that the average frequency and size of shocks in Europe and the US is similar, one may expect that the dollar-euro exchange rate will be more stable than the dollar-mark exchange rate.

2.4.4 ERM

When studying the impact of the start of monetary union in Europe, it is common to compare floating rates and EMU. This approach can be defended on the grounds that, in the long run, the relevant choice is between floating rates versus full monetary union (Persson and Tabellini, 1995). However, it seems more appropriate to compare ERM and EMU. Not only were the EMU countries required to participate in the exchange rate mechanism of the European Monetary System in the two years before the start of the monetary union, the so-called 'core countries' had been participating in the ERM for almost twenty years.

The ERM had two essential characteristics. The first is that the system was asymmetric. The Bundesbank set its policy, after which the central banks of the other countries that participated in the ERM set their policy so as to stabilise the exchange rate against Germany. This element is captured by having the Bundesbank act as a Stackelberg leader against the Banque de France. The second characteristic is the possibility of an ERM break-up. I will assume that France is expected to stay in the ERM with probability \( p \) and to leave the ERM with probability \( 1 - p \). Intuitively, \( p \) can be seen as the
2.4. Monetary policy and the exchange rate

credibility of the ERM. In this counterfactual experiment, probability $p$ is determined by factors beyond the scope of the model. Such factors could be political pressure inside France to abrogate the ERM agreement or market speculation which forces the central bank to give up its exchange rate commitment. The probability $p$ is known by all players in the model.\footnote{\textsuperscript{20}The assumption that the probability of an ERM break-up is exogenously determined and known to all players is arguably quite strong. Relaxing this assumption is left for future research.}

Taking into account the asymmetric character of the ERM and the introduction of uncertainty about the continuation of the ERM (the case $0 < p < 1$) will turn out to affect the policy stance of all central banks in the model. Therefore, analysing this more realistic case provides a useful check on the robustness of the results obtained in the previous subsection.

The timing of this ERM game is as follows. First, private inflation expectations are formed. Second, wages are set. Third, shocks occur. Fourth, the Bundesbank and the Federal Reserve set their policies. Fifth, the markets determine whether the ERM is sustained or not. Sixth, the Banque de France sets its policy.

The loss function of the Banque de France depends on the continuation or break-up of the ERM. If France stays in the ERM, the exchange rate is the overriding objective, i.e. there is no trade-off between inflation and output. If France has left the ERM, the Banque de France’s loss function has the same functional form as under floating rates:

\begin{align}
L_{F,\text{ERM}} &= \frac{1}{2}(\pi_{F,\text{ERM}} - \pi_G)^2, \\
L_{F,\text{BU}} &= \frac{1}{2}(\pi_{F,\text{BU}}^2 + \beta y_{F,\text{BU}}^2),
\end{align}

where the subscript $\text{ERM}$ indicates the situation where France continues to participate in the ERM and the subscript $\text{BU}$ stands for the situation of an ERM break-up. The first-order conditions in the two cases are:

\begin{align}
\pi_{F,\text{ERM}} &= \pi_G, \\
\pi_{F,\text{BU}} &= -\alpha \beta y_{F,\text{BU}}.
\end{align}

Combining the first-order conditions (2.18) and (2.19) and the supply function for France yields the reaction function of the Banque de France, which is conditional on the con-
continuation or break-up of ERM:

\[
\begin{align*}
\pi_{F,ERM}^R &= \pi_G, \quad (2.20) \\
\pi_{F,BU}^R &= \frac{\alpha^2 \beta}{2(1 + \alpha^2 \beta)} (\pi_G + \pi_S) - \frac{\alpha \beta}{2(1 + \alpha^2 \beta)} \varepsilon_F. \quad (2.21)
\end{align*}
\]

where \(\pi_{F,ERM}^R = \pi_{F,ERM}^R(\pi_G)\) is the reaction function of the Banque de France if ERM is successfully maintained and \(\pi_{F,BU}^R = \pi_{F,BU}^R(\pi_G, \pi_S)\) is its reaction function in the case of an ERM break-up. Note that the Fed’s policy choice does not feature independently in the Banque de France’s inflation choice if France continues to participate in the ERM (i.e. \(\partial \pi_{F,ERM}^R / \partial \pi_S = 0\)).

