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EMU and Transatlantic Exchange Rate Stability

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SUMMARY

The question of the impact of EMU on the stability of the transatlantic exchange rate raises the more general question of whether the exchange rate is a useful adjustment instrument or an additional source of shocks. The end of the Bretton Woods system was motivated by the hope that flexible exchange rates would isolate the economies from shocks coming from their partners', and help them to face domestic shocks. This hope was largely shattered by the experience of the post-Bretton Woods system. In particular flexible exchange rates did not translate into a reduced instability of other macroeconomic variables (Flood and Rose, 1995). Hence, fixing the intra-European exchange rates may not lead to more instability elsewhere and specifically on the transatlantic exchange rate.

In this paper, we compare the role of the intra-European exchange rate as an instrument for economic stabilisation to its role as a source of economic instability, in order to infer the potential impact of EMU on the transatlantic exchange-rate variability. To do so, we estimate a simple, three-country model for the United States, Germany and France, over the 1972-1995 period. The structure of each economy is assumed to be independent of the exchange rate regime: a general floating regime, EMU and the ERM. Regimes are defined along the way European central banks settle the nominal interest rate. In the general floating regime, each follows strictly domestic objectives. In the ERM, France follows the German interest rate. In EMU, the single European interest rate is settled with respect to the averages of French and German objectives. Stochastic simulations are performed in order to compare the variability of various macroeconomic variables, including the transatlantic exchange rate, in the three regimes, and to highlight the role of the intra-European exchange rate as a source of shocks or as an adjustment variable.

Our simulations show that EMU could reduce the variability of the transatlantic exchange rate compared both to the ERM and to a floating regime. Eliminating the shocks to the intra-European exchange rate is crucial for the stabilisation of the European economies, as suggested by Minford *et al.* (1992). However, EMU stabilises the transatlantic exchange rate even if the removal of shocks to the intra-European risk premium is not attributed to the regime shift. By contrast, the ERM is the regime producing the most unstable transatlantic exchange rate because it is an asymmetric regime.

Due to structural and stochastic asymmetries, the benefits of EMU are smaller for France than for Germany, in terms of the variability of inflation and of the real effective exchange rate. Finally, EMU is the regime producing the largest instability in the US economy, because it eliminates the stabilising fluctuations of the transatlantic exchange rate.

More generally, our simulations show that the transfer of volatility is not systematic and can be indirect. Here, fixing the intra-European exchange rate does not increase the variability of the extra-European exchange rate, but it destabilises a third economy.

JEL classification: E52, F02, F31, F33.

Key words: EMU, euro exchange rate, stochastic simulations.

RÉSUMÉ

L'impact de l'UEM sur la stabilité du taux de change transatlantique s'inscrit dans un débat plus large sur le rôle du taux change, une variable d'ajustement macroéconomique ou source d'instabilité supplémentaire. La fin du système de Bretton Woods et la généralisation des changes flexibles avaient fait naître l'espoir que les ajustements de change permettrait d'isoler chaque économie des perturbations issues de ses partenaires et de réagir plus efficacement aux chocs internes. Force est de constater qu'il n'en a rien été. La variabilité des taux de change s'est fortement accrue, sans pour autant aboutir à une stabilisation des autres variables macroéconomiques (Flood et Rose 1995). En retournant l'argument, la fixation définitive des parités intra-européennes ne se traduira pas nécessairement par un transfert de leur volatilité vers d'autres variables macroéconomiques et en particulier vers le taux de change transatlantique.

Nous évaluons le rôle des taux de change intra-européens dans les ajustements macroéconomiques. Permettent-ils un meilleur ajustement des autres variables macroéconomiques où sont-ils des sources de perturbations supplémentaires ? Notamment, le passage à l'UEM se traduira-t-il par une baisse ou par une hausse de la variabilité du taux de change transatlantique ?

Nous estimons un modèle simplifié à trois pays, Allemagne, Etats-Unis et France entre 1972 et 1995. La structure de chaque économie, en terme de boucle prix-salaire, de demande intérieure et de demande d'importation et d'exportation, est supposée invariante à travers trois régimes de change entre l'Allemagne et la France : UEM, SME et changes flottants. Chaque régime est défini par le comportement des banques centrale européennes. En changes flottant, la banque centrale de chaque pays fixe le taux d'intérêt nominal en référence à des objectifs nationaux. En SME, la Banque de France suit le taux d'intérêt allemand. Enfin, en UEM, le taux d'intérêt nominal européen évolue en fonction de la moyenne des objectifs de la France et de l'Allemagne.

Nous mettons en oeuvre des simulations stochastiques qui permettent de comparer les performances de chaque régime de change en terme de variabilité des principales variables macroéconomiques.

Nos simulations montrent que l'UEM se traduit par une baisse de la variabilité du taux de change transatlantique, que le régime de référence soit le SME ou le régime de changes flottants. Cette stabilisation a lieu même dans les simulations où le taux de change dépend uniquement des autres variables macroéconomique, c'est-à-dire qu'il n'est pas lui-même source de perturbation . A l'opposé, c'est le SME qui se traduit par la variabilité la plus forte du taux de change transatlantique.

Nous obtenons également que le passage à l'UEM est davantage stabilisante pour l'Allemagne que pour la France, dont les ajustements de la demande et de l'inflation requièrent des variations plus importantes de taux d'intérêt. Enfin, l'UEM est le régime de change le moins stabilisant pour les Etats-Unis parce que les variations du taux de change transatlantique, réduites en UEM, sont un vecteur de stabilisation macroéconomique. Globalement, nos résultats ne vont pas dans le sens d'un transfert systématique de la volatilité d'un taux de change vers les autres variables macroéconomique. En particulier, la fixation du taux de change entre le franc et le mark en UEM, ne se traduit pas par une déstabilisation du taux de change transatlantique.

EMU and Transatlantic Exchange-Rate Stability

Agnès Bénassy-Quéré () and Benoît Mojon (**)*

1. INTRODUCTION

The question of the impact of EMU on the stability of the transatlantic exchange rate raises the more general question of whether the exchange rate is a useful adjustment instrument or an additional source of shocks. The end of the Bretton Woods system was motivated by the hope that flexible exchange rates would isolate the economies from shocks coming from their partners', and help them to face domestic shocks. This hope was largely shattered by the experience of the post-Bretton Woods system. In particular flexible exchange rates did not translate into a reduced instability of other macroeconomic variables (Flood and Rose, 1995). Hence, fixing the intra-European exchange rates may not lead to more instability elsewhere and specifically on the transatlantic exchange rate.

Existing papers generally conclude that the creation of the euro will increase the variability of the dollar against European currencies, compared to its variability with a flexible regime in Europe. This is because the euro zone will be larger and mechanically less open than the constituting member countries. Thus the European Central Bank (ECB) could be less interested in achieving exchange-rate stability (See Artus (1997a), Cohen (1997) and Bénassy-Quéré, Mojon and Pisani-Ferry (1997)). This view is challenged by Martin (1997) who argues that large countries (like the forthcoming monetary union) have less incentive to use their exchange rate strategically to stabilise the real economy, and by Artus (1997b) who thinks that the Federal Reserve may have more incentive to stabilise the dollar.

