SONDERFORSCHUNGSBEREICH 303

„INFORMATION UND

KOORDINATION WIRTSCHAFTLICHER AKTIVITÄTEN“

Projektbereich B
Discussion Paper No. B-420

SOURCES OF PURCHASING POWER DISPARITIES: EUROPE VERSUS THE UNITED STATES

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November 1997

ABSTRACT

In order to design appropriate exchange rate policies, it is instrumental to understand the sources of real and nominal exchange rate movements. We apply and extend the structural vector autoregressive (SVAR) model of Clarida and Galí (1994) in order to identify the importance of various types of real shocks (labour supply, aggregate supply and aggregate demand) and nominal shocks (money demand and money supply) for European and transatlantic exchange rate movements. It is found that whilst real and nominal U.S. dollar exchange rates are driven predominantly by relative demand shocks, European real and nominal exchange rate movements have distinctly different roots. The bulk of European relative price and nominal exchange rate movements can be explained by the differential long-run impact of monetary policy, and moving to EMU will eliminate both. However, misaligments are likely to persist between the Euro-area and the economies outside the Union. It is argued that for these fringe currencies the pegging the exchange rate vis-a-vis the Euro has to be supplemented by special institutional arrangements (formal policy coordination or a currency board) in order to avoid potentially destabilizing asymmetric monetary policy shocks.

JEL classification: F0, F3

Keywords: purchasing power parity, exchange rates, shocks, structural vector autoregression, impulse response functions, variance decompositions

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*) This work is also part of a CEPR research programme on Macroeconomics, Politics and Growth in Europe (grant No. ERBCHRXCT930234). Financial support by the Commission of the European Communities under its Human Capital and Mobility Programme is gratefully acknowledged. I should like to thank David Begg, John Rogers, Allan Taylor, Harris Dellas, Werner Röger, and participants at a CEPR workshop in Brussels and a joint CEPR/PIES Conference at Georgetown University, Washington D.C., for useful discussions and comments. The usual disclaimer applies.

1. Introduction

When attempting to explain real exchange rate movements one typically faces the problem that only few macro variables are found to be significantly connected with real exchange rate movements. For example, there is no clear connection between the behaviour of real exchange rates and a country's experience with inflation or money growth. Instead, real exchange rates are frequently viewed as reflecting primarily real factors, such as real productivity growth differentials (Balassa-Samuelson), accumulated current account imbalances, movements in the terms of trade or the relative price of traded and non-traded goods, trade restrictions, tax policies, government spending, and so on. But the details of the links between these real variables and the real exchange rate have not yet been worked out empirically and economist to date have failed to systematically link real exchange rate movements to obvious economic fundamentals.

Real exchange rates are typically measured in terms of deviations from purchasing power parity (PPP). A well-established stylized fact in international economics is that PPP holds less well under the flexible exchange rates that have prevailed since the early 1970s than under fixed rates. Furthermore, PPP deviations tend to be quite substantial and relatively persistent. This can be seen from Figure 1, which displays the nominal bilateral DM/$ exchange rate against the ratio of consumer prices in the United States relative to Germany. It is obvious that the consumer price ratios have moved substantially less than the corresponding exchange rate, and hence there are substantial real exchange rate misalignments. PPP, therefore, does not seem to hold very well. The same is true in Figure 2a to 2d for each bilateral combination of selected European countries against the U.S. dollar. Based on these data PPP is typically judged to be a bad approximation of both the short-term and medium-term properties of the data, since persistent movements and long-term swings in real exchange rates exist. Figure 2e to 2h shown that this important stylized fact in international economics applies to the U.S.

dollar, but not to intra-European exchange rates. European exchange rates relative to the German mark obviously behave differently, and in Europe relative PPP appears to hold quite well. On average, intra-European PPP deviations are much smaller (by a factor 3) and substantially less variable. How can we explain this fact? Does the obvious difference between the intra-European and transatlantic violations of PPP have any strong policy implications, and what does this suggest for the future exchange rate policy of the Euro? This paper will try to address these issues.