The Bundesbank and the Federal Reserve set their policies simultaneously and in an uncoordinated fashion, taking the policy stance of the other central bank as given (i.e. they play Nash against each other). They both act as Stackelberg leaders against the Banque de France. By moving first, the Bundesbank and the Federal Reserve commit themselves to a certain monetary policy. They will take into account the reaction function of the Banque de France when setting their policy. However, they do not know yet whether France will stay in the ERM. They expect the Banque de France to play the strategy defined by equation (2.20) with probability \(p\) and to play the strategy defined by equation (2.21) with probability \(1 - p\). The Bundesbank sets \(\pi_G\) so as to minimise its loss:

\[
L_G = E[\frac{1}{2} \pi_G^2 + \frac{1}{2} \beta y_G^2] = \chi \frac{1}{2} \pi_G^2 + \frac{1}{2} \beta y_G^2, \quad (2.22)
\]

where

\[
\begin{align*}
y_{G,ERM} &= \alpha (\pi_G - \pi_G^c) - \frac{\alpha}{2} [\pi_{F,ERM}^R - \pi_F^c] - \frac{\alpha}{2} (\pi_S - \pi_S^c) + \varepsilon_G, \\
y_{G,BU} &= \alpha (\pi_G - \pi_G^c) - \frac{\alpha}{2} [\pi_{F,BU}^R - \pi_F^c] - \frac{\alpha}{2} (\pi_S - \pi_S^c) + \varepsilon_G.
\end{align*}
\]

The loss function for the Federal Reserve is a similar expression. Because the Bundesbank anticipates the Banque de France’s reaction to its own policy, the first-order condition for the Bundesbank is defined by:

\[
\frac{\partial L_G}{\partial \pi_G} + \frac{\partial L_G}{\partial y_{G,ERM}} \frac{\partial y_{G,ERM}}{\partial \pi_G} + \frac{\partial L_G}{\partial y_{G,BU}} \frac{\partial y_{G,BU}}{\partial \pi_G} + \frac{\partial L_G}{\partial \pi_{F,ERM}^R} \frac{\partial \pi_{F,ERM}^R}{\partial \pi_G} + \frac{\partial L_G}{\partial \pi_{F,BU}^R} \frac{\partial \pi_{F,BU}^R}{\partial \pi_G} = 0. \quad (2.23)
\]
Using the reaction functions (2.20)-(2.21), this can be rewritten as:  \(^{(21)}\)

\[ \pi_G = -\alpha\beta[p\frac{1}{2}y_{G,ERM} + (1 - p)H_{y_{G,BU}}]. \]  

(2.24)

where \( H = \frac{4 + 3\alpha^2\beta}{4 + 4\alpha^2\beta}. \) The first-order condition for the Federal Reserve becomes:

\[ \pi_S = -\beta[p_{S,ERM} + (1 - p)H_{y_{S,BU}}]. \]  

(2.25)

The optimal responses are derived and presented in appendix B. In all cases, negative supply shocks lead to a more accommodative monetary policy stance.

For \( p = 1 \), the Bundesbank and the Fed know that France will stay in the ERM for sure and they fully internalise the fact that the Banque de France will copy German monetary policy. The policies under such a stable ERM will be almost equivalent to the optimal policies under EMU. The difference is that under ERM, shocks to the French economy do not affect Bundesbank policy, whereas German and French shocks both matter (and are equally important in this model) for ECB policy in EMU.  \(^{(22)}\)

For \( p = 0 \), France will leave the ERM for sure and the Bundesbank and the Fed know this. When determining their policies, they fully internalise the fact that the Banque de France has the ‘opportunistic’ reaction function \( \pi_{F,BU}^R \). It is straightforward to show that, under ERM, inflation will generally be closer to zero than under floating rates, but further away from zero than under EMU. This corresponds to the familiar theoretical result that losses for all policy makers tend to be lower in a Stackelberg equilibrium than in a Nash equilibrium.

For \( 0 < p < 1 \), the absolute value of the policy responses under ERM is decreasing in \( p \) in the case of symmetric shocks.  \(^{(23)}\) If \( p \) is high, the existing externalities in monetary policy will be internalised to a larger extent. Intuitively, central banks on both sides of the Atlantic will keep inflation closer to zero in case of a more credible ERM (higher value of \( p \)).