However, such theoretical analyses do not take into account structural asymmetries other than differences in openness: if monetary policy has the same impact in the various European economies, then switching from a floating regime towards the European Monetary Union (EMU) has little impact on the variability of the transatlantic exchange rate, except if the single monetary policy differs from the previous average of national policies due to a

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size effect, an openness effect or to coordination gains. By contrast, the euro/dollar reaction to shocks in Europe may be different from the pre-EMU average reaction of individual currencies against the dollar. This might be due to asymmetries in the transmission channels of the monetary policy like those highlighted by Barran, Coudert and Mojon (1996).

In addition, a diagnosis on the likely variability of the euro requires all macroeconomic shocks to be considered simultaneously. This is done by Masson and Turtelboom (1997) who perform stochastic simulations with Multimod and find an increase in the dollar variability in EMU compared to its variability in the European exchange-rate mechanism (ERM) regime. However, this increased exchange-rate variability is difficult to analyse in a large macroeconomic model. Besides, Masson and Turtelboom do not compare EMU with a flexible regime in Europe, which European countries have not experienced since 1979. Yet, a free-floating regime can be viewed as the actual alternative to EMU since fixed exchange rates are hardly sustainable in a world with perfect capital mobility.

In this paper, we compare the role of the intra-European exchange rate as an instrument for economic stabilisation to its role as a source of economic instability, in order to infer the potential impact of EMU on the transatlantic exchange-rate variability. To do so, we estimate a simple, three-country model for the United States, Germany and France, over the 1972-1995 period. The structure of each economy is assumed to be independent of the exchange rate regime: a general floating regime, EMU and the ERM. Stochastic simulations are performed in order to compare the variability of various macroeconomic variables, including the transatlantic exchange rate, in the three regimes, and to highlight the role of the intra-European exchange rate as a source of shocks or as an adjustment variable.

Section 2 presents the model. In Section 3, the strategy for stochastic simulations is detailed. The results of the stochastic simulations are presented in Section 4. Conclusions are given in Section 5.

2. THE MODEL

2.1. Invariant structures

In line with most theoretical work on the external impact of EMU, we assume that the world economy is made up of three countries: the United States, Germany and France, the last two countries forming the euro-zone after EMU is completed¹. Within each country, the specification of the model is a simplified version of Taylor (1993), Deutsche Bundesbank (1997), Masson *et al.* (1990) and some quarterly models of the French economy (OFCE, 1996). The behavioural equations, which are limited to dynamic wage and price settings, domestic demand, import and export demand equations, are estimated from 1972 to 1995 with quarterly data. The key long-run elasticities between prices and

quantities, i.e. the impact of the output gap on prices and the impact of the real interest rate on domestic demand, are constrained to be the same in France and in Germany. This choice is motivated by the fact that in the EMU regime, symmetric shocks in Europe should not lead the real exchange rate between France and Germany to diverge in the long run. Thus, we consider that both countries have already converged in terms of the long-run transmission channels, although they may behave differently in the short run. It is also likely that the European economies have converged to some extent in the recent period, in part because of the Maastricht criteria, and that this convergence process is not accounted for by the average behaviour of the French and German economies over the period of estimation.

The main characteristics of the model are reported in Table 1 (identities and estimations are detailed in Appendix). Wage inflation depends on past wage inflation and on consumer price inflation, with a unit long-term elasticity. Producer prices are determined by a mark-up on wages and also depend on excess demand, defined as an output gap. The long-term elasticity of the producer price to the output gap is 0.42 in the European countries. Consumer, import and export prices are defined by identities for which coefficients are estimated over the sample period. As expected, the share of the import price in the consumer price index in France and Germany is twice as large as in the US. In addition, France is relatively more price-taker than the other two countries.

Domestic demand reacts negatively to the real interest rate and to the increase in consumer prices (real balance effect). In France and Germany, a one-point increase in the real interest rate and in inflation reduces growth of domestic demand by 0.14% and 0.09% respectively. Exports depend on the two foreign partners' domestic demand, as well as on the terms of trade. Imports are related to domestic demand and to the real, effective exchange rate². As their major long-term elasticities are constrained to being equal, France and Germany mainly differ in their dynamics: growth of domestic demand exhibits more inertia in France than in Germany, while wages are more flexible in France than in Germany³.

¹ The euro-zone is called Europe for the sake of simplicity.

² The terms of trade have no long-run impact on US imports, while the effective exchange rate has no impact on German exports (like in Taylor, 1993).

³ It is a well-known feature of French macroeconomic models that wage inflation adjusts rapidly on CPI inflation (OFCE, 1996). Here, additional inertia stems from the fact that wage inflation is modelled in yearly growth rates, as in Deutsche Bundesbank (1997).

Table 1 : Invariant behaviours

Nominal-wage inflation, year on year wage increase:	
$dw_t = a dw_{t-1} + (1-a) [cpi_t - cpi_{t-4}]$	(1)
Output-price level:	
$p_t = b p_{t-1} + (1-b) [g(L) w_{t-1} + d (y_{t-1} - \bar{y}_{t-1})]$	(2)
Domestic-demand growth:	
$dd_t = r(L) dd_{t-1} + (1-r(L)) [c r_{t-j} + f (cpi_{t-k} - cpi_{t-k-4})]$	(3)
Exports:	
$x_t = h x_{t-1} + (1-h) [j (px_{t-1} - pm_{t-1}) + n ad_t]$	(4)
Imports:	
$m_t = k m_{t-1} + (1-k) [q (pm_{t-1} - p_{t-1}) + z d_t]$	(5)
<p>Greek letters stand for estimated parameters; d is the first difference operator; w_t, p_t, d_t, y_t, cpi_t, x_t, m_t, px_t, pm_t, ad_t and \bar{y}_t stand respectively for the logarithm of wages, producer prices, domestic demand, output, consumer prices, exports, imports, export prices, import prices, addressed demand (the sum of the two partners domestic demand), and potential output, and r_t is the real interest rate. The results of the estimations and the identities are detailed in Appendix.</p>	

The real effective exchange rate is the average of the real bilateral exchange rates with respect to the two partner countries. Potential output is exogenous in the model. It is derived from a complementary-factor production function with long-term trends of employment and capital as inputs⁴.

⁴ We are grateful to F. Thibault for providing the series of potential output (cf. Thibault, 1996).

