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Monetary and real shocks, the business cycle and the value of the euro

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Abstract

The appreciation of the dollar in the aftermath of the launch of the euro came as a surprise to most observers; furthermore, traditional models do not seem to be able to capture the fluctuations of the dollar/euro exchange rate. Is this a confirmation of earlier research according to which no structural model can explain exchange rate dynamics?

More optimistically, this study shows that a structural VAR model of the Mundell-Fleming type well explains the behaviour of the euro and its relationships with the fundamentals. Our estimates indicate that the dollar appreciation is primarily due to the cyclical strength of US demand. By contrast, they do not support the often-voiced theory that the appreciation of the dollar is explained by the "new economy". Finally, the model shows that monetary shocks have limited effects on the exchange rate and very strong ones on inflation.

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Introduction[1]

The strong appreciation of the dollar following the introduction of the euro came as a surprise to the majority of observers. The monetary policy of the ECB, designed to give the new institution anti-inflationary credibility, had been expected to imply higher interest rates than in the United States and hence to create favourable conditions for a lasting appreciation of the euro. Moreover, various other factors should have underpinned the European currency:[2] an increase in the productive potential of the euro area fostered by the creation of the single currency, an inflow of investment aimed at exploiting the opportunities offered by an expanding market, the integration of European financial markets, and possibly a diversification of central banks' official reserve holdings into the euro. What we saw instead was a persistent strengthening of the dollar in 1999 and most of 2000. Furthermore, around this trend there were short-term fluctuations in the dollar exchange rate that were not explained by movements in interest rate differentials or the relative level of real activity. News at times produced an effect contrary to that expected or was ignored by the markets.[3] Finally, the numerous estimations of the equilibrium level of the US currency vary widely and do not allow us to say whether at any given moment in time we were witnessing misalignments and, if so, how pronounced these were. Not surprisingly, therefore, ex post rationalisations were put forward. Inevitably, they proved to be short-lived and unsatisfactory. Among them, the theory that the appreciation of the dollar could be explained by faster productivity growth in the United States, due in turn to the advent of the new economy, was long predominant but, like many others, did not stand the test of time.

All this seems therefore to support the conclusions reached in major research dating as far back as the beginning of the 1980s and confirmed more recently: "Negative findings such as [Meese and Rogoff (1983)], Campbell and Clarida (1987), and Flood and Rose (1993) suggest more than a failure of specific models of exchange rate determination or typical economic difficulties. Instead, such results indicate that no model based on such standard fundamentals like money supplies, real income, interest rates, inflation rates and current account balances will ever succeed in explaining or predicting a high percentage of the variation in the exchange rate, at least at short- or medium-term frequencies".[4] Other research,[5] however, suggests less pessimistic conclusions.

First, it is known - taking, for example, purchasing power parity (PPP) models - that exchange rate dynamics are dominated by short-term factors and that exchange rates are mean-reverting, ie they tend to revert towards a long-term trajectory, probably traced by the long-run trend of productivity. The failure of much empirical research may thus be linked to the fact that the distinction between the transitory and the permanent components of exchange rate dynamics may not have been estimated with sufficient precision (or that it may have been neglected). Second, when analysing the relationship between the business cycle and real exchange rates, it is crucial to distinguish between the shocks that affect the cycle. According to standard Mundell-Fleming models, for example, positive supply shocks tend to raise output, but to depress the exchange rate (competitiveness increases); positive demand shocks, while increasing output, tend instead to push up the exchange rate through the traditional Mundell-Fleming effect, whereby an increase in demand raises the returns on financial assets and attracts capital inflows. Both types of shock, moreover, have permanent effects on the real exchange rate, while monetary shocks have only a temporary impact. This suggests that the relationship between the business cycle, returns on financial assets and exchange rates cannot be robust if the origin of the forces that determine cyclical fluctuations is ignored.

Bearing these considerations in mind, this paper has two complementary objectives. By estimating a trivariate structural VAR (SVAR) the first objective is to test whether and to what extent the scepticism as regards the interpretive power of structural exchange rate models is justified. The second is to identify what kind of shocks have determined the dynamics of the dollar/euro exchange rate, returning,

1 I would like to thank Gabriele Galati and the anonymous referee for the useful suggestions they made to improve the paper. I would also like to thank Angelika Donaubauer and Michela Scatigna for their accurate and timely research assistance.

2 Brooks et al (2001).

3 Galati and Ho (2001).

4 Frankel and Rose (1994) p 29.

5 Eichenbaum and Evans (1994), Clarida and Galí (1994), Detken et al (2002) and Lyons (2001).

in particular, to the question that has traditionally focused research along two major lines: are exchange rates determined by the interaction between monetary shocks and price rigidity (Mussa (1986)), or is it rather real shocks that give rise to exchange rate changes (Meese and Rogoff (1988))? To that end, we will use the structural VAR model that enables the source of shocks and their persistence to be separately identified. The model is used to estimate the determinants of the dollar's exchange rate against the euro. We also estimate the SVAR for the yen, the pound sterling and the Swiss franc to evaluate how general is the explicative power of the proposed approach.

1. Some stylised facts

After bottoming out in 1995, the dollar strengthened markedly and continuously up to early 2002.[6] Against the euro, its maximum cumulative appreciation was 58%, against the yen 59%, against the Swiss franc 76% and against sterling 21%; in nominal effective terms, the appreciation was also sizeable (43%). On the basis of these data, it is not difficult to agree with Bergsten and Williamson when they describe the rise of the US currency thus: "When Larry Summers was at the Treasury Department, he often said that 'the charts of exchange rate movements over the last twenty years revealed the 1980s as the Himalayas and the 1990s as the foothills.' In the past few years, the 1990s have become at least the Alps and maybe the Andes, if not quite the Himalayas of the 1980s".[7]

Since its peaks, the dollar has been losing value at a rapid but orderly pace: –21% against the euro, –24% against the Swiss franc, and –12% and –13% respectively against the yen and sterling. By March 2003, the dollar had given up all its gains over the euro since the latter's introduction (see Graph 1).

The long list of studies which, between 1999 and 2000, attempted to measure the size of this misalignment of the dollar encompasses a broad range of estimation methodologies (PPP, FEER and DEER models, internal and external equilibrium models, interest rate monetary models, etc) and equilibrium values. Koen et al (2001) published a useful summary of estimations of equilibrium values of the euro, which vary, depending on the methodologies used, between 0.87 and 1.45.

These divergences reflect the fact that exchange rate dynamics are not stably correlated with those of economic fundamentals. Thus the exchange rate did not always reflect countries' relative cyclical position (normally represented by the relative trend of real output or of productivity) or the financial asset supply/demand dynamics, again in relative terms, which drive international capital flows.

As regards the dollar/euro exchange rate, its relationship with the main indicators of the relative yield on financial assets (short- or long-term, nominal or real interest rates, and measures of equity market returns) is highly unstable, in that not only is there no constant proportionality between their movements and those of the exchange rate, but also that the correlation changes sign over time. Graph 1 shows the development of the real long-term interest rate differential and the dollar/euro exchange rate. The correlation between the two variables is very unstable between 1986 (not shown in the graph) and 1994. In the four subsequent years, on the other hand, the two series move somewhat more in step, but the correlation is never close. They cease to do so completely during the period of greatest dollar appreciation, resuming only in late 2002 and early 2003. Similar considerations apply for other measures of the relative return on financial assets, making it difficult to infer that the path of the dollar is traced by the main determinants of capital flows. Turning to sterling, it can be seen that a positive relationship between interest rates and the exchange rate exists only for the period 1992–98, during which the UK currency appreciated constantly against its US counterpart. The interest rate differential does not show any relationship with the exchange rate either before 1992 (a period characterised by markedly erratic exchange rate and real interest rate dynamics) or after 1998, when, as in the case of the euro, stable interest rate differentials contrasted with large

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6 The dollar reached lows against the yen and Swiss franc in April 1995, and vis-à-vis the euro in July. Against sterling, the low was not recorded until September 1998. The dates on which the dollar peaked are similarly spread out over time: October 2000 against the euro, November 2000 against the Swiss franc, June 2001 against the pound and February 2002 against the yen.