---

\(^{(21)}\) Since the Bundesbank and the Federal Reserve move before the status of ERM is determined and since they are assumed to have full control over the domestic inflation rate, there will be a unique solution for inflation in Germany and the United States. However, output in each country will be affected by the continuation or break-up of the ERM and the consequent policy choice of the Banque de France. Thus, there are two solutions for output in each country: \( y_{j,ERM} \) may differ from \( y_{j,BU} \), \( j = 1,2,3 \).

\(^{(22)}\) Note that the policy response of each individual central bank is exactly equivalent to its response under EMU only after substituting \( \frac{1}{2}(\varepsilon_1 + \varepsilon_2) \) for \( \varepsilon_1 \) in equations (B8)-(B10).

\(^{(23)}\) It is easy to check that \( \pi_j > 0 \) and \( \frac{d\pi_j}{dp} \) < 0, if all shocks are negative. If all shocks are positive, then \( \pi_j < 0 \) and \( \frac{d\pi_j}{dp} \) > 0. Therefore, an increase in \( p \) will generally bring the absolute value of \( \pi_j \) closer to zero, \( j = 1,2(ERM),2(BU).3 \).
2.4.5 Comparison of ERM and EMU

Recall that purchasing power parity is assumed to hold. Therefore, the exchange rate change is equal to the inflation differential, which in turn is entirely determined by the policy response. The response of the exchange rate to specific types of shocks under ERM is summarised in Table 2.

Table 2: Exchange rate response to different types of shocks

<table>
<thead>
<tr>
<th>Type of Shock</th>
<th>ERM (dollar-mark)*</th>
<th>EMU (dollar-euro)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asymmetric shock in EU $(\varepsilon_G = -1; \varepsilon_F = 1; \varepsilon_S = 0)$</td>
<td>$p \frac{2a \beta}{4+4\beta+\alpha^2\beta} + (1 - p) \frac{2H \alpha \beta N_1}{D}$</td>
<td>0</td>
</tr>
<tr>
<td>2. Symmetric shock in EU $(\varepsilon_G = \varepsilon_F = -1; \varepsilon_S = 0)$</td>
<td>$p \frac{2a \beta}{4+4\beta+\alpha^2\beta} + (1 - p) \frac{2H \alpha \beta N_2}{D}$</td>
<td>$\frac{2a \beta}{4+4\beta+\alpha^2\beta}$</td>
</tr>
<tr>
<td>3. Shock in US $(\varepsilon_G = \varepsilon_F = 0; \varepsilon_S = -1)$</td>
<td>$p \frac{-4\beta}{4+4\beta+\alpha^2\beta} + (1 - p) \frac{-2H \beta N_3}{D}$</td>
<td>$\frac{-4\beta}{4+4\beta+\alpha^2\beta}$</td>
</tr>
<tr>
<td>4. World wide shock $(\varepsilon_G = \varepsilon_F = \varepsilon_S = -1)$</td>
<td>$p \frac{2\beta(\alpha-2)}{4+4\beta+\alpha^2\beta} + (1 - p) \frac{2H \beta(\alpha-1) N_4}{D}$</td>
<td>$\frac{2\beta(\alpha-2)}{4+4\beta+\alpha^2\beta}$</td>
</tr>
</tbody>
</table>

*A positive (negative) entry in the Table indicates an appreciation (depreciation) of the dollar.

with

$$N_1 = 2 + (1 + H) \beta + \alpha^2 \beta,$$
$$N_2 = 2 - (1 - H) \beta + 3\alpha^2 \beta,$$
$$N_3 = 2 + (3 + H) \alpha^2 \beta,$$
$$N_4 = 2 + (1 - H) \alpha \beta + 3\alpha^2 \beta,$$

and $H$ and $D$ as defined in Appendix B. All terms $(D, N_1, ..., N_4)$ are positive.

The results that were obtained when comparing floating rates and EMU still hold when comparing ERM and EMU. I recall these results for easy reference: EMU will result in smaller exchange rate reactions to both symmetric and asymmetric shocks in Europe, in larger exchange rate reactions to US shocks and in smaller exchange rate reactions to worldwide shocks.