2.2. Exchange rates and monetary policy

It is assumed that the monetary policy aims at minimising a loss function $L(X)$, where X represents a set of macroeconomic variables. The choice of X can be discussed. Here a standard specification is assumed where the monetary authorities are concerned with the square deviations of consumer price inflation and of the output gap from some targets. The minimisation of the loss function determines the reaction function of the interest rate. Bénassy-Quéré *et al.* (1997) show that the switch to EMU may reduce the incentive of European countries as a whole to stabilise the consumer price index (which depends heavily on the exchange rate), and increase their incentive to stabilise output. However, this result does not necessarily apply here, as several simplifying assumptions are dropped. For instance, our macroeconometric model is truly dynamic: because output prices are sluggish, consumer prices *fall* in the short run after an inflationary shock (because the exchange rate appreciates due to monetary tightening). In addition, international linkages include quantity spillovers together with price spillovers. Here, all central banks (except the *Banque de France* in the ERM regime) are supposed to use the same reaction function (Table 2) ⁵.

⁵ Such *Taylor-like* reaction functions are the most general representation of central bank strategies. For instance, the official *Bundesbank* strategy of targeting a money aggregate is not so different from a Taylor rule, because money demand increases with prices and output. Indeed, Clarida and Gertler (1996) and Bernanke and Mihov (1997) show that the operating interest rates of the *Bundesbank* can better be predicted by prices and /or output than by M3.

Table 2 : Interest rate and exchange rate equations across the monetary regimes

	Interest rates	Exchange rates
Float	$i_i = \frac{3}{2} dcpi_i + \frac{1}{2}(y_i - \bar{y}_i) \quad i = F, G, U$	$e_G = E[e_G(+1)] + (i_U - i_G)/400 + rp_G$ $e_F = E[e_F(+1)] + (i_G - i_F)/400 + rp_F$
ERM	$i_i = \frac{3}{2} dcpi_i + \frac{1}{2}(y_i - \bar{y}_i) \quad i=G,U$ $i_F = i_G + \frac{3}{2}(dcpi_F - dcpi_G)$	$e_G = E[e_G(+1)] + (i_U - i_G)/400 + rp_G$ $e_F = E[e_F(+1)] + (i_G - i_F)/400 + rp_F$
EMU	$i_F = i_G = \frac{3}{4}(dcpi_F + dcpi_G) + \frac{1}{4}((y_F - \bar{y}_F) + (y_G - \bar{y}_G))$ $i_U = \frac{3}{2} dcpi_U + \frac{1}{2}(y_U - \bar{y}_U)$	$e_G = E[e_G(+1)] + (i_U - i_G)/400 + rp_G$ e_F is constant

i is the nominal interest rate, e is the logarithm of the nominal exchange rate, $dcpi$ is the year-on-year variation of the consumer price index, y is the logarithm of GDP, and rp is the risk premium. $E[]$ is the expectation operator.

In a floating regime, each country sets its interest rate on the basis of its national inflation and output gap. In EMU, the ECB reacts to the European inflation and output gap. Finally, in the ERM regime, the *Banque de France* sets its nominal interest rate at the level of the German nominal interest rate plus 1.5 times the inflation differential between French and German inflation. This specification builds on the fact that the differential between French and German interest rates is cointegrated with the inflation differential between the two countries during the EMS period (Equipe Mephisto, 1992). The *Banque de France* raises its interest rate above the German one when nominal convergence is losing pace. This formulation catches the functioning of a "convergence ERM". It does not deal with speculative attacks that would require either large movements in the interest rate differential or realignments to be modelled explicitly. Nevertheless, it is representative of the "competitive disinflation" policy of France since 1983, with the 1992 and 1993 crises appearing as exceptions.

The exchange-rate block of the model is the most delicate. We assume that DM/USD and FF/DM exchange rates are governed by uncovered interest parity (UIP) with rational expectations and stochastic risk premiums. Perfect arbitrage sets the FF/USD exchange rate. Over the estimation period, the risk premiums are calculated as differences between interest-rate differentials and exchange rate expectations. Therefore, the specification of expectations has an influence on the shocks introduced in the simulations, and consequently it affects the potential impact of EMU on stability. The calculation of the shocks to the risk premiums is discussed in Section 3.

2.3. Dynamic properties of the model

The dynamic properties of the model are captured through deterministic simulations where the UIP condition is specified with an exogenous risk premium and with model-consistent expectations. The terminal condition is given by the neutrality of temporary shocks to the real exchange rate in the long run, given the perfect indexation of wages to prices.

Due to model-consistent expectations, the bilateral nominal exchange rate initially jumps to ensure that the bilateral real exchange rate gradually comes back to the baseline within 24 quarters, which matches the period needed for the demand shock to adjust. The case of the real exchange rate between France and Germany in EMU differs: the FF/DM nominal exchange rate being fixed, there is no reason why the bilateral real exchange rate should return to the baseline in the long run. That is why we enforce symmetry between the two economies in the long run. The bilateral real exchange rate is then stabilised, although its level may differ from the baseline.

We simulate the impact of symmetric and anti-symmetric, demand and wage shocks⁶. A temporary demand shock (four quarters) increases the output gap, which puts upward pressure on prices. The central bank raises the nominal interest rate so that the increase in the real interest rate drives demand back to the baseline after five years. A temporary, positive shock on wages (one quarter) behaves as a typical inflationary supply shock: the reaction of the central bank reduces the output gap *via* the increase in the real interest rate. As far as exchange rate regimes are concerned, the simulations show that demand shocks have more impact on most exchange rates (except on the FF) in EMU than in a floating regime, while results from wage shocks are more ambiguous.

These simulation exercises underline how the "country specificity" channel influences exchange rate variability. For instance, a transfer of demand from Germany to France (an anti-symmetric shock) is more inflationary in France than it is deflationary in Germany. In the EMU regime, the rise in the European interest rate is too small for France (which in addition cannot benefit from an appreciation of the FF against the DM) and too tight for Germany: the reaction of aggregate European inflation and interest rates to the shock is larger in EMU than in a floating regime, and so is the response of the transatlantic exchange rate. It is also interesting to note that the impact of EMU is different in France and in Germany. The latter is stabilised more rapidly after a shock while the former is stabilised more slowly.

However, the results differ according to the nature of the shocks. Before concluding on the overall variability of the forthcoming euro, it is thus necessary to take into account the different kinds of shocks simultaneously. This is the reason why we undertake the stochastic simulations.

⁶ Symmetric shocks are identical shocks to both European economies, while anti-symmetric shocks are shocks of equal magnitudes, but opposite signs.

3. The strategy for stochastic simulations

The stochastic-simulation method builds on a constructive Lucas critique (Taylor 1993). It designates the structure of the economy as behaviours and shocks, which are assumed invariant to economic policy regimes. In particular, the shocks have some invariant stochastic properties estimated by their empirical covariance matrix over the period of estimation of the structural behaviour equations. Then, one can draw randomly from a joint distribution of shocks and rebuild sequences of shocks which have the assumed invariant stochastic properties. Eventually, the simulated variance of macroeconomic variables is computed *ex post*, and the instability of the variables of interest can be compared across the policy regimes.