7 Bergsten and Williamson (2003), p 1.

movements in the US currency, first upwards and then downwards. Finally, no relationship between interest and exchange rates can be statistically identified as regards the yen and the Swiss franc. Simple regressions produce coefficients close to zero.

Equally unsatisfactory results are obtained if seeking a stable and statistically significant connection between, on the one hand, the business cycle represented, in Graph 1, by the ratio of the industrial production index of the four geographical regions to that of the United States and, on the other hand, exchange rates.

A test of the significance of traditional explanatory exchange rate variables based on simple univariate regressions confirms[8] that, in the case of the euro, neither short-term interest rates, nor a relative real GDP growth index, nor stock market returns, nor the current account balance are correlated with the dollar/euro exchange rate. The latter might, however, be correlated with equity portfolio flows from Europe to the United States (despite the absence of correlation between stock market returns and the exchange rate) and with long-term interest rate differentials (note, however, that bond flows and the exchange rate are not correlated).[9] Fender and Galati (2001) have shown that mergers and acquisitions have been correlated with the dollar/euro exchange rate during the period of dollar appreciation.

The surprise of a sharply depreciating euro gave rise to a long series of ex post rationalisations,[10] but these too were not very robust. According to one theory, the euro exchange rate was correlated with expected growth differentials. This theory, which for a while was given a good deal of credence, was based on the results of studies aimed at confirming the existence of a large structural increase in the growth rate of US productive potential. The technology shock caused by the new economy, it was claimed, had pushed up the value of the dollar. After initial success, however, the correlation tended to weaken as early as in 2000. A second explanation is based on the negative effect thought to have been exerted on the euro by the more pronounced rigidities of product and labour markets in Europe compared with the United States. But, obviously, there is no evidence that these rigidities increased after 1999. On the contrary, research by the OECD shows that in the period of euro depreciation these rigidities decreased.[11] A third hypothesis, which casts doubt on the findings of Brooks et al (2001), concerns the fact that European equity market returns surpassed those of the United States in the period of euro depreciation. A fourth argument attributes the weakening of the euro to excessive European bond issuance, but seems to ignore the fact that a large proportion of these issues was placed within the euro area and is therefore of little help in explaining the dollar/euro exchange rate.

2. Monetary exchange rate models

For a more in-depth examination than one based on the mere observation of plotted data or on simple univariate regressions, as in Brooks et al (2001), it is useful to look at the structural models that have been used repeatedly in related empirical research. To that end, three models will be estimated using the most recent data: the flexible price monetary model (FPMM), a more generalised version of the latter (RIRMM), which eliminates the expectations theory of the term structure implicitly assumed by the FPMM, and the real uncovered interest parity (RUIP) model, which postulates a relationship between the real exchange rate and real interest rate differentials. The description of the models that follows is based on MacDonald and Swagel (2000).

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[8] Brooks et al (2001).

[9] See also BIS (2002), p 79.

[10] See also the more extensive treatment by Koen et al (2001), referred to only briefly here, and Meredith (2001).

[11] See Nicoletti and Scarpetta (2003) and the literature referred to there.

Flexible price monetar y model (FPMM)

This model is based on two fundamental hypotheses.[12] First, the PPP holds in the long run (ie the real exchange rate is not fixed at all times; rather, it reverts to its long-run value after having exhibited important transitory fluctuations). Second, there is asset market equilibrium, with financial assets being represented by the money stock.[13] Finally, the model implicitly assumes that the short-term interest rate differential is fully representative of the return on assets, since, under the expectations hypothesis of the term structure, long-term rates are implicitly determined by expected short-term rates.

The traditionally estimated reduced form of the model is the following (the symbols are defined in the footnote):

$$s_t = m'_t - \alpha y'_t + \beta i'_t \qquad (1)$$

In this model, the negative coefficient of the relative level of real activity (the ratio between domestic and foreign output trends) reflects the relationship normally observed between the exchange rate and the business cycle: the exchange rate tends to appreciate in the upward phase of the cycle and depreciate in the downward phase.

As is known, the interpretive power of the model is limited by the fact that "in a flexible price equilibrium, an exchange rate is driven purely by conditions of asset market equilibrium (relative excess money supplies), with goods market conditions having no independent influence". In other words, income influences the exchange rate "only through the demand for assets, with relative prices moving to satisfy asset market equilibrium and not through interest rates, which simply equal expected inflation".[14]

The estimations of this model for the four currencies considered are reported in Table 1 and confirm these interpretive limits.[15]

First, the sign of the coefficient of relative money supply (µ) is always the opposite of that expected; nor is there any evidence that the results are better if the coefficients of the money stocks (M2) are not constrained to be equal. Second, the income coefficient is negative and statistically significant in the case of the euro and sterling, but has the opposite sign to that expected for the other two currencies. The data, therefore, reject the hypothesis that there is a relationship between exchange rate and cycle that is valid independently of the choice of reference currency. In addition, the coefficient on the short-term interest rate differential has the expected sign and is statistically significant only in the case of the euro. Finally, none of the equations is able to explain the dollar cycle that occurred between 1999 and 2003. The size of dollar appreciation between 1999 and 2000 and the subsequent depreciation are markedly underestimated, both when the estimation includes the data up to 2003 and, obviously, when the equation is estimated up to December 1998 and the values of the exchange rates are extrapolated for the rest of the period.

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[12] See MacDonald and Taylor (1992, 1993) and Frankel and Rose (1994).

[13] These hypotheses are represented by the following equations:

$$s_t = p'_t \qquad \text{[PPP]} \qquad (a)$$

$$m'_t - p'_t = \alpha y'_t - \beta i'_t \qquad \text{[money market equilibrium]} \qquad (b)$$

where s_t is the spot exchange rate (quantity of domestic currency per unit of foreign currency), p_t is the price level, m_t is the money stock, y_t is the yield and i_t is the short-term nominal interest rate. The generic variable $x'_t = x_t - x^*_t$ is the relative level of x_t. The asterisk indicates the foreign variable. Combining (a) and (b) gives expression (1) in the text.

[14] MacDonald and Swagel (2000), p 132.

[15] The data used in this paper are the industrial production index, three-month money market interest rates and long-term government bond rates. Real rates are obtained using 12-month CPI inflation. The CPI is also used to obtain real exchange rate values. Before 1999 a measure of synthetic euro is used.

Exchange rates and real interest rates

A variant of the monetary model just discussed is that based on the theory of determining exchange rates using real interest rates.