In comparing ERM and EMU, I will consider the different possibilities case by case:

1. Asymmetric shocks in Europe: Under EMU, the exchange rate will not react to an asymmetric shock in Europe at all, since neither the ECB nor the Fed will allow inflation
to differ from zero. However, there will be a non-trivial move in the dollar-mark exchange rate under ERM. Therefore, the conclusion that EMU results in a smaller exchange rate reaction to asymmetric shocks in Europe is still valid.

2. Symmetric shock in Europe: It is straightforward to show that the exchange rate reaction to a symmetric shock in Europe under ERM is larger than under floating rates (for \( p = 0 \)) and equal to the reaction under EMU (for \( p = 1 \)) respectively. Intuitively, even in an ERM which is sure to fail, the Bundesbank leadership (it sets its policy before the Banque de France does) induces central banks to keep inflation somewhat closer to zero than under floating rates. Conversely, for a highly credible ERM, the policy responses to a symmetric shock in Europe are the same as those under EMU.\(^\text{24}\) For intermediate values of \( p \) (i.e. \( 0 < p < 1 \)), the size of the exchange rate reaction under the ERM scenario is a weighted average of these two extreme cases. It follows directly that the earlier results (EMU results in a smaller exchange rate reaction to symmetric shocks in Europe than floating rates) still hold when comparing EMU and ERM.

3. Shocks in the US: The same reasoning as sub 2 leads to the conclusion that the earlier result (EMU results in a larger exchange rate reaction to a US shock than floating rates) must still be valid when comparing EMU and ERM.\(^\text{25}\)

4. Worldwide shocks: The exchange rate reaction to a worldwide shock under ERM is intermediate between floating rates and EMU.\(^\text{26}\)

To summarise this paragraph, all results that we established for the comparison of floating rates and EMU are still qualitatively valid.

2.4.6 A future expansion of the euro area

So far, I have excluded the possibility that the euro area would be larger than the United States (i.e. I have assumed \( \alpha \geq 2 \)). However, if the current outs (particularly the United Kingdom, but also Sweden and Denmark) were to join EMU, and if the candidate member states in Central and Eastern Europe (notably a large country like Poland) were to join the European Union and EMU, the euro area would become larger than the US. The sensitivity of the earlier results to such a future expansion of the euro area can easily be explored using the size parameter (\( \alpha \)) in the model.

\(^{24}\)The latter is only true if \( \frac{1}{2}(\varepsilon_1 + \varepsilon_2) = \varepsilon_1 \) (that is: if \( \varepsilon_1 = \varepsilon_2 \)). This condition is satisfied for a symmetric shock in Europe.

\(^{25}\)The condition \( \varepsilon_1 = \varepsilon_2 \) is satisfied in this case as well (as both values are zero), so that, for an ERM with \( p = 1 \), the policy choices are equal to those under EMU.

\(^{26}\)Again, the condition of symmetry in Europe (\( \varepsilon_1 = \varepsilon_2 \)) is satisfied, so that for an ERM with \( p = 1 \), the policy choices are equal to those under EMU.
This subsection discusses the previous results with respect to exchange rate stability for the case $1 < \alpha < 2$. I will thus maintain the assumption that, even after the expansion of the euro area, the US is larger than half of the euro area.\textsuperscript{27} I will first compare floating rates and EMU and then turn to the comparison of ERM and EMU.\textsuperscript{28}

It turns out that the results remain qualitatively the same for shocks that originate either in the euro area or in the US.\textsuperscript{29} However, the relative size of the euro area and the US may affect the conclusion in case of a worldwide shock. Therefore, in what follows, I will focus on a worldwide shock.

Floating rates and EMU

A symmetric world supply shock (defined as a simultaneous shock of equal size in Europe and the US) will lead to smaller exchange rate volatility after the start of EMU, unless the euro area were to become more than 50% larger than the United States.\textsuperscript{30} In the latter case, the US would obtain stronger incentives to actively use the exchange rate as an instrument. This size effect could ultimately dominate the mitigating impact of the internalisation of externalities in Europe as a result of EMU.