The pioneer simulations of the European Commission (1990) were strongly criticised by Minford, Rastogi and Hughes Hallett (1992) who argued that the EC overestimated the volatility of the shocks to intra-European exchange rates by wrongly modelling exchange-rate expectations and the risk premium. This overestimation of the intra-European shocks lead to overestimating the welfare improvement when intra-European exchange rates were definitely fixed (in EMU). We first discuss this crucial point and justify our specification (3.1). Then the variance-covariance matrix of the shocks is presented (3.2). Finally, the "technology" for solving the model with rational expectations is explained, and some of its properties are underlined (3.3).

3.1. Defining the shocks to the foreign-exchange markets

Under the risk-neutrality assumption, the exchange rate is determined by the UIP condition:

$$e_t = i_t^* - i_t + e_{t,t+1}^a$$

where e_t stands for the logarithm of the nominal exchange rate at time t , i_t the domestic interest rate, i_t^* the foreign interest rate and $e_{t,t+1}^a$ the logarithm of the exchange rate expected in t for $t+1$. There are two major problems with this specification. Firstly, it does not allow for specific shocks to the foreign-exchange markets; the excessive volatility of the exchange rate compared with its macroeconomic determinants must be accounted for by overshooting effects. Secondly, the UIP does not hold for a large range of assumptions concerning exchange-rate expectations.

Therefore, it is necessary to drop the risk-neutrality assumption and to include a risk premium rp_t in the foreign-exchange equilibrium condition:

$$e_t = i_t^* - i_t + e_{t,t+1}^a + rp_t$$

Shocks to the foreign exchange market can now be introduced as shocks to the risk premium. But the assumption made for exchange rate expectations is crucial for the amount and volatility of the risk premium. Following the EC (1990) four solutions can be suggested:

(i) Exact expectations: $e_{t,t+1}^a = e_{t+1}$. At first sight, this solution is consistent with the rational expectations used in the simulations. But rational expectations at time t are based on the *available* information, while the actual exchange rate at $t+1$ depends on the news in $t+1$, which cannot be expected in t : the news at $t+1$ should not impact on the exchange rate at t . This first solution is rejected by the EC (1990), Minford *et al.* (1990) and Masson and Symansky (1992).

(ii) Naive expectations: $e_{t,t+1}^a = e_t$. This specification is consistent with the random-walk hypothesis supported by Meese and Rogoff (1983), but it is inconsistent with the forward looking expectations of the model. Being equal to the interest-rate differential, the risk premium may appear to be insufficiently volatile. This solution is rejected by the EC, as well as by Minford *et al.*, but Masson and Symansky, and Masson and Turtleboom, select it as the most realistic time-series model.

(iii) Model-consistent expectations: the expected exchange rate is given by the dynamic simulation of the model itself. By construction, this specification is consistent with the model, and with the idea that the model is a good proxy for the technology which is available to predict exchange rates. Minford *et al.* use this specification (within the Liverpool World model). But Masson and Symansky point out that, in one sense, (iii) is equivalent to (i) since exact expectations have to be made for all exogenous variables until the terminal condition holds.

(iv) A partial model for expectations: exchange rate expectations are modelled as a function of selected variables, with long-run consistency with the full model. This is the specification chosen by the EC. It is criticised by Minford *et al.* as inconsistent with Multimod, which is the model used for the simulations, and because it leads to excessively volatile risk premiums.

In this paper, the risk premium is calculated with the assumption that forecasters expect the nominal exchange rate to move in compensation for the inflation differential and to allow a partial adjustment of the real exchange rate towards its long-run value \tilde{q}_t :

$$e_{t,t+1}^a = e_t + (p_t - p_{t-1}) - (p_t^* - p_{t-1}^*) + a(\tilde{q}_t - q_t), \quad 0 < a < 1$$

This specification is consistent with the model where the real exchange rate returns to the baseline in the long run, the baseline level being calculated with a Hodrick-Prescott filter. Hence, this formulation can be called *semi-rational expectations*. The parameter a is chosen to be roughly consistent with the speed of adjustment of the model. We take $a = 0.1$, meaning that the adjustment is expected to take 10 quarters.

As in EC (1990), the risk premium is modelled as an autoregressive process, so that shocks to the risk premium have a lasting effect: $rp_t = b rp_{t-1} + u_t$. This assumption is consistent with the sluggish nature of the risk premium which depends on risk aversion, on perceived risk and on accumulated external disequilibria. The error terms u_t are then identified to the shocks to the risk premium.

At the stage of the simulations, we assume rational expectations (see Table 2). The expected path of the exchange rate is assumed consistent with the model. Thus, the exchange rate at time t depends on the sum of the risk premiums from to the end of the simulation. Because shocks to the risk premium have a lasting effect, the exchange rate jumps in the short run, and the amount of the jump is $1/(1-b)$ times the shock. That is why shocks to the exchange rate are much larger than shocks to the risk premium. This overshooting pattern of the exchange rate dynamics can be very destabilising if the autoregressive coefficient is high, as in the estimations reported in Table 3. Following Taylor (1993), we limit the overshooting effect by setting the autoregressive coefficient of the risk premium to 0.25. Thus, the shock to the exchange rate is 1.33 times the shock to the risk premium. Altogether, this assumption reduces the volatility of the exchange rate stemming from shocks to the risk premium. It also reduces the possibility that EMU appear a better regime because it would erase some artificially boosted sources of instability (cf. Minford *et al.*, 1992).

Table 3 : Quarterly shocks on the foreign exchange markets: 1972-1995 (1)

In % per quarter	DM/\$	FF/DM
S.D. of the log-variations of the exchange rate	5.24	2.31
S.D. of the risk premium	1.1	1.0
Estimated autoregressive coefficient b	0.67	0.51
S.D. of the shocks to the risk premium	1.0	0.9
S.D. of the shocks to the exchange rate (2)	3.0	1.8
Correlation of the shocks to the risk premiums	-0.49	
Calibrated autoregressive coefficient b	0.25	0.25
S.D. of the shocks to the risk premium	1.0	1.0
S.D. of the shocks to the exchange rate (2)	1.33	1.33
Correlation of the shocks to the risk premiums	-0.32	

(1) 1972-1979 for FF/DM (2) $1/(1-b) \times$ S.D. of the shocks to the risk premium.

Bold-face letters designate the variability properties with the assumptions used in the simulations.

Source: authors' calculations.

3.2. The variance-covariance matrix of the shocks

The other major macroeconomic disturbances of the model are the shocks to domestic demand, to producer prices and to wages. Their distributions are those of the residuals of the estimations (Table 4). The magnitudes of the shocks are standard (Taylor, 1993). The standard deviation of domestic-demand shocks amounts to about 1 %, while it is inferior to 0.5 % for price shocks and around 0.7 % for wage shocks, in Europe. It is interesting to note that demand shocks as well as wage shocks are positively correlated,

although the correlation within Europe is not much superior to what it is across the Atlantic, and that the shocks to the risk premiums have the same order of magnitude as demand shocks.