In a recent PPP survey, Rogoff (1996) notes that most explanations of short-term nominal exchange rate volatility suggest a large role for monetary and financial shocks as opposed to real shocks to technology, productivity or preferences, which typically are considered not to be volatile enough to explain this phenomenon. If nominal shocks dominate short-term nominal exchange rate movements, they must also account for most of the short-run real exchange rate changes in the face of sticky prices and wages. But prices and wages will ultimately adjust in the long run. Why then do transatlantic deviations from PPP die out at such a low rate (of 15 percent per year)? Again, the PPP puzzle suggests that some real disturbances, rather than nominal shocks, must be important for real exchange rates in the medium-run to long run. Cassel (1922), on the other hand, has argued that PPP appears to frequently hold better under managed as opposed to fixed exchange rates. Cassel explains this in terms of the exchange rate targeting policies which use PPP as a benchmark to which nominal exchange rates are re-set to restore competitiveness. Figures 1 and 2 strongly support this view. Intra-European medium to long-run nominal exchange rate movements appear to be closely linked to relative price movements, whilst this is not the case for transatlantic exchange rates. A structural approach, which links nominal and real exchange rates to economic fundamentals, may therefore work quite well for Europe, whilst our data and a mountain of empirical evidence suggest that for the United States any structural approach to modelling exchange rates is likely to fail.

In this paper we advocate a semi-structural approach by viewing bilateral real and nominal exchange rates as being jointly driven by a number of shocks. We will aim at isolating the important real and nominal disturbances underlying long-run exchange rate movements. We employ an approach pioneered by Clarida and Galí (1994, 1995) and Rogers (1995), who use structural vector autoregressions (SVARs). However, the present paper extends this line of research by quantifying a larger number of shocks and using exchange rates data for both the U.S. dollar and the German mark after the collapse of the Bretton Woods system. An interesting issue thereby is which type of shocks has dominated nominal and real exchange rate movements and at what frequency. Clarida and Galí (1996) suggest that for the U.S. dollar real exchange rates aggregate demand shocks play a key role in the long-run, whilst monetary shocks have primarily short-run effects which die out slowly (with a half-life of 16 quarters). They also find that supply shocks play virtually no role for real exchange rate movements over any time horizon. How robust are these results if we split the supply shocks into a labour supply and a productivity component, or, if we view monetary shocks to be composed of money demand and a money supply component? Do these results also apply for Europe, which has adhered to a system of fixed but adjustable managed exchange rates? Has this system helped Europe to cope better with the increased importance of real shocks? If yes, does this have any implications for the exchange rate policy of the Euro-area relative to the U.S. dollar? To evaluate these issues a quantitative assessment is required.

In order to identify the major forces behind real and nominal exchange rate movements we look at the joint behaviour of real exchange rate changes, employment and output growth differentials, inflation differentials, and money growth differentials. The joint behaviour of these variables is viewed as being driven by five distinct disturbances: labour supply and productivity shocks, aggregate demand shocks, and monetary or financial shocks, such as money demand and money supply disturbances. Based on a simple Mundell-Flemming-Dornbusch IS-LM model[1] we construct and estimate a structural VAR model, and we rely exclusively on long-run theoretical restrictions in order to identify these shocks. The long-run restrictions rest on the long-run neutrality of nominal shocks and the predominant influence of supply shocks on potential output and employment, whilst in the short-run both nominal and real shocks can have real effects due to sluggish price adjustment. Having identified the shocks, we then look at the components of real and nominal exchange rate movements of European U.S. dollar and German mark exchange rates which is due to these shocks. We also analyse the variance decomposition of real and nominal exchange rates at various time horizons in order to determine whether the same factors which drive the short-term volatility of real and nominal exchange rates also determine their long-run trend movements.