\textsuperscript{27}This assumption seems realistic for the foreseeable future. In terms of economic size (gross domestic product), the United States are currently 25% larger than the euro area (EU-12). If the outs and the accession countries were to join, this would make the euro area (EU-27) 5% larger than the US. Thus, expansion would imply a decline in $\alpha$ from 2.5 to 1.9. In terms of population, the EU-12 is already slightly larger than the United States, whereas the enlarged euro area EU-27 would be 80% larger than the US, implying a decline of $\alpha$ to 1.1.

\textsuperscript{28}It is not the purpose of this subsection to look at the effect of the euro area expansion on exchange rate stability. Rather, I check whether the earlier results about the impact of EMU on exchange rate stability would still be valid if the euro area were to expand significantly.

\textsuperscript{29}These are the special cases 1-3 that I have looked at in earlier subsections. For easy reference, these results are summarised here. The exchange rate will be more stable in response to (both asymmetric and symmetric) shocks in Europe under EMU than under floating rates; the exchange rate will be less stable in response to US shocks under EMU than under floating rates, even if the euro area were to become larger than the US.

\textsuperscript{30}This can be seen by comparing the absolute values of the entries in the bottom row of Table 1. The exact condition is that the exchange rate response is smaller under EMU than under floating rates if and only if $(6\alpha - 8)(\beta + 1) + (2\alpha - 3)\alpha^2\beta > 0$. It is easy to see that for this inequality to hold, it is sufficient that $\alpha > 1.5$. Numerical evaluation shows that the inequality is likely to be satisfied for $\alpha > 1.34$ (i.e. for $\frac{1}{\alpha} < 1.49$, that is if the euro area is less than roughly 50% larger than the United States). The inequality is rather insensitive to $\beta$ (maintaining our assumption that $\beta > 0$). Even if $\beta \to \infty$, the inequality will be satisfied for all $\alpha > 1.4$. 


ERM and EMU

If the euro area were to become significantly larger than the United States, then world supply shocks would lead to larger exchange rate reactions than before EMU. The more credible ERM was thought to be at the outset (i.e. the higher $p$), the more likely our result is to break down. This should come as no surprise, since in a highly credible ERM intra-European externalities are internalised to a large extent, making this situation very similar to EMU. For instance, if $p = 0$, the reversal takes place when the euro area were to become more than 50% larger than the US. For $p = \frac{1}{2}$ the reversal would take place as soon as the euro area were more than 20% larger than the US and for $p = \frac{3}{4}$, this would occur as soon as the euro area were more than 10% larger than the US. However, in the extreme case of a fully credible ERM ($p = 1$) the exchange rate response to a worldwide shock will be equivalent to the response under EMU. Thus, no reversal takes place.\(^{31}\)

To summarise this paragraph, our results for both asymmetric and symmetric shocks in Europe and for shocks in the US remain valid, even if the euro area were to become much larger than the US. Only the result for worldwide shocks may be reversed if the euro area were to become (significantly) larger than the United States in terms of population.

2.5 Conclusion

In this paper, I have looked at the possible impact of EMU on transatlantic exchange rate stability. The very essence of EMU is that it changes the rules of the monetary policy game. As a result, the start of EMU has consequences for the behaviour of monetary policy makers, which may affect the euro-dollar exchange rate.

In the run-up to EMU, it was widely expected that exchange rate volatility would increase as a result of benign neglect of the exchange rate on both sides of the Atlantic. However, using a simple two-country model which focused on country size, Martin (1997) argued that exchange rates would become more stable. I have extended his model to a three-country version. This enables me to take into account a number of changes as a result of EMU that a two-country model cannot address. Moreover, in contrast to Martin, I am able to distinguish between symmetric and asymmetric shocks in Europe and between shocks in Europe and abroad.

\(^{31}\)The exact condition for the exchange rate response to be smaller under EMU than under ERM can be derived from comparing the absolute values of the expressions in the bottom line of Table 2. The exact condition is a rather cumbersome expression. Numerical evaluation gives the results in the main text. Intermediate values for $p$ give intermediate critical values for $\alpha$. 