Table 4 : Correlation matrix of the major macroeconomic shocks, standard deviations (in %) on the diagonal, 1972-1995

		1	2	3	4	5	6	7	8	9	10	11
Price fr	1	0.43										
Price ge	2	0.04	0.49									
Price us	3	-0.18	0.03	0.27								
Wage fr	4	-0.28	0.00	0.26	0.79							
Wage ge	5	-0.18	0.16	0.19	0.22	0.69						
Wage us	6	-0.00	-0.15	0.11	0.26	0.18	0.53					
Demand f	7	0.13	0.09	0.13	0.00	-0.16	-0.26	0.92				
Demand g	8	-0.08	-0.12	0.07	0.21	-0.08	-0.00	0.26	1.0			
Demand u	9	-0.04	-0.03	-0.03	-0.24	-0.11	-0.11	0.22	0.14	0.84		
Risk dm \$	10	-0.11	-0.34	0.20	0.06	-0.10	0.14	-0.08	0.04	-0.00	1.0	
Risk ff dm	11	-0.38	0.57	0.04	-0.12	0.23	-0.08	-0.02	-0.13	0.02	-0.32	1.0

Source: authors' calculations

3.3. Implementing stochastic simulations with rational expectations

Three sets of stochastic simulations are implemented. In each one, 20 histories of shocks, each of 30 quarters in a row, are drawn from a joint normal distribution with a zero mean and a covariance matrix corresponding to the residuals of the estimations. Each simulation starts on the first quarter of 1985. In each period t , the model is shocked and solved forward. The value of all of the variables of the model in period t is set when the paths of exchange rates have converged to the paths consistent with the terminal conditions, the latter being defined as the neutrality of real bilateral exchange rates to the shocks. The same procedure is started again in period $t+1$ ⁷. After the 30 periods have been simulated, a new 30-quarter history of shocks is drawn out of the joint distribution. After the 20 simulations have been performed over 30 quarters, the standard deviations and correlations of endogenous variables are calculated, dropping the 10 first quarters of each simulation in order to provide independence from initial conditions.

The joint distribution used to draw the shocks corresponds to the residuals of estimations over the whole 1972-1995 period, except for the shocks to the risk premiums, for which the three sets of simulations differ. In the first set of simulations (standard simulations), shocks to the risk premiums are calculated on the whole estimation period for DM/USD, but over the 1972-1979 quasi-floating sub-period for DM/FF. In the second set of simulations, all shocks to the risk premiums are set to zero. In the third set of simulations (which allows a comparison with the ERM regime), the shocks to DM/USD are drawn in the same way as in the first set, but shocks to FF/DM are set to zero, as in the second set.

4. Results from the stochastic simulations

4.1. EMU versus a floating regime: standard simulations

In this first set of simulations, the exchange rates (when flexible) are considered both instruments for domestic stabilisation and sources of additional shocks to the economies. Hence, the exchange rates are both stabilising and destabilising. We call *useful adjustment* the first effect and *useless volatility* the second one. Useless volatility stemming from shocks to the FF/DM risk premium disappears in EMU. The results are reported in Table 5.

⁷ The horizon is limited to twelve quarters in order to limit computations. Exchange-rate expectations are rational, but not perfect: at time t , agents forecast the model-consistent paths of exchange rates stemming from all shocks until t , but not the paths stemming from shocks in $t+1$ or later.

Table 5 : EMU versus a floating regime: standard simulations

Simulated	France		Germany		Europe		United States	
	Float	EMU	Float	EMU	Float	EMU	Float	EMU
Standard deviations (%)								
CPI inflation (1)	1.55	1.45	1.25	1.08	1.13	1.02	1.48	1.68
Output gap	2.46	2.00	2.54	2.55	1.90	1.89	1.89	2.14
Correl. infl./output gap	0.11	0.58	-0.19	0.14	-0.17	0.37	0.09	0.35
Nominal interest rate	3.09	2.03	2.19	2.03	2.09	2.03	2.49	3.07
Real interest rate	2.15	1.46	1.74	2.03	1.39	1.54	1.81	2.17
Nominal exchange rate (2)	10.14	0.00	15.04	9.71	13.22	9.71	13.22	9.71
REER (3)	9.66	4.98	11.74	5.50	13.82	10.16	13.82	10.16
Correlation output gap/ Nominal exchange rate (2)	0.13	0.00	-0.35	-0.03	-0.37	0.08	-0.40	0.05
Simulated correlations	CPI inflation		Output gap		Nom. interest rate			
	Float	EMU	Float	EMU	Float	EMU		
France/Germany	0.06	0.11	0.20	0.38	-0.04	1.00		
Europe/United States	0.14	-0.15	-0.52	-0.66	0.04	-0.46		

(1) S.D. of the year-to-year CPI log-variation. (2) S.D. of year-to-year log-variation of FF/DM, DM/USD and USD/European average. (3) S.D. of year-to-year log-variations in the real, effective exchange rate.

Source: model simulations.

4.1.1. The stabilisation of the European economies

In EMU, each European country suffers from the loss of a useful adjustment variable, but it benefits from the elimination of useless volatility. The second effect is dominant. However, France and Germany are unequally affected by the regime shift, which can be explained by structural asymmetries. Specifically, the ECB reaction to a positive, symmetric demand shock is tighter for Germany and looser for France compared to national reactions in a floating regime. Thus, the volatility of the interest rate is reduced by 1.06 points in France and by only 0.16 points in Germany.

The European economy as a whole is merely affected by the regime shift: CPI inflation variability is reduced both in France and in Germany, but as the correlation between prices in the two countries increases (because the FF/DM adjustment no longer isolates the economies), the European inflation rate is not much stabilised. The same thing applies to the European output gap and to the European interest rate (by definition, the correlation between French and German interest rates rises to 1 in EMU).

4.1.2. The stabilisation of the transatlantic exchange rate

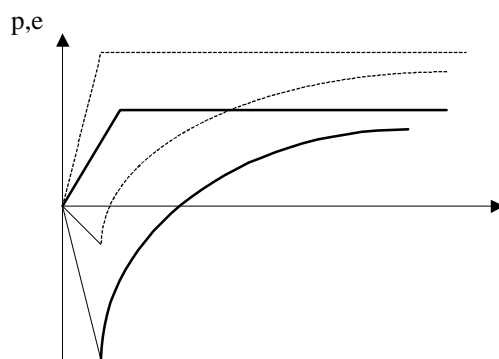
The main result of the simulations is the reduction in the transatlantic exchange-rate variability in EMU, compared to the variability in a floating regime. This is the net effect of three different channels:

(i) *The useful adjustment effect*: EMU raises the correlation between CPI inflation and the output gap in each European country. For instance, a positive demand shock in France is no longer stabilised by an appreciation in the FF/DM exchange rate. Thus, inflation increases with the output gap. In the case of an inflationary wage shock in France, no FF/DM appreciation occurs in the short run, and demand is reduced less. Because the two target variables are positively correlated in EMU, the monetary policy no longer faces a conflict between them: the European interest rate reaction to given shocks is stronger.