The remainder of the paper is organized as follows: section 2 outlines our theoretical model and presents the rational expectations reduced forms under sluggish price adjustment and fully flexible prices. In section 3 the SVAR methodology is discussed and our econometric approach to identification based on the long-run flexible-price properties of the model is described. Section 4 presents our empirical results, and section 5 concludes.

2. A stochastic rational expectations open economy macro model

Based on Weber (1997a), this section presents an extended version of the stochastic two-country rational expectations open economy macro model developed by Obstfeld (1985) and Clarida and Galí (1994). The model also draws heavily on papers by Dornbusch (1976), Branson (1979), Flood (1981), Mussa (1982), Buiter

[1]On theoretical grounds an intertemporal optimizing approach would clearly be preferable, but to compare our results to those obtained in previous research, we stick to this more traditional approach.

and Miller (1983), McCallum (1988), Shapiro and Watson (1988), Canzoneri and Henderson (1991) and Galí (1993). Both short-run and long-run properties of the model are discussed in detail, and it is found that the model not only reflects most the standard Mundell-Fleming-Dornbusch short-run results when prices adjust sluggishly to various shocks, it also displays all the long-run properties that typically characterize macroeconomic equilibrium in a more neoclassical framework once prices have adjusted fully to all shocks. Following the usual tradition all variables except interest rates are in logarithms and represent home relative to foreign levels. For example, $y_t \equiv y_t^h - y_t^f$ represents the logarithm of the output ratio home (y_t^h) and abroad (y_t^f).

The goods market is characterized by a standard output demand function which displays the real exchange rate ($q_t = s_t - p_t$), the real interest rate differential $\left(i_t - E_t\left(p_{t+1} - p_t\right)\right)$ and the real wage rate $(w_t - p_t)$ as its main arguments:

$$y_t^d = h\left(s_t - p_t\right) - s\left(i_t - E_t\left(p_{t+1} - p_t\right)\right) + f\left(w_t - p_t\right) + d_t \ , \tag{1}$$

where d_t is a relative demand shock. Contrary to Clarida and Galí (1994) we only allow for a permanent component (e_t^d) of the relative demand shock. In particular, we suppose that the shock to relative demand in period t is given by:

$$d_t = d_{t-1} + e_t^d \tag{2}$$

where e_t^d is a normally independently distributed (n.i.d.) with zero mean and constant finite variance.

The basic structure of the supply side of the simple open economy macro model follows Shapiro and Watson (1988) in assuming that firms in the long-run produce consumer goods with a Cobb-Douglas technology:

$$y_t^s = A_t + a l_t + (1-a)k_t, \tag{3}$$

where k_t is the log level of the capital stock, l_t is the log level of the labour input, and A_t is the log level of technology. In order to avoid having to incorporate the capital stock into our model we adopt the assumption that the long-run steady state capital-output ratio is constant:

$$k_t = y_t + k, \tag{4}$$

and given by a value of κ. Substituting (4) into (3) and rearranging yields the long-run log level of output:

$$y_t^s = \frac{(1-a)k}{a} + \frac{1}{a} A_t + l_t, \tag{5}$$

where the constant ((1-α)κ/α) will be suppressed below. To capture the dynamics of technology we introduce a stochastic forcing process which reflects the impact of permanent stochastic production technology innovations (e_t^z):

$$A_t = A_{t-1} + e_t^z, \tag{6}$$

with the technology shocks (e_t^z) assumed to be normally independently distributed with zero mean and constant finite variance.

The demand for labour in each country depends on relative factor costs for labour and is a negative function of the real wage rate. As a result, home relative to foreign labour demand is given by:

$$l_t^d = -\beta(w_t - p_t), \tag{7}$$

and is decreasing in the real wage differential. Labour supply, on the other hand is a positive function of the real interest rate differential and the real wage differential:

$$l_t^s = j\left(i_t - E_t(p_{t+1} - p_t)\right) + g(w_t - p_t) + w_t, \tag{8}$$

where w_t represents the stochastic component of the evolution of the labour supply resulting from permanent labour supply shocks (e_t^w):

$$w_t = w_{t-1} + e_t^w, \tag{9}$$

and the labour supply shocks (e_t^w) are assumed to be normally independently distributed with zero mean and constant finite variance.