The real interest rate monetary model (RIRMM) rests on two basic hypotheses.[16] According to the first, the difference between the forward and the spot exchange rate, and hence the expected depreciation (*d*), is equal to the nominal short-term interest rate differential (i'_t), namely $d = i'_t$. The second states that the expected depreciation is a function of the spread $(s_t - \bar{s})$ between the current and the equilibrium exchange rate $(\bar{s})$, and also of the long-run inflation differential (π'), and hence that $d = -\theta(s_t - \bar{s}) + \pi'$. These hypotheses imply that, in the short term, the exchange rate tends to return towards its equilibrium value and that, in equilibrium, it depreciates in proportion to the inflation differential.[17]

The reduced form of the RIRMM model is expressed by:

$$s_t = m'_t - \alpha y'_t + \beta_1 i'_t + \beta_2 \pi' \qquad (2)$$

The empirical test contains the additional hypothesis that the long-term interest rate differential approximates the inflation differential under the assumption that monetary restraint raises long-term rates and gives rise to a lower rate of future inflation.

With the RIRMM too, the econometric results differ from those expected based on the theory. First, the coefficient of the relative money supply (μ) is positive – but different from unity – only for the United Kingdom and Switzerland, and only in the equations where the nominal effective exchange rate is used as the dependent variable (see Table 2). For all the other equations, the coefficient is negative. As regards the other variables, the estimations conform to the theoretical model only in the case of the euro and the Swiss franc (both in the equation where the dependent variable is the bilateral dollar exchange rate and when the effective exchange rate is used). In these equations, the variables have the expected sign and are statistically significant. With reference to the euro, therefore, the results seem to confirm the relationship between exchange rates, the business cycle and returns on financial assets better than do the univariate equations of Brooks et al (2001). For sterling, however, the (short- and long-term) interest rate coefficients are significant, but their signs are opposite to those expected; in the case of the yen, they are not significantly different from zero.

Finally, the relationship between real exchange rates and real long-term interest rates[18] was estimated by considering domestic and foreign interest rates separately (coefficients β and β*, respectively, in Table 3).

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[16] Frankel (1979).

[17] As a formula, this is expressed by:

$$s_t - \bar{s} = -\frac{1}{\theta}\left[i' - \pi'\right] \qquad (a)$$

It is also supposed that, in the long run, PPP holds, and hence that:

$$\bar{s} = \bar{p} - \bar{p}^* \qquad (b)$$

Combining (b) with the traditional equation defining money market equilibrium gives the exchange rate equilibrium equation:

$$\bar{s} = \overline{m}' - \alpha\bar{y}' + \beta'\pi' \qquad (c)$$

In this equation, the interest rate differential is equal to the inflation differential when, for (a), it is $s_t = \bar{s}$.

Substituting (c) into (a) gives the equation for determining the exchange rate (2) in the text, where

$$\beta_1 = -\frac{1}{\theta}, \beta_2 = \frac{1}{\theta} + \beta$$

[18] The references to the literature which supports this approach are in MacDonald and Swagel (2000).

The results match expectations for all the currencies: an increase in the domestic real rate gives rise to currency appreciation, while a rise in foreign rates produces the opposite effect. These results are valid whether the domestic and foreign interest rate coefficients are estimated separately (before the two equations estimated for each currency) or whether the coefficients are constrained to be equal (second equation). But even in this case, the out-of-sample forecasts are not able to explain the recent dollar cycle.

3. Monetary and real shocks, the business cycle and exchange rates

The lack of success of monetary models may be due to the very restrictive hypotheses used for their construction. However, it is suggested here that the limits of these models are principally attributable to the fact that the reduced forms discussed above do not distinguish between the transitory and permanent components of exchange rate dynamics, and that they ignore the circumstance that the exogenous shocks on which the behaviour of the business cycle depends produce different effects on exchange rates depending on the source of the shock.

This suggests that a traditional Mundell-Fleming type stochastic model that takes explicit account of the source of the shocks that determine the dynamics of economic fundamentals can be a promising alternative. An "eclectic" stochastic SVAR model of this type is the two-country one proposed by Clarida and Galí (1994). This is used here to explain the (real and nominal) exchange rate of the dollar against the other major currencies, with particular attention to the euro.[19]

The SVAR has two basic features. First, the exchange rate is determined by the conditions that ensure equilibrium in goods and asset markets simultaneously. The second feature is that, once the stochastic behaviour of the model has been specified, it is possible to choose between two important and opposing hypotheses concerning the origin of exchange rate changes. On the one hand, Mussa (1986) asserted that price rigidity and the existence of monetary shocks played a major role in explaining exchange rate developments after the abandonment of the Bretton Woods system. The opposite conclusion was drawn by Stockman (1987), who argued that real exchange rate dynamics depend mainly on real shocks. This hypothesis is supported by the work of Meese and Rogoff (1988), who show that there is no empirical evidence that real exchange rate fluctuations are due to the interaction of rigid prices and monetary shocks.

With a view to testing which of the opposing conclusions is consistent with the data, Clarida and Galí specify a particular stochastic process for each of the variables of the model and adopt an econometric approach that enables the various shocks to be identified.

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[19] The Clarida-Galí model is made up of the following four equations:

$$y_t^d = d_t + \eta(s_t - p_t) - \sigma[i_t - E_t(p_{t+1} - p_t)] \quad (1)$$

$$p_t = (1-\theta)E_{t-1}p_t^e + \theta\, p_t^e \quad (2)$$

$$m_t^s - p_t = y_t - \lambda i_t \quad (3)$$

$$i_t = E_t(s_{t+1} - s_t) \quad (4)$$

where y_t^d is GDP, d_t is a real demand shock, s_t is the spot exchange rate, p_t is the price level, p_t^e is the equilibrium price level, m_t^s is the money supply, i_t is the nominal interest rate and E is the expectations operator. As in the Clarida-Galí model, all variables except the interest rate represent the value of the variables in a given country relative to those abroad.

The first equation represents a standard IS curve: output rises if there is a positive demand shock (d_t) and if the real exchange rate depreciates; output falls if the real interest rate increases. The second equation defines price formation: if $\theta = 1$, prices immediately adjust to the equilibrium level p_t^e ; otherwise prices are fixed $(\theta = 0)$. If $0 \le \theta \le 1$, the model is, in the short run, similar to a Dornbusch type sticky price model. The third equation is a traditional LM curve and the fourth represents the UIP.

There are three main identifying assumptions. The first is that in equilibrium the level of activity depends only on supply shocks. These synthesise all real shocks (such as the introduction of new technologies or exogenous terms-of-trade changes) that have a permanent impact on the level of output. The second is that real demand shocks (δ_t) have only a temporary impact on output but may have a permanent influence on the exchange rate (real and nominal).[20] Finally, the model assumes that money is neutral, ie that monetary shocks do not have a permanent impact on the real exchange rate and output.[21]

Thus in equilibrium, the model has a lower triangular structure[22] and possesses the following properties. The level of output is influenced solely by supply shocks. The real exchange rate permanently depreciates as a result of permanent positive supply shocks and appreciates as a result of positive permanent demand shocks. Nominal shocks do not impact the value of the real equilibrium exchange rate. Prices are completely flexible. Their equilibrium level rises in response to a positive demand shock or a monetary shock and falls following a positive supply shock. In the short-run, prices are sticky and the coefficients of the SVAR are unconstrained. As a consequence, the level of output depends on all three types of shock and the real exchange rate is also affected by nominal shocks. A permanent positive (negative) nominal shock produces a real depreciation (appreciation), but by construction the real depreciation (appreciation) is only transitory.

The econometric approach necessary to identify the three shocks is that proposed by Blanchard and Quah (1989).[23]

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20 The model also assumes that a fraction γ of a demand shock occurring at time *t* may have the opposite sign in the following period.

21 Even if, ideally, it would be preferable to model the stochastic process that guides the model in such a way that the three fundamental variables are affected by temporary as well as permanent shocks, Clarida and Galí assume, for the sake of simplicity, that supply and monetary shocks are random walks and therefore permanent.