The establishment of the ECB comes with full monetary policy coordination within the euro area, ensuring that all externalities within the euro area are internalised in the decision making process in the ECB Governing Council. As a result, the ECB will keep the economy closer to price stability in response to economic shocks than the national central banks did before the start of EMU.

It turns out that the impact of EMU on exchange rate stability critically depends on the origin of shocks. The lower responsiveness of the ECB to European shocks will translate into more exchange rate stability, whereas the lower responsiveness of the ECB to US shocks will translate into stronger exchange rate movements. Under the assumption that the average frequency and size of shocks in Europe and the US is similar, one may expect that the dollar-euro exchange rate will be more stable than the dollar-mark exchange rate.

The conclusions remain valid when taking into account that Europe had an exchange rate mechanism (ERM), rather than freely floating currencies, in the pre-EMU era. The specification of the ERM accounts for the fact that the ERM was an asymmetric arrangement, in the sense that the Bundesbank had a leading role, whereas the other national central banks had an exchange rate target against the German mark. It also takes into account the possibility of a break-down of the arrangement. This increases the practical relevance of my conclusions.

Finally, the model’s country size parameter is used to explore what happens if the euro area expands. This is likely to become relevant, given the foreseen enlargement of the European Union and the expected future participation of the new member states in the monetary union. Most of the results do not change. However, if the euro area were to become (significantly) larger than the US, the exchange rate may become more, not less, responsive to a symmetric worldwide shock than it used to be before EMU.
Appendices

A Supply per capita and country size

The derivation of the size coefficients follows Martin (1997). Think of a world of $N$ identical regions, which compete with each other on the basis of real wages. The supply function in region $i$ is as follows:

$$y_i = -(w_i - p_i) + \frac{1}{N-1} \sum_{j \neq i} (w_j - p_j) + \eta_i,$$

where $w_i$ is (the natural logarithm of) the nominal wage rate, $p_i$ is the price level and $\eta_i$ is a region-specific random supply shock. Notice that if the nominal wage is equal to the general price level region by region then, in the absence of shocks, output will be equal to potential output.

Now let us take a three-country world, where each country consists of a number of regions. The country indices will henceforth refer to specific countries: 1 for Germany, 2 for France and 3 for the United States. Countries need not have the same size. In fact, Germany and France are of equal size (normalised to unity) and the United States has size $\alpha$, which is larger than 1. Size refers to the population of a country. The United States is large when compared to either Germany and France individually. However, the euro area (consisting of Germany and France only) may be either larger or smaller than the United States. For a country of (population) size 1, aggregate output is equal to output per capita. This is not true in the more general case of country size $\alpha$.

The step from output in $N$ identical regions of size 1 to output per capita in three countries of different size is as follows. Define a partition of the world in three countries, comprising $n_1, n_2, n_3$ regions, respectively ($n_1 + n_2 + n_3 = N$). Shocks $\eta_i$ have expected value zero and variance $\sigma^2, i = 1, ..., N$. Assume that shocks within each country are perfectly correlated, whereas shocks in different countries are uncorrelated. Now define $\varepsilon_k = \frac{1}{n_k} \sum_{i \in n_k} \eta_i, k = 1, 2, 3$. Then

$$\text{Var}(\varepsilon_k) = (\frac{1}{n_k})^2 \text{Var}(\sum_{i \in n_k} \eta_i) = (\frac{1}{n_k})^2 \sum_{i \in n_k} [\text{Var}(\eta_i) + \sum_{i,j \in n_k, i \neq j} \text{Cov}(\eta_i, \eta_j)]] =$$

$$= (\frac{1}{n_k})^2 [n_k \sigma^2 + (n_k - 1)\sigma^2] = \sigma^2, \quad k = 1, 2, 3. \quad (A2)$$

All regions in the same country have the same inflation rate. Therefore, the wage rate is identical in every region in the same country. Then per capita supply in each country
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is given by

\[ y_1 = \frac{1}{n_1} \sum_{i \in n_1} \left[ -(w_i - p_i) + \frac{1}{N-1} \sum_{j \neq i} (w_j - p_j) + \eta_i \right] \]

\[ = \frac{1}{n_1} \sum_{i \in n_1} \left\{ -(w_i - p_i) + \frac{1}{N-1} \left[ (n_1 - 1)(w_i - p_i) + n_2(w_2 - p_2) + n_3(w_3 - p_3) \right] + \eta_i \right\} \]

\[ = -(\frac{N-n_1}{N-1})(w_1 - p_1) + \frac{n_2}{N-1}(w_2 - p_2) + \]

\[ + \frac{n_3}{N-1}(w_3 - p_3) + \varepsilon_1. \]  \hspace{2cm} (A3)