To introduce some nominal rigidities into the model we adopt a version of the price setting equation that has been studied in open economy macro models by Flood (1981), Mussa (1982), Clarida and Gali (1995), and others:

$$p_t = (1-\theta)E_{t-1}p_t^e + \theta p_t^e . \quad (10)$$

According to this price setting rule the price level in period t is a weighted average of the market clearing price expected in period t-1 to prevail in period t, $E_{t-1}p_t^e$, and the price that would actually clear the output market in period t, p_t^e. When $\theta = 1$, prices are fully flexible and output is supply determined. When $\theta = 0$, prices are fixed and predetermined one period in advance.

The money market of the simple open economy rational expectations model is described by a standard demand for money function which features relative incomes (y_t) and the nominal interest rate differential (i_t) as its main arguments:

$$m_t^d - p_t = y_t - \lambda i_t + (\varepsilon_t^m - d_t), \quad (11)$$

and where $\varepsilon_t^m - d_t$ is the relative velocity shock with ε_t^m as its relative money demand shock component, which is normally independently distributed with zero mean and constant finite variance. Interest rates are assumed to be determined by the uncovered interest rate parity condition:

$$i_t = E_t(s_{t+1} - s_t) + rp_t , \quad (12)$$

where rp_t represents the risk premium. Such risk premia reflect the fact that domestic and foreign bonds may not be perfect substitutes: in order to induce domestic agents to hold the more risky foreign bonds they have to be granted such a risk premium. In this paper we will follow Clarida and Galí (1994) and the bulk of the literature on the Mundell-Flemming model and exclude such risk premia. However, as pointed out in Clarida and Galí (1994) and demonstrated in Weber (1997b), our results and identifications would still go through if we model the risk premium as a stationary stochastic process, which itself may be a function of our structural shocks.

We close the model by specifying the relative money supplies. We assume that central banks attempt to target a constant money growth rate, which for simplicity is assumed to have a deterministic component that is identical in both countries, and hence the deterministic component of the money growth differential is zero. The relative money supply may thus be captured by a simple stochastic trend:

$$m_t^s = m_{t-1} + e_t^m, \tag{13}$$

with e_t^m as a relative money supply shock, which again is assumed to be normally independently distributed with zero mean and constant finite variance.

Note that the above policy rule strictly only applies under a free float. Modifying the money supply rule to a feedback-rule in which the central bank responds to contemporaneous shocks in order to stabilize nominal exchange rates or prices will qualitatively alter the behaviour of prices and exchange rates. But since no restrictions are imposed on these variables in our model, this would not alter our basic identification strategy. Thus, to economize on notation we will stick to equation (13) as our monetary policy rule.

2.1 The long-run solution of the model

The solution of the model is described in detail in Appendix B of the paper. The dynamic response of our five key variables to the various shocks in the "long-run" flexible-price solution can be summarized as:

$$\begin{bmatrix} l_t \\ y_t \\ s_t - p_t \\ m_t - p_t \\ p_t \end{bmatrix} = \begin{bmatrix} l_{11} & 0 & 0 & 0 & 0 \\ l_{21} & l_{22} & 0 & 0 & 0 \\ l_{31} & l_{32} & l_{33} & 0 & 0 \\ l_{41} & l_{42} & l_{43} & l_{44} & 0 \\ l_{51} & l_{52} & l_{53} & l_{54} & l_{55} \end{bmatrix} \begin{bmatrix} e_t^w \\ e_t^z \\ e_t^d \\ e_t^m \\ e_t^m \end{bmatrix}. \tag{14}$$