(ii) *The useless volatility effect*: the removal of the shocks to the FF/DM risk premium in EMU stabilises the European economies, which leads to lesser needs for monetary policy. Because shocks are weaker, the European interest rate is less volatile. But EMU also removes the asymmetry of the shocks to the risk premiums: in a floating regime, the DM appreciates against the FF when it appreciates against USD, which makes the German REER relatively more unstable, and the French and US REERs relatively more stable in a floating regime than in EMU.

(iii) *The expectation effect*: the correlation between European and US inflation becomes negative in EMU, leading to larger swings in the inflation differential. Because private agents expect the real exchange rate not to be affected by inflationary shocks in the long run, larger inflation differentials mean larger expected variations in the transatlantic, nominal exchange rate. This reduces the initial jump of the nominal exchange rate after an inflationary shock (Figure).

**Figure: The price and exchange rate reactions to an inflationary shock,
in a float (plain) and in EMU (dots).**



In EMU, the increase in the transatlantic price differential ($p_E - p_U$) is larger. Thus, a larger depreciation is expected. This limits the initial appreciation of the transatlantic exchange rate e due to the European monetary tightening.

Table 5 shows that the useless volatility effect and the expectation effect outweigh the useful adjustment effect: altogether, the transatlantic exchange rate is more stable in EMU than in a floating regime, and this is more the case for Germany than in France or in the US.

4.1.3. The destabilisation of the US economy

Because it is hardly transmitted to European aggregates, the stabilisation of each European economy does not stabilise the US partner. On the contrary, the US economy is destabilised by the regime shift. This is because the stabilisation of the transatlantic exchange rate weakens the useful adjustment role of the exchange rate for the US, while useless volatility stemming from shocks to the risk premium remains.

The loss in terms of useful adjustment is the following: in both regimes there is a strong, negative correlation between the output gap in Europe and in the US, meaning that a boom in Europe is concomitant with a recession in the US. In a floating regime, dollar depreciations coincide with falls in the US output gap, which is stabilising. In EMU, the smaller dollar fluctuations fail to stabilise the US economy. By stabilising the transatlantic exchange rate, EMU reduces the role of the exchange rate as a useful adjustment variable in the US. This effect is confirmed by the large, negative correlation between interest rates in Europe and in the US that appears in EMU: because the exchange rate is less stabilising for the US economy, the Federal Reserve uses the interest rate more actively ⁸.

⁸ The negative correlation between European and US interest rates is not inconsistent with reduced volatility in the transatlantic exchange rate. This is because the interest-rate

4.2. EMU versus a floating regime: the role of shocks to the risk premiums

Minford *et al.* (1992) claim that the removal of shocks to the FF/DM risk premium should not be attributed to EMU. They say that the UIP, which is a market-equilibrium condition, is a non-stochastic relationship: the residuals should be interpreted as a model error rather than as a time-varying risk premium, and no stochastic term should be included in the equation. Yet it can be argued that the risk premium varies according to changes in the perceived risk when agents are risk-averse. Nevertheless, the measurement of the shocks to the risk premiums is a debatable issue. In order to study whether our results derive from specific assumptions concerning risk premiums, we implemented stochastic simulations where all shocks to the risk premiums are set equal to zero. Thus, FF/DM and DM/USD exchange-rate movements are due to shocks to other macroeconomic variables which affect both interest rates and exchange-rate expectations. The results are reported in table 6.

differential equals the *forward* variation of the exchange rate, while the exchange-rate volatility is computed with *backward* variations (initial jump). EMU may reduce the initial jump of the exchange rate, while increasing the rate of adjustment towards the long term. However, the path towards the long run remains hypothetical since new shocks lead to new jumps at each period.

Table 6 : EMU Versus a floating regime

Simulations without shocks to the risk premiums.

Simulated Standard deviations (%)	France		Germany		Europe		United States	
	Float	EMU	Float	EMU	Float	EMU	Float	EMU
CPI inflation (1)	1.04	1.37	1.14	1.24	0.82	1.04	1.74	1.93
Output gap	1.31	1.95	2.36	2.55	1.43	1.81	1.74	2.11
Correl. Inflation/outputgap	-0.11	0.67	-0.31	0.15	-0.34	0.44	0.13	0.44
Nominal interest rate	1.57	2.08	1.74	2.08	1.23	2.08	2.73	3.32
Real interest rate	1.00	1.59	1.27	1.89	0.87	1.47	1.66	2.24
Nominal exchange rate (2)	6.70	0.00	11.96	9.09	9.77	9.09	9.77	9.09
REER (3)	5.56	5.01	9.60	5.00	10.60	9.60	10.60	9.60
Correlation output gap/ Nominal exchange rate (2)	0.10	0.00	-0.43	-0.08	-0.50	-0.02	-0.45	-0.11
Simulated correlations	CPI inflation		Output gap		Nom. Interest rate			
	Float	EMU	Float	EMU	Float	EMU		
France/Germany	0.21	0.28	0.17	0.29	0.03	1.00		
Europe/United States	0.24	-0.25	-0.43	-0.66	0.12	-0.54		

Notes: see Table 5.

Source: model simulations.

When shocks to the risk premiums are eliminated both in a floating regime and in EMU, the volatility of all variables is lower in both regimes, but the shift from a floating regime to EMU *destabilises* the European economies (and not only the US economy). This is because European countries lose a useful adjustment variable, whereas the exchange rate is already not a source of useless volatility in a floating regime.

Nevertheless, EMU still stabilises the transatlantic exchange rate, although the contrast between the two regimes is smaller than in standard simulations. This results can be explained by the expectation effect, which dominates the useful adjustment effect even in the absence of the useless volatility effect.

Despite the absence of the asymmetric useless volatility effect, the French REER is not much more stable in EMU than in a floating regime, whereas its stabilisation is clear cut in standard simulations. This can be explained by the fact that France suffers from more volatile inflation in EMU, without being able to stabilise its real, bilateral exchange rate against Germany through FF/DM adjustment. This mechanism does not apply to Germany where inflation is positively correlated to the FF/DM nominal exchange rate (i.e. the DM appreciates when German inflation rises): FF/DM variations destabilise the German REER in a floating regime.

Our results confirm that the shocks to the risk premiums are determinant for the EC result of more economic stability in an EMU regime. However, the reduction in the variability of the transatlantic exchange rate remains when EMU is no longer held responsible for the removal of the shocks to the FF/DM.