Analogously:

\[ y_2 = \frac{n_2}{N-1} (w_1 - p_1) - (\frac{N-n_2}{N-1})(w_2 - p_2) + \]

\[ + \frac{n_3}{N-1}(w_3 - p_3) + \varepsilon_2. \]  \hspace{2cm} (A4)

\[ y_3 = \frac{n_1}{N-1} (w_1 - p_1) + \frac{n_2}{N-1}(w_2 - p_2) + \]

\[ - (\frac{N-n_3}{N-1})(w_3 - p_3) + \varepsilon_3. \]  \hspace{2cm} (A5)

Normalise: \( n_1 = n_2 = \frac{1}{1+\alpha}; n_3 = \frac{\alpha}{1+\alpha} \). This means that \( N-1 = n_1 + n_2 + n_3 - 1 = \frac{1}{1+\alpha} \). Then:

\[ y_1 = -(1+\alpha)(w_1 - p_1) + (w_2 - p_2) + \alpha(w_3 - p_3) + \varepsilon_1, \]  \hspace{2cm} (A6)

\[ y_2 = (w_1 - p_1) - (1+\alpha)(w_2 - p_2) + \alpha(w_3 - p_3) + \varepsilon_2, \]  \hspace{2cm} (A7)

\[ y_3 = (w_1 - p_1) + (w_2 - p_2) - 2(w_3 - p_3) + \varepsilon_3. \]  \hspace{2cm} (A8)

The symmetry of the European countries in the model ensures that the US is equally sensitive to real wage developments in Germany and France. Applying the size argument consistently would imply that Germany is more sensitive to US than to French real wage developments [as reflected in the coefficients for the French and US wage rate in equation (A6)]. However, in the main text, I will assume those coefficients are equal. This amounts to assuming that each of the European countries is influenced as much by
real wage changes in the US as by real wage changes in the other European country. I make this assumption for reasons of algebraic simplicity.\footnote{The fact that Germany and France are geographically closer to each other than to the United States would argue for adjusting the weights even more, so that each European country would be more sensitive to developments in the other European country than to developments in the US. However, the distance between countries is not in my model. See Bayoumi and Eichengreen (1998) or Ghironi and Giavazzi (1998) for an application of the gravity model to international trade.}

Substituting the optimal wage rule \((w_i = p_i^*)\) into the supply per capita functions yields equations (2.1)-(2.3) in the main text.

**B Optimal responses under ERM**

After substituting the supply curves into the first-order conditions (2.18), (2.19), (2.24) and (2.25), the first-order conditions can be rewritten in terms of inflation:

\[
\pi_G = -\alpha \beta \{p + 2H(1 - p)\} \left\{ \alpha (\pi_G - \pi_G^c) - \frac{\alpha}{2} \frac{p}{p + 2H(1 - p)} \pi_{F,ERM} + \right.
\]
\[+ \frac{2H(1 - p)}{p + 2H(1 - p)} \pi_{F,BU} - \pi_F^c \left. \right\} - \frac{\alpha}{2} (\pi_S - \pi_S^c) + \varepsilon_G \}, \tag{B1}
\]
\[
\pi_{F,ERM} = \pi_G. \tag{B2}
\]
\[
\pi_{F,BU} = -\alpha \beta \left\{ -\frac{\alpha}{2} (\pi_G - \pi_G^c) + \alpha (\pi_{F,BU} - \pi_F^c) - \frac{\alpha}{2} (\pi_S - \pi_S^c) + \varepsilon_F \right\}, \tag{B3}
\]
\[
\pi_S = -\beta \{p + H(1 - p)\} \left\{ -\frac{1}{2} (\pi_G - \pi_G^c) - \frac{1}{2} \frac{p}{p + H(1 - p)} \pi_{F,ERM} + \right.
\]
\[+ \frac{H(1 - p)}{p + H(1 - p)} \pi_{F,BU} - \pi_F^c \right\} + (\pi_S - \pi_S^c) + \varepsilon_S \}, \tag{B4}
\]