This matrix of "long-run" multipliers is lower triangular: only the price level is driven by all five shocks, whilst the relative employment and output only respond to supply shocks (labour supply and technology shocks) and not to aggregate demand shocks or nominal shocks (money supply and money demand shocks). These nominal shocks only drive nominal variables, such as the nominal interest rate differential, the nominal exchange rate and the relative price of output. Monetary shocks thereby have identical long-run effects on the nominal exchange rate and relative prices (or wages), which in turn renders the real exchange rate independent of monetary shocks in the long run. This is not true for shifts in favour of demand for domestic goods, which for a given relative supply of goods and labour will result in a real depreciation if markets are to clear.

2.2 The short-run solution of the model

The short-run sluggish-price-adjustment solution of our model results when quantities are demand rather than supply determined, and can, as shown in Appendix B, be summarized as:

$$\begin{bmatrix} l_t \\ y_t \\ s_t - p_t \\ m_t - p_t \\ p_t \end{bmatrix} = \begin{bmatrix} f_{11} & f_{12} & f_{13} & f_{14} & f_{15} \\ f_{21} & f_{22} & f_{23} & f_{24} & f_{25} \\ f_{31} & f_{32} & f_{33} & f_{34} & f_{35} \\ f_{41} & f_{42} & f_{43} & f_{44} & f_{45} \\ f_{51} & f_{52} & f_{53} & f_{54} & f_{55} \end{bmatrix} \begin{bmatrix} e_t^w \\ e_t^z \\ e_t^d \\ e_t^{\mathrm{m}} \\ e_t^m \end{bmatrix}. \tag{15}$$

This matrix of "short-run" multipliers displays no neutrality characteristics, and all five variables are jointly driven by linear combinations of all five basic structural shocks. To achieve identification, we will therefore focus on the "long-run" characteristics of the model.

Before turning to the empirical results it is worthwhile to mention some interesting features of the above five equation model, which could not be analyzed in the context of the three equation model of Clarida and Galí (1994). Firstly, endogenizing the labour market amounts to endogenizing average labour productivity (y_t/l_t), and this may be used to judge the Balassa (1964) and Samuelson (1964) hypothesis that productivity differentials play a key role in explaining persistent real exchange rate movements.[2] In fact, labour productivity in the long-run flexible-price solution of our model is driven only by relative technology shocks, and according to the Balassa-Samuelson hypothesis such real shocks should play the central role in accounting for real exchange rate movements. A second interesting aspect of our model relates to the close link between real exchange rate changes and real interest rate differentials. In the long-run flexible-price solution of our model ex ante real interest rate differentials simply reflect the transitory component of the level of real exchange rates. In view of the empirical finding that real exchange rates appear to possess a unit root (Campell and Clarida (1987), Meese and Rogoff (1988), Clarida and Galí (1994)) this points towards the fact that most of the long-run movements in the level of real exchange rates must be attributed to permanent real shocks, and only a small part is likely to be accounted for monetary shocks. In our model we will be able to pin down empirically the contribution of each of these types of real or nominal disturbances to the movements of nominal and real exchange rates, as is described in more detail below. Note that this last point is closely linked to the desirability of fixed versus flexible exchange rates at the intra-European and transatlantic level, as discussed in the optimal currency area literature

3. The SVAR approach and the identification of structural shocks

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[2] Samuelson (1964) and Balassa (1964) actually relate persistent real exchange rate movements to sectoral productivity in a model with traded and non-traded goods sectors. To link this to our approach we refer to Canzoneri, Cumby and Diba (1996), who show that for a wide class of production functions (much less restrictive than Cobb-Douglas) and competitive domestic labour markets one may use average labour productivity to judge the Balassa-Samuelson hypothesis.