4.3. EMU versus a floating regime and the ERM

Our specification of the ERM does not consider the possibility of speculative attacks or realignments, so that the French monetary rule only applies if there are no shocks to the FF/DM risk premium. The model is simulated with the same shocks (randomly drawn from the whole-period variance-covariance matrix) under the three regimes: free-float, ERM and EMU. But the shocks to the FF/DM risk premium are set to zero in the three regimes. The results are reported in Table 7.

Table 7 : EMU versus a floating regime or the ERM

4.3.1. EMU versus a floating regime again: the role of the shocks to the FF/DM

Not surprisingly, the comparison between a floating regime and EMU is in the way between the results from the standard simulations and the simulations with no shocks to the risk premiums (FF/DM and DM/USD). The variability of the transatlantic exchange rate is lower in EMU than in a floating regime, the difference between the two regimes being smaller than in standard simulations, but larger than in the simulations without shocks to the DM/USD risk premium: shocks to the DM/USD risk premium appear relatively more destabilising for the transatlantic exchange rate in a floating regime than in EMU.

4.3.2. EMU versus ERM

As in Masson and Turtelboom (1997), switching from the ERM regime to EMU has little impact on the European economies. This is because in the ERM regime, the intra-European exchange rate is already a limited adjustment variable, while its useless volatility is already removed. In the ERM regime, the French interest rate only reacts to the German interest rate and to the inflation differential. In EMU, the European interest rate takes the French output gap into account, which slightly stabilises the latter. As in other simulations, the ECB policy is more reactive for Germany than was the policy of the *Bundesbank*, and the inflation rate is stabilised. At the European level, inflation is stabilised while the output gap is destabilised. This scissor effect can be explained by the fall in the correlation of inflation in the two countries (from 0.48 to 0.14) and by the rise in the correlation of the output gap (from 0.02 to 0.44).

Because it is asymmetric, *the ERM regime is the regime producing the highest volatility in the transatlantic exchange rate*. This can be explained by the reaction to asymmetric shocks in Europe. For instance, assume a transfer of demand from Germany to France (an anti-symmetric shock). The European interest rate falls *ex ante* in the ERM regime, while it rises very slightly in EMU. In the ERM regime, European currencies depreciate against the USD, whereas in EMU, the euro appreciates slightly. In brief, the French monetary policy aiming at stabilising the FF/DM in the ERM destabilises the transatlantic exchange rate in the presence of asymmetric shocks⁹. Hence, the ERM is not a compromise between EMU and a floating regime. The anti-symmetric component of the shocks is neutral on the USD in EMU and in a floating regime, but not in the ERM.

Finally, the worst regime for the United States is EMU, where both inflation and the output gap are more unstable than in the ERM regime. These results stem from the loss

of the stabilising impact of dollar fluctuations. Artus (1997b) suggested that EMU might force the Federal Reserve to use the monetary policy partly to stabilise the transatlantic exchange rate because the ECB would have less incentive to do so. Our simulations show

⁹ The destabilising impact of the ERM on the transatlantic exchange rate is confirmed by the reduced variability of the dollar effective exchange rate after the ERM had partially broken up (1993-1996), compared to the hard ERM period (1987-1992).

that the US interest rate may become more variable in EMU than in both a floating regime and the ERM *despite* reduced volatility in the transatlantic exchange rate. In fact, dollar fluctuations are stabilising for the US economy, and moving to EMU weakens this source of automatic adjustment.

5. CONCLUSIONS

Our simulations show that EMU could reduce the variability of the transatlantic exchange rate compared both to the ERM and to a floating regime. Eliminating the shocks to the intra-European exchange rate is crucial for the stabilisation of the European economies, as suggested by Minford *et al.* (1992). However, EMU stabilises the transatlantic exchange rate even if the removal of shocks to the intra-European risk premium is not attributed to the regime shift. By contrast, the ERM is the regime producing the most unstable transatlantic exchange rate because it is an asymmetric regime.

Due to structural and stochastic asymmetries, the benefits of EMU are smaller for France than for Germany, in terms of the variability of inflation and of the real effective exchange rate. Finally, EMU is the regime producing the largest instability in the US economy, because it eliminates the stabilising fluctuations of the transatlantic exchange rate.

More generally, our simulations show that the transfer of volatility is not systematic and can be indirect. Here, fixing the intra-European exchange rate does not increase the variability of the extra-European exchange rate, but it destabilises a third economy. Of course, our results depend on several debatable assumptions.

First, the monetary policy, when independent, is the same across the monetary regimes. It may be argued that reaction functions are derived from optimisation behaviours that take the change in the interest-rate multipliers into account (see Bénassy-Quéré *et al.*, 1997). However, modifying the monetary rules would need solving the model analytically in order to control for the optimality of the rules.

Second, our modelling of the ERM is rather crude. It matches the functioning of the ERM between 1987 and 1992 but ignores speculative attacks and realignments. Despite this deficiency, however, the ERM regime leads to the greatest volatility both in European economies and in the transatlantic exchange rate.

Finally, both stochastic and structural asymmetries in Europe are minimised in the model which reduces Europe to France and Germany. Enlarging the model to other European countries would provide a better, more exhaustive, stochastic representation of European-wide sources of shocks, but this would have the drawback of impeding the interpretation of the results.

Appendix : The Estimated Model

F: France; G: Germany; U: the US. All variables are in logarithms, except growth rates (which are log-differences) and interest rates (which are in percentage points). Estimation period: 1972:1-1995:3. Bold-face coefficients are constrained to be equal in France and in Germany. Estimations are run with TSP. There are two blocks in the model: a wage-price block and a volume block. The structure is a block-recursive, as prices depend on lagged output gap to avoid simultaneity between the two blocks.

The wage and price equations are estimated with FIML, which allows accounting for the relevant identities, thus taking into account simultaneity. The volume block is estimated with the TSP non-linear, least-square estimator (LSQ), because it involves no identities, and it converges to better estimates than the FIML procedure.

WAGE-PRICE BLOCK

Nominal wage inflation (with $\dot{w}_i(t) = w_i(t) - w_i(t-4)$)

$$\dot{w}_F = 0.009 - 1.2 \cdot 10^{-4} \text{ time} + 0.80 \dot{w}_F(-1) + 0.20 [cpi_F - cpi_F(-4)]$$

(0.002) (5 $\cdot 10^{-5}$) (0.05)

$$\dot{w}_G = 0.002 + 0.88 \dot{w}_G(-1) + 0.12 [cpi_G - cpi_G(-4)]$$

(0.002) (0.03)

$$\dot{w}_U = -5 \cdot 10^{-4} + 0.95 \dot{w}_U(-1) + 0.05 (cpi_U - cpi_U(-4))$$

(0.002) (0.03)

with cpi_i the logarithm of the consumer price index ($i = F, G, U$).