22 Resolving forwards the model yields the following system:

$$y_t^e = y_t^s$$

$$q_t^e = \left(y_t^s - d_t\right)/\eta + \left[\eta(\eta + \sigma)\right]^{-1}\sigma\gamma\delta_t$$

$$p_t^e = m_t - y_t^s + \lambda(1+\lambda)^{-1}(\eta+\sigma)^{-1}\gamma\delta_t .$$

23 Blanchard and Quah's model is given by

$$x_t = \theta(L)\varepsilon_t \qquad (1)$$

where x_t is the vector of the endogenous variables, $\theta(L)$ is a quadratic matrix polynomial θ_i , *L* is the lag operator and ε_t is the vector of the unknown structural shocks. The unrestricted estimation of (1) gives the MA representation of the model

$$x_t = \mathbf{R}(\mathrm{L})\, e_t \qquad (2)$$

where the first matrix of the polynomial equation **R**(L) = **R** + $\mathbf{R}_2$L + $\mathbf{R}_3$L^2 + … is the identity matrix, and e_t is the vector of the estimated residuals whose variance and covariance matrix is Σ.

From [1] and [2], it is possible to derive the relationship between the residuals and the structural shocks:

$$e_t = \theta_0\varepsilon_t \qquad (3)$$

The restrictions necessary to identify the structural shocks are as follows: assume that the matrix

$$\theta(1) = \theta_0 + \theta_1 \ldots\ldots$$

has values equal to one along the main diagonal, that the shocks are independent and that the matrix θ (1) is lower triangular.

From equations [1]-[3] we obtain **R**(1) = $\theta(1)\theta_0^{-1}$.

4. Estimation results

By estimating the SVAR described in the previous section[24] we will attempt to answer the questions posed at the beginning of this paper. How far does a traditional structural model like that used here explain the pronounced dollar cycle that occurred after the introduction of the euro? Are the short-run and cyclical fluctuations in the US currency attributable mainly to monetary or to real shocks? What role was played by the supply or technology shocks so often adduced to explain the prolonged depreciation of the euro? Did the dollar's appreciation in the second half of the 1990s represent an increase in the equilibrium value of the US currency, or was it rather just a temporary phenomenon?

A plausible answer to these questions can only be obtained from the empirical evidence if the estimated impulse response functions are in line with those of the theoretical model.

As regards the estimations for the euro (Graph 2), the path of the impulse responses fully matches that of the theoretical model and their values are significantly different from zero, as can be seen from the confidence bands shown in the graph. Thus a supply shock immediately raises the level of activity. Over time this converges towards a steady state level higher than the starting level. The shock also leads to the expected depreciation of the real exchange rate, reflecting both the reduction in the price level caused by the shock and, above all, the accompanying nominal depreciation.[25] A demand shock, for its part, has the expected inflationary effects. It gives rise to a temporary increase in real activity that peaks after around 18 months and fades away after around 36 months. It also generates a permanent rise in the price level (ie a temporary increase in inflation) and an appreciation of the real exchange rate. The latter is greater than the rise in prices because the shock also leads to an appreciation of the nominal exchange rate. Finally, similar inflationary effects (a temporary rise in real activity and in inflation) are produced by a positive nominal shock due to monetary expansion. This also generates a real exchange rate depreciation owing to a nominal depreciation that is proportionately greater than the increase in prices. The graph shows that the impact of nominal shocks on the real variables is only temporary, with the level of activity and of the real exchange rate converging towards their starting values after around 36 months.

These results are more encouraging than those of a comparable study by Detken et al (2002) . In the section of the study where the authors use the same approach employed here, they obtain results that, in their own assessment, are not "fully convincing". This is because the various shocks, while explaining a large part of the exchange rate dynamics, do not appear to have a significant impact on the fundamentals. Hence the behaviour of the exchange rate would appear to be largely independent of what happens to real activity, prices and money. In fact, in the Detken et al study supply shocks genera te a non-significant response of the real exchange rate, while real demand shocks have no impact on output and produce only a "very temporary positive effect on relative prices".[26] Finally, nominal shocks do not have any effect on the real exchange rate since a monetary expansion appears to engender a nominal exchange rate depreciation that is completely and immediately absorbed by a rise in prices. The pass-through effect implicit in these dynamics therefore does not seem realistic.

The contrast between our results and those of Detken et al seems to be principally attributable to the different frequency of the data used (monthly in our case and quarterly in their study). However, the

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The Cholesky decomposition $\mathbf{R}(1)\,\Sigma\,\mathbf{R}(1)'$ gives $\theta(1)$ and therefore $\theta_0 = \mathbf{R}(1)^{-1}\,\theta(1)$. This makes it possible to calculate an estimate of the unobservable structural shocks.

24 The system was estimated for the period 1981.1–2002.12 using natural logs of monthly data for the industrial production index, dollar exchange rates and consumer price indices. As the variables are not stationary the SVAR was estimated using the first differences of the variables. Cointegration tests indicate that there is at least one cointegrating vector. This allows us to decompose the dynamics of the variables into permanent and transitory components (see MacDonald and Swagel (2000)). There were 12 lags in each equation, chosen on the basis of the Akaike information criterion.

25 Note that the model does not estimate the effects of shocks on the nominal exchange rate. These are obtained algebraically from the effects produced on the real exchange rate and the (relative) price level.

26 Detken et al (2002), pp 19-20.

difference in the basic data used (real GDP and GDP deflator in their study vs industrial production and CPI in ours) does not appear to matter much.[27]

In our case, though, the estimates of the VAR model for the yen, sterling and the Swiss franc confirm the results of Detken et al (2002). According to these results, not reported here, the various shocks do not appear to have a significant influence on the fundamentals (the level of activity and prices) or on exchange rates, or their effect on these variables at times has the opposite sign to that expected.

Hence the answers to the questions posed at the start of this section relate only to the empirical evidence on the dynamics of the euro.

An examination of the variance decomposition (see Table 4) reveals that the development of the euro exchange rate, in both real and nominal terms, is predominantly due to real demand shocks. The impact of such shocks on the exchange rate is equal to 97% for the real rate and 99% for the nominal rate. Over time these percentages decline, but at the end of the period of extrapolation they converge on levels still above 67%. Correspondingly, the proportion of the variance explained by supply shocks rises: starting from very low levels, at the end of the period this stands at 32.6% for the real exchange rate and 28.5% for the nominal rate. Thus the hypothesis that the increase in productivity in the United States in 1999 and 2000 is the primary determinant of the depreciation of the euro in its first two years of existence does not appear to be borne out by the empirical evidence presented here. Nor, as the model clearly shows, are the temporary or cyclical fluctuations in the euro attributable to monetary policy (the interaction between monetary shocks and price rigidity), as maintained by Mussa, given that the variance of the euro explained by such shocks does not exceed 1.5% for the real exchange rate and 4% for the nominal rate.

These results indirectly confirm two important conclusions reached by Clarida and Galí as far back as 1994 when they stated that "... virtually all of the dollar's real depreciation against the DM in the late 1970s is attributed to nominal shock, while most of the dollar's real appreciation against the DM in the first half of the 1980s is attributed to demand shock",[28] with the consequence that "... in light of the variance decomposition results ..., monetary shocks are attributed only a trivial role in accounting for the history of the dollar".[29] As regards supply shocks, our estimations are similar, albeit not identical, to those of Clarida and Galí: "Supply shocks are not attributed a significant role in explaining the dollar-DM real exchange rate since the collapse of Bretton Woods".[30]

Finally, an examination of the historical variance decomposition, ie the decomposition of the dynamics of the exchange rate over time into the components due to the effects produced by each of the three shocks considered in isolation, enables us to obtain further insights. We would expect to observe an appreciation of the exchange rate during periods of expanding demand or because of negative supply shocks, and, conversely, a depreciation when relative demand falls or when positive technology shocks occur.