where \(H = \frac{3 - \alpha^2 \beta}{4 + \alpha^2 \beta} \). Note that \(p\pi_{F,ERM} + (1 - p)\pi_{F,BU} \) is the policy of the Banque de France as expected by the other central banks, i.e. after shocks occur, but before the markets determine whether or not France stays in the ERM, whereas \(\pi_F^c \) is the BdF policy as expected by wage setters, i.e. before shocks occur.

The assumption of rational expectations implies:

\[
E(\pi_G) = \pi_G^c. \tag{B5}
\]
\[
E(\pi_F) = p\pi_{F,ERM} + (1 - p)\pi_{F,BU} = \pi_F^c. \tag{B6}
\]
\[
E(\pi_S) = \pi_S^c. \tag{B7}
\]

Taking expectations on both sides of (B.1)-(B.4) and applying the assumption of rational expectations results in a non-singular system of four equations in four unknowns.
(π_G, π_F.ERM, π_F.BU, π_S). These equations need to be satisfied for all admissible values of α, β, and p, which is only the case for \( \pi_G = \pi_F.ERM = \pi_F.BU = \pi_S = 0 \).

This simplifies the first-order conditions, which can then be rewritten to the following reduced-form equations:

\[
\pi_G = \pi_F.ERM = p \frac{-\alpha \beta}{4 + 4\beta + \alpha^2 \beta} \left[ 2(1 + 3) \varepsilon_G + \alpha 3 \varepsilon_S \right] + (1 - p) \frac{-H \alpha \beta}{D} [A_1 \varepsilon_G + A_2 \varepsilon_F + A_3 \varepsilon_S],
\]

\[
\pi_F.BU = p \frac{-\alpha \beta}{1 + \alpha^2 \beta} \left\{ \varepsilon_F + \frac{\alpha \beta}{4 + 4\beta + \alpha^2 \beta} \left[ \alpha (1 + 2 \beta) \varepsilon_G + (2 + \alpha^2 \beta) \varepsilon_S \right] \right\} + (1 - p) \frac{-H \beta}{D} [B_1 \varepsilon_G + B_2 \varepsilon_F + B_3 \varepsilon_S],
\]

\[
\pi_S = p \frac{-\beta}{4 + 4\beta + \alpha^2 \beta} \left[ 2\alpha \beta \varepsilon_G + (4 + \alpha^2 \beta) \varepsilon_S \right] + (1 - p) \frac{-H \beta}{D} [C_1 \varepsilon_G + C_2 \varepsilon_F + C_3 \varepsilon_S],
\]

with

\[
H = 4 + 3\alpha^2 \beta,
\]
\[
D = 4 + 4H \beta + 4(1 + H)\alpha^2 \beta + 3H(1 + H)\alpha^2 \beta^2 + 3H\alpha^4 \beta^2,
\]
\[
A_1 = 4 + 4H \beta + 4\alpha^2 \beta + 3H\alpha^2 \beta^2,
\]
\[
A_2 = 2\alpha^2 \beta + 3H\alpha^2 \beta^2,
\]
\[
A_3 = 2H\alpha \beta + 3H\alpha^3 \beta^2,
\]
\[
B_1 = 2\alpha^2 \beta + 3H\alpha^2 \beta^2,
\]
\[
B_2 = 4 + 4H \beta + 4H\alpha^2 \beta + 3H^2 \alpha^2 \beta^2,
\]
\[
B_3 = 2H\alpha \beta + 3H^2 \alpha^3 \beta^2,
\]
\[
C_1 = 2H\alpha \beta + 3H\alpha^3 \beta^2,
\]
\[
C_2 = 2\alpha \beta + 3H\alpha^3 \beta^2,
\]
\[
C_3 = 4 + 4(1 + H)\alpha^2 \beta + 3H\alpha^4 \beta^2.
\]

All terms \((H, D, A_1, A_2, A_3, B_1, B_2, B_3, C_1, C_2, C_3)\) are positive.