Output price level^{A1}, with og_i the output gap ($i = F, G, U$)

$$p_F = 0.20 + 0.88 p_F(-1) + 0.49 w_F - 0.40 w_F(-1) + 0.12 * \mathbf{0.42} og_F(-1)$$

(0.06) (0.04) (0.06) (0.08) (0.18)

$$p_G = 0.25 + 0.86 * p_G(-1) + 0.10 * w_G + 0.14 * \mathbf{0.42} og_G(-1)$$

(0.04) (0.03) (0.02) (0.18)

$$p_U = -0.002 + 0.70 p_U(-1) + 0.30 w_U + 0.30 * 0.06 og_U(-1) + u_{pu}$$

^{A1} The producer prices are estimated in levels in spite of unit roots. This is the common practise in macroeconomic models where such prices result from a mark-up over wages (cf Taylor 1993).

$$u_{pu} = 0.87 u_{pu}(-1) \\ (0.001) \quad (0.06) \\ (0.06)$$

VOLUME BLOCK

Domestic demand growth

$$\dot{d}_F = 0.016 + 0.67 \dot{d}_F(-1) - 0.34 \dot{d}_F(-2) + 0.23 \dot{d}_F(-3) - 0.19 \dot{d}_F(-4) \\ (0.003)(0.12) \quad (0.14) \quad (0.12) \quad (0.09) \\ + 0.63 [-0.14 r_F(-3) - 0.09(cpi_F(-2) - cpi_F(-6))] \\ (0.02) \quad (0.02)$$

$$\dot{d}_G = 0.016 + 0.08*d911 + 0.26 \dot{d}_G(-1) - 0.24 \dot{d}_G(-2) + 0.20 \dot{d}_G(-3) \\ (0.29) \quad (0.008) \quad (0.08) \quad (0.08) \quad (0.06) \\ + 0.78[-0.14(r_G(-1) - 0.09(cpi_G(-3) - cpi_G(-7)))] \\ (0.02) \quad (0.02)$$

with a first-order autocorrelation for both \dot{d}_F and \dot{d}_G :

$$u_{di} = -0.62 u_{di}(-1) \quad \text{for } i = F, G \\ (0.09)$$

$$\dot{d}_U = 0.01 - 0.20 \dot{d}_U(-1) + 1.20 [-0.21(r_U(-2) - 0.17(cpi_U(-1) - cpi_U(-5)))] \\ (0.002) \quad (0.11) \quad (0.06) \quad (0.06)$$

$$u_{du} = 0.56 u_{du}(-1) \\ (0.10)$$

with r_i the real interest rate and d911 a German reunification dummy.

Exports

$$x_F = -1.54 + 0.73 x_F(-1) + 0.27 [-0.68 (px_F(-1) - pm_F(-1)) + 0.81 (d_G + d_U)]$$

(0.31) (0.05) (0.11) (0.02)

$$x_G = -2.64 + 0.56 x_G(-1) + 0.44 [-0.38 (px_G(-1) - pm_G(-1)) + 0.79 (d_F + d_U)]$$

(0.40) (0.06) (0.07) (0.02)

$$x_U = -0.36 + 0.92 x_U(-1) + 0.05 [-1.2 \Delta (px_U(-1) - pm_U(-1)) + 1.94 (d_G + d_F + d_W)]$$

(0.09) (0.02) (0.34)

with px_i the price of exports, pm_i the price of imports, and d_W the exogenous volume of the domestic demand in G7 countries, other than the three mentioned.

Imports

$$m_F = -1.34 - 0.05 (pm_F(-1) - p_F(-1)) + 1.78 d_F \quad \text{with autocorrelation } u_{mf} = 0.79 u_{mf}(-1)$$

(0.35) (0.05) (0.07) (0.05)

$$m_G = -1.97 + 0.02 d_{904} + 0.68 m_G(-1) + 0.32 (1.75 d_G)$$

(0.32) (0.01) (0.05) (0.04)

$$m_U = -3.24 - 0.21 (pm_U(-1) - p_U(-1)) + 2.06 d_U \quad \text{with autocorrelation } u_{mu} = 0.67 u_{mu}(-1)$$

(0.62) (0.06) (0.06) (0.05)

MAIN IDENTITIES

Consumer price index

$$cpi_i = 0.63 cpi_i(-1) + 0.33 p_i + 0.04 pm_i + p_{0i} \quad i = F, G$$

$$cpi_i = 0.70 cpi_i(-1) + 0.28 p_i + 0.02 pm_i + p_{0i} \quad i = U$$

with p_{0i} representing other determinants of consumer prices (exogenous).

Price of exports

$$px_F = 0.3 px_F (-1) + 0.4 p_F + 0.15 (e_F + p_U) + 0.15 (e_F - e_G + p_G) + pv_F$$

$$px_G = 0.5 px_G (-1) + 0.4 p_G + 0.1 (e_G + p_U) + pv_G$$

$$px_U = 0.84 px_U (-1) + 0.11 p_U + 0.05 (-e_G + p_G) + pv_U$$

with e_G the DM/USD nominal exchange rate, e_F the FF/USD nominal exchange rate, and pv_i the exogenous price of partners other than F,G,U.

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Simulations without shocks to the DM/FF.

Simulated standard dev. (%)	France			Germany			Europe			United States		
	Float	ERM	Emu	Float	ERM	Emu	Float	ERM	Emu	Float	ERM	Emu
CPI inflation (1)	1.06	1.26	1.25	1.16	1.18	1.07	0.96	1.12	0.94	1.53	1.53	1.67
Output gap	1.64	2.12	2.06	2.36	2.50	2.49	1.66	1.72	1.92	1.77	1.80	2.14
Corr. infl/output gap	-0.01	0.37	0.71	-0.51	-0.49	0.03	-0.38	-0.27	0.48	0.23	0.14	0.57
Nom. Interest rate	1.79	1.91	1.96	1.69	1.71	1.96	1.48	1.66	1.96	2.60	2.62	3.08
Real interest rate	1.19	1.47	1.38	1.40	1.34	1.86	1.07	1.30	1.43	1.74	1.85	2.38
Nom. Exch. rate (2)	5.86	4.85	0.00	14.7	15.6	9.56	12.8	14.8	9.56	12.8	14.8	9.56
REER (3)	5.79	8.12	5.13	10.2	9.56	4.95	13.4	15.2	9.80	13.4	15.2	9.80
Correlation output gap/nominal exchange rate (2)	0.28	-0.35	0.00	-0.51	-0.59	-0.13	-0.58	-0.52	-0.00	-0.51	-0.53	-0.17
Simulated correl.	CPI inflation			Output gap			Nominal interest rate					
	Float	ERM	EMU	Float	ERM	EMU	Float	ERM	EMU			
France/Germany	0.25	0.48	0.14	0.31	0.02	0.44	0.17	0.51	1.00			
Europe/UnitedStates	0.38	0.26	-0.33	-0.52	-0.41	-0.71	0.25	0.12	-0.61			

Notes: see Table 5.

Source: model simulations.