Graph 3 confirms these expectations and suggests four main conclusions.

First, the evolution of the euro over time (in both real and nominal terms) is dominated, over the last 20 years, by the effects produced by demand shocks: the short-run or cyclical variations due to exogenous shocks of this type closely parallel the path of the exchange rate. A partial exception is the period from the late 1980s to 1991, when sustained (albeit variable) demand does not prevent a trend depreciation of the dollar.

The second major conclusion is that at no time do nominal or monetary shocks explain much of the dynamics of the dollar.

Third, supply shocks appear to shadow the long-term trend of the dollar. As already noted, however, their quantitative impact is relatively modest compared with that of demand shocks. It is therefore difficult to identify prolonged periods during which there is a close correlation between the exchange

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[27] The check was conducted by re-estimating our SVAR, where the indices of industrial production and CPI were replaced by real GDP and the GDP deflator. The estimates are very similar to those obtained by Detken et al.

[28] Clarida and Galí (1994), p 38.

[29] Clarida and Galí (1994), p 39.

[30] Clarida and Galí (1994), p 39.

rate and the contribution of supply shocks. This is particularly true for the period following the introduction of the euro, whose rapid, uninterrupted decline in fact coincided with constant and even diminishing values for the contribution of supply shocks.

This contrasts with the conclusion reached by Corsetti and Pesenti (1999), and taken up by Coppel et al (2000), whereby a sizeable part of the dollar's appreciation is to be attributed to the advent of the new economy. According to these authors, the increase in productivity due to technological innovation boosted economic growth and the profitability of investment in the United States, driving up the value of the US currency. The estimates presented here instead suggest that the strengthening of the dollar up to 2000 and its return to 1999 levels in 2003 are due to the relative demand cycle.

Fourth, the empirical evidence does not appear to indicate that demand shocks had persistent effects on the exchange rate. It is therefore likely that the dollar's appreciation which took place between 1999 and 2000 does not wholly represent an increase in its equilibrium value, but rather some overshooting of the equilibrium value.

Moreover, the importance of demand shocks in explaining the exchange rate behaviour of the dollar does not appear to be confined only to the euro. Graph 4 shows that such shocks explain the major part of the variance of the real rate of the dollar against the yen, sterling and the Swiss franc. For these three currencies, supply shocks are considerably less important than for the euro, while the share of monetary shocks in the variance of the real and nominal exchange rate is proportionately greater, as in the case of the Swiss franc. For the latter, they explain a large share of the variance of the real exchange rate (a 40% impact; see Table 4) which, although gradually decreasing over time, remains at significantly higher values than those estimated for the other currencies.

Conclusions

The unexpected weakness of the euro against the dollar in the period immediately following its introduction, and the reversal of this trend from autumn 2000 onwards, strengthened the conviction that the dynamics of the major currencies in the international markets cannot be interpreted on the basis of traditional exchange rate models.

More optimistically, however, the present paper finds that an "eclectic" Mundell-Fleming type stochastic model offers a good explanation of the dynamics of the euro/dollar exchange rate and its link to economic fundamentals.

The empirical evidence produced here suggests that the recent movements of the euro against the dollar are dominated by the economic cycle and very short-run transitory factors. Based on the estimations presented, the cyclical dynamics of relative demand account for over two thirds of the variability of the euro.

At the same time, the model does not support the often-voiced theory that the depreciation of the euro between 1999 and 2000 was the consequence of the contemporaneous acceleration in productivity seen in the United States. Supply shocks such as those induced by the new economy seem rather to explain the long-term evolution of the US currency but not its short-run movements. The empirical evidence produced in this paper shows that the effects of supply shocks gradually pushed up the value of the dollar from the early 1990s onwards, but that the fluctuations of the exchange rate around this rising trend were modulated by demand. The model estimated here also seems to suggest that the path of the dollar follows a mean-reverting process in that, as the effects of temporary or cyclical shocks diminish, the level of the US currency converges towards the long-run value traced by the contribution of supply shocks. The predominance of demand in explaining the exchange rate dynamics of the dollar relates not only to its bilateral parity vis-à-vis the euro but also to that against the yen, the pound sterling and the Swiss franc. The empirical evidence also shows that the impact of monetary policy on (real and nominal) exchange rates is negligible, a conclusion already reached in other studies. Only in the case of the Swiss franc does the empirical evidence indicate that monetary policy produces a substantial effect.

While bearing in mind that the model does not provide satisfactory answers in the case of currencies other than the euro, these results do suggest some implications for economic policy that tally, directly or indirectly, with other studies.[31]

A first implication is that changes in bilateral exchange rates between the major currencies are a consequence of the lack of synchronisation in the international business cycle. This is consistent with the observation that the large and persistent exchange rate misalignments of the 1970s and 1980s became less pronounced in more recent years as a result of the greater cyclical correlation across economies and, at the same time, of the lower variability of real activity in each country.

A second possible inference is that real exchange rate changes due to the divergence in cyclical positions across countries can act as automatic equilibrating mechanisms for the international economy. One obvious mechanism is that whereby an exchange rate strengthening due to an economic expansion tends over time to slow the more rapid growth relative to economies experiencing a real depreciation as a result of recession. In addition, the results obtained here support the view that exchange rate fluctuations due to cyclical differences tend to stabilise global inflation because of the effects of opposite sign which the exchange rate changes induce in the price level in each economy.

A third implication is that the emphasis placed by monetary policy on the pursuit of domestic objectives (controlling inflation and the business cycle), rather than on the external objective of exchange rate stability, seems to be justified by the importance of such shocks for the control of inflation.

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[31] See for example IMF (2000), Mussa et al (2000) and OECD (2001).

References

Bank for International Settlements (2002): *72nd Annual Report*, Basel, July.

Bergsten, C F and J Williamson (eds) (2003): "Dollar overvaluation and the world economy", Institute for International Economics, *Special Report* 16, February.

Blanchard, O and D Quah (1989): "The dynamic effects of aggregate demand and supply disturbances", *American Economic Review*, no 79, pp 655-73.

Brooks, R, H Edison, M Kumar and T Slok (2001): "Exchange rates and capital flows", *IMF Working Paper*, WP/01/190, November.

Campbell, J and R Clarida (1987): "The dollar and real interest rates", *Carnegie-Rochester Conference Series on Public Policy*, no 27, August.

Clarida, R and J Galí (1994): "Sources of real exchange rate fluctuations: how important are nominal shocks?", *National Bureau of Economic Research Working Paper Series*, no 4658.

Coppel, J M, M Durand and I Visco (2000): "EMU, the euro and the European policy mix*", OECD Working Paper*, no 232.

Corsetti, G and P Pesenti (1999): "Stability, asymmetry and discontinuity: the launch of European Monetary Union", *Brookings Papers on Economic Activity*", no 2, pp 295-372.

Detken, C, A Dieppe, J Henry, C Marin and F Smets (2002): "Model uncertainty and the equilibrium value of the real effective euro exchange rate", *European Central Bank Working Paper Series*, no 160.

Eichenbaum, M and C Evans (1994): "Some empirical evidence on the effects of shocks to monetary policy on exchange rates", *The Quarterly Journal of Economics*, vol CX, Issue 4, pp 975-1009.

Fender, I and G Galati (2001): "The impact of transatlantic M&A activity on the dollar/euro exchange rate", *BIS Quarterly Review*, pp 58-68, December.

Flood, R and A K Rose (1993): "Fixing exchange rates: a virtual quest for fundamentals", *NBER Working Paper Series*, no 4503, October.

Frankel, J A (1979): "On the mark: a theory of floating exchange rates based on real interest differentials", *The American Economic Review*, vol 69, Issue 4, pp 610-22, September.

Frankel, J A and A K Rose (1994): "A survey of empirical research on nominal exchange rates", *NBER Working Paper Series*, no 4865, September.

Galati, G and C Ho (2003): "Macroeconomic news and the euro/dollar exchange rate", *Economic Notes*, no 32 (2), pp. 371-398.

International Monetary Fund (2000), *World Economic Outlook Supporting Studies*, Washington.

Koen, V, L Boone, A De Serres and N Fuchs (2001): "Tracking the euro", *OECD Economics Department Working Papers*, no 298, June.

Lyons, R K (2001): The microstructure approach to exchange rates, MIT Press, December.

Macdonald, R and M P Taylor (1992): "Exchange rate economics: a survey", *IMF Staff Papers*, vol 39, no 1, March, pp 1-57.

——— (1993): "The monetary approach to the exchange rate", *IMF Staff Papers*, vol 40, no 1, March, pp 89-106.

Macdonald, R and P Swagel (2000): "Business cycle influences on exchange rates: survey and evidence", *IMF World Economic Outlook Supporting Studies*, Chapter IV, pp 129-60.

Meese, M and K Rogoff (1983): "The out-of-sample failure of empirical exchange rate models: sampling error or misspecification?" in, J A Frenkel (ed), *Exchange rates and international macroeconomics*, University of Chicago Press, Chicago, pp 67-112.

——— (1988): "Was it real? The exchange rate-interest rate differential relation over the modern floating-rate period", *Journal of Finance*, vol 43, pp 933-48.

Meredith, G (2001): "Why has the euro been so weak?", *IMF Working Paper*, WP/01/155, October.

Mussa, M (1986): “Nominal exchange rate regimes and the behaviour of real exchange rates: evidence and implications”, *Carnegie-Rochester Conference Series on Public Policy*, no 26.

Mussa, M, P Masson, A Swoboda, E Jadresic, P Mauro and A Berg (2000): “Exchange rate regimes in an increasingly integrated world economy”, *IMF Occasional Paper*, no 193.

Nicoletti, G and S Scarpetta (2003): “Regulation, productivity and growth: OECD evidence”, *Economics Department Working Papers*, no 347, Organisation for Economic Co-operation and Development, January.

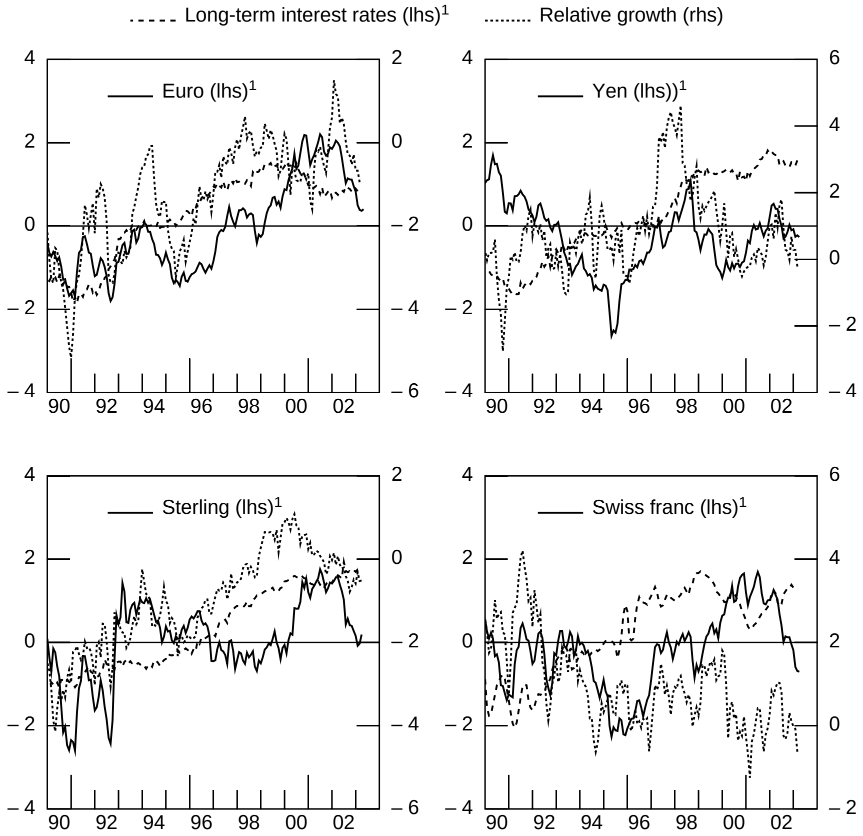
Organisation for Economic Co-operation and Development (2001): *OECD Economic Outlook*, vol 2001/2, no 70, December.

Stockman, A (1987): “The equilibrium approach to exchange rates”, *Federal Reserve Bank of Richmond Economic Review*, vol 73, no 2, March-April, pp 12-30.

Graphs and tables

Graph 1

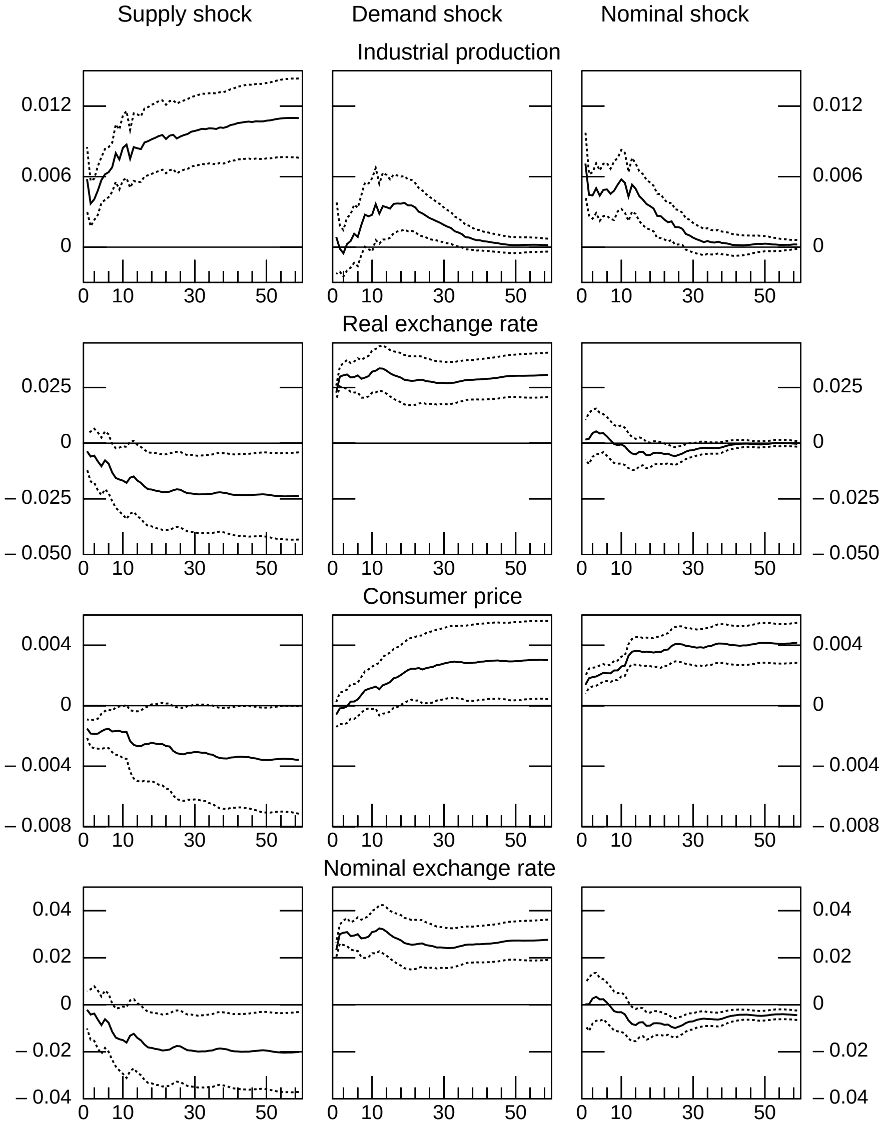
Dollar exchange rates, real long-term interest rate differentials and relative growth



[1] Normalised data.

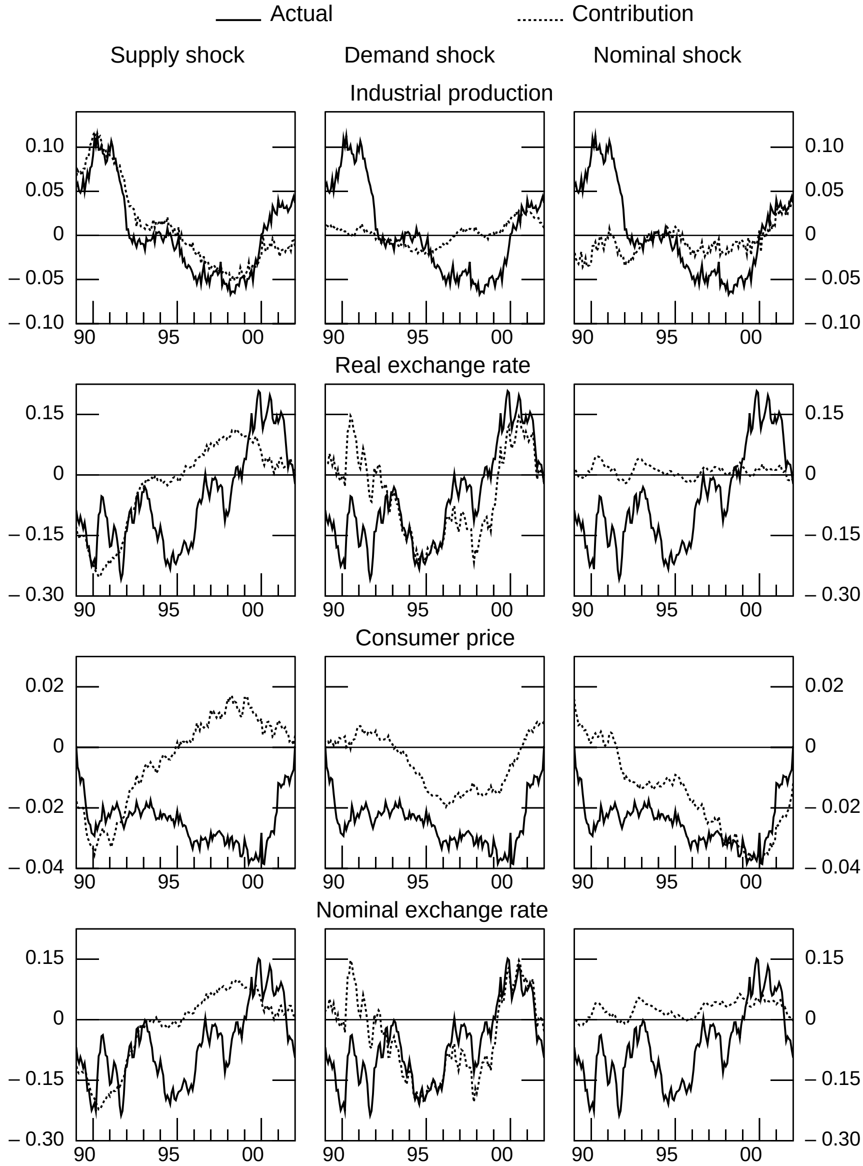
Graph 2

Impulse response of euro area fundamentals to real and nominal shocks



Graph 3

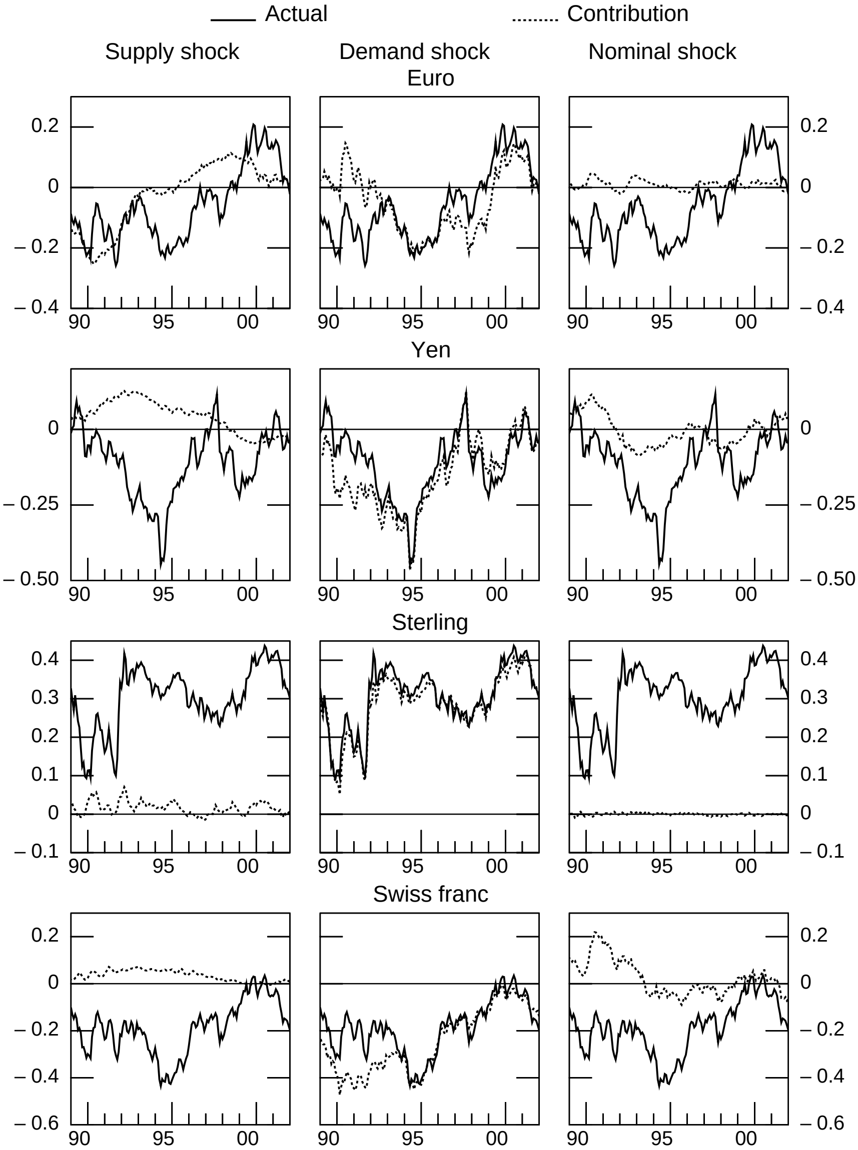
Historical decomposition of euro area fundamentals[1]



[1] Actual values and cumulative contribution of individual shocks (deviation from baseline).

Graph 4

Historical decomposition of real dollar exchange rates of major currencies[1]



[1] Actual values and cumulative contribution of individual shocks (deviation from baseline).

Table 1

Flexible price monetary model

Currencies/countries	**Dollar exchange rates**			R^2c
	μ	α	β	
Euro	–1.0312 (–10.9)	–1.9207 (–11.4)	0.0121 (3.0)	0.511
Yen	–1.3104 (–11.5)	0.6173 (8.6)	0.0070 (1.6)	0.509
Sterling	–0.1449 (–4.2)	–0.2778 (–3.7)	–0.0165 (–6.0)	0.302
Swiss franc	–0.9947 (–11.7)	0.5204 (4.7)	–0.0144 (–4.3)	0.399
	Effective exchange rates			
Euro area	–0.5039 (–8.8)	–1.0184 (–10.0)	0.0035 (1.4)	0.493
Japan	–0.8458 (–8.2)	0.8650 (13.4)	0.0062 (1.5)	0.638
United Kingdom	0.2920 (11.2)	0.9961 (17.9)	–0.0231 (–11.1)	0.622
Switzerland	0.0182 (0.5)	0.5159 (9.9)	0.0006 (0.4)	0.473

Table 2

Real exchange rate monetary model

Currencies/countries	Dollar exchange rates				R^2c
	μ	α	β_1	β_2	
Euro	–0.8924 (–7.1)	–1.6578 (–7.2)	0.0160 (3.5)	–0.0214 (–1.7)	0.516
Yen	–1.3435 (–10.6)	0.6195 (8.7)	0.0040 (0.6)	0.0081 (0.6)	0.508
Sterling	–0.2216 (–6.6)	–0.6278 (–7.4)	–0.0275 (–9.2)	0.0471 (6.8)	0.430
Swiss franc	–0.9217 (–11.3)	–0.0271 (–0.2)	0.0089 (1.6)	–0.0466 (–4.9)	0.463
	Effective exchange rates				
Euro area	–0.3820 (–5.1)	–0.7874 (–5.8)	0.0069 (2.5)	–0.0188 (–2.5)	0.506
Japan	–0.8473 (–7.4)	0.8651 (13.4)	0.0061 (1.0)	0.0004 (0.0)	0.636
United Kingdom	0.2057 (9.7)	0.6021 (11.2)	–0.0354 (–18.7)	0.0530 (12.0)	0.779
Switzerland	0.0662 (1.8)	0.1554 (2.3)	0.0160 (6.3)	–0.0307 (–7.3)	0.583

Table 3

Real exchange rate changes and real long–term interest rate differentials

Currencies/ countries	Long–term interest rates		R^2c	Currencies/ countries	Long–term interest rates		R^2c
	β	β*			β	β*	
Euro area				United Kingdom			
Euro	–0.0956 (–19.6)	0.0297 (4.5)	0.680	Sterling	–0.0106 (–3.7)	0.0214 (5.9)	0.079
	–0.0832 (–13.7)		0.476		–0.0120 (–4.1)		0.039
Effective exchange rate	–0.0483 (–17.5)	0.0037 (1.0)	0.664	Effective exchange rate	0.0422 (9.4)	0.0122 (2.0)	0.432
	–0.0399 (–10.7)		0.358		0.0320 (5.9)		0.143
Japan				Switzerland			
Yen	–0.0359 (–6.5)	0.0216 (3.1)	0.105	Swiss franc	–0.0660 (–13.6)	0.0294 (8.4)	0.340
	–0.0342 (–6.2)		0.088		–0.0392 (–11.2)		0.246
Effective exchange rate	–0.0265 (–5.6)	–0.0011 (–0.2)	0.142	Effective exchange rate	–0.0384 (–16.7)	–0.0008 (–0.5)	0.457
	–0.0233 (–4.7)		0.051		–0.0097 (–4.8)		0.053

Table 4

Effects of real and nominal shocks on fundamentals

(variance decomposition)

Month	Source of shock											
	Supply	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**
	Industrial production			**Real exchange rate**			**Nominal exchange rate**			**Consumer prices**		
	Euro area											
1	39.4	0.9	59.7	2.5	97.0	0.5	0.8	99.1	–	50.2	7.6	42.2
12	58.7	4.9	36.4	13.6	85.6	0.9	10.9	88.4	0.6	36.0	6.7	57.2
24	68.7	8.7	22.6	22.4	76.3	1.3	18.8	77.8	3.4	30.3	14.3	55.4
36	78.0	7.0	14.9	28.3	70.5	1.2	24.2	71.7	4.1	30.1	18.5	51.4
48	84.1	5.1	10.8	31.1	68.0	0.9	27.0	69.3	3.7	30.9	20.2	48.9
60	87.8	3.9	8.3	32.6	66.7	0.7	28.6	68.2	3.2	31.4	21.1	47.6
	Japan											
1	3.7	12.4	83.9	–	91.8	8.2	3.1	90.5	6.3	90.5	8.9	0.6
12	20.6	4.2	75.2	0.2	91.8	8.1	1.4	94.2	4.4	74.0	5.5	20.6
24	42.4	2.5	55.1	0.8	91.0	8.2	5.8	91.4	2.8	63.5	4.0	32.5
36	59.4	1.7	38.9	2.2	91.5	6.4	10.2	88.0	1.8	58.9	3.4	37.7
48	70.2	1.2	28.6	3.6	91.5	4.9	13.6	84.7	1.7	56.5	3.1	40.4
60	77.1	0.9	22.0	4.8	91.4	3.9	16.0	82.0	2.0	55.0	3.0	42.0
	United Kingdom											
1	81.4	12.0	6.6	12.2	87.4	0.4	14.3	79.5	6.1	8.1	2.3	89.5
12	90.6	6.0	3.4	5.5	94.4	0.1	6.1	89.1	4.8	2.4	0.5	97.1
24	94.0	3.6	2.3	2.6	97.3	0.1	2.8	90.3	6.9	1.8	0.4	97.8
36	95.7	2.6	1.7	1.7	98.2	0.1	1.8	89.9	8.3	1.9	0.3	97.8
48	96.6	2.0	1.3	1.3	98.6	0.1	1.4	89.4	9.2	2.1	0.2	97.7
60	97.2	1.7	1.1	1.0	98.9	–	1.1	89.0	9.9	2.2	0.2	97.6
	Switzerland											
1	88.2	7.5	4.3	0.3	59.5	40.2	1.0	70.6	28.4	12.8	40.6	46.6
12	85.8	5.0	9.2	0.2	63.5	36.3	0.8	74.3	24.9	19.7	21.0	59.3
24	89.1	3.3	7.6	0.4	72.3	27.3	1.9	83.4	14.7	18.3	17.8	63.8
36	91.6	2.4	6.1	0.9	78.1	21.0	3.3	87.4	9.2	17.9	16.3	65.9
48	93.3	1.8	4.9	1.5	82.0	16.5	4.6	88.8	6.6	17.7	15.4	66.9
60	94.5	1.5	4.0	2.1	84.6	13.3	5.8	88.8	5.4	17.5	14.9	67.6

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