To outline our approach to identification, we re-write the flexible-price solution (14) of our system as:

$$\begin{bmatrix} l_t \\ y_t \\ s_t - p_t \\ m_t - p_t \\ p_t \end{bmatrix} = C(L) \begin{bmatrix} e_t^w \\ e_t^z \\ e_t^d \\ e_t^{\mathrm{m}} \\ e_t^m \end{bmatrix}, \qquad (16)$$

where in order to allow for some short-term dynamics we have replaced the "long-run" multipliers by a matrix polynomial C(L), which is a function of the lag polynomials in the various structural shocks. The long-run identifying restrictions adopted in this paper can be written in terms of the long-run multipliers, that is the elements of C(1). Setting the lag operator L equal to one results in the following specification of C(1):

$$C(1) = \begin{bmatrix} l_{11} & 0 & 0 & 0 & 0 \\ l_{21} & l_{22} & 0 & 0 & 0 \\ l_{31} & l_{32} & l_{33} & 0 & 0 \\ l_{41} & l_{42} & l_{43} & l_{44} & 0 \\ l_{51} & l_{52} & l_{53} & l_{54} & l_{55} \end{bmatrix}. \qquad (17)$$

In the structural VAR analysis below we will exclusively rely on long-run identifying restrictions, and employ the features of our theoretical model to restrict C(1) to be lower block triangular.

In order to apply the structural VAR approach, we follow Galí (1992) in assuming that $x=[x_1,x_2,x_3,\dots,x_k]$ is a covariance stationary vector process. Each element in x has zero mean, or rather, has been demeaned or detrended prior to the estimation. Each element in x can be expressed as a linear combination of current and past structural shocks $\boldsymbol{\varepsilon}=[\varepsilon_1,\varepsilon_2,\varepsilon_3,\dots,\varepsilon_k]$. Formally, x has a moving average representation, as described in equation (16), and is given by:

$$x=C(L)\boldsymbol{\varepsilon}, \qquad (18)$$

and the reduced form Wold moving average representation is given by:

$$x=E(L)\eta, \tag{19}$$

where $E(L)=[E_{ij}(L)]$, $E(0)=I$, and $E(L)$ is required to be invertible. The vector of reduced form shocks $\eta=[\eta_1,\eta_2,\eta_3,...,\eta_k]$ is assumed to have a zero mean vector and a variance covariance matrix $\mathbf{\Omega}$.

The reduced form autoregressive representation in terms of the shocks η is given by:

$$B(L)x=\eta, \tag{20}$$

with $B(L)=[B_{ij}(L)]$, $B(L)=E(L)^{-1}$, and $B(0)=I$, whilst the autoregressive representation in terms of the structural shocks ε follows as:

$$A(L)x=\varepsilon, \tag{21}$$

with $A(L)=[A_{ij}(L)]$, $A(L)=C(L)^{-1}$ and $A(0)=S^{-1}$. The reduced form innovations η are assumed to be a linear combination of the structural disturbances ε:

$$\eta=S\varepsilon. \tag{22}$$

Given equations (28) and (29) this implies

$$C(L)=E(L)S. \tag{23}$$

Since OLS estimation of equation (20) yields estimates of B(L) and hence estimates of its inverse, $E(L)=B(L)^{-1}$, the structural shocks can be uniquely identified from the estimated reduced form shocks to the extent that we introduce enough restrictions to just-identify either the matrix S or the matrix C(L), or any combination of the two.

How may such restrictions be derived? First, it is straightforward to assume that the structural shocks ε are mutually orthogonal, which together with a convenient normalization condition[3] implies that $E(\varepsilon\varepsilon')=I$. Using this normalizing condition together with equation (22) implies:

$$SS'=\Omega, \tag{24}$$

and this factorisation provides k(k+1)/2 non-linear restrictions on the elements in S, given the OLS estimate of the variance-covariance matrix Ω of the reduced form errors η. This leaves us with the problem of determining the remaining k(k-1)/2 restrictions on the elements of S.

Blanchard and Quah (1989) were the first to propose identification of S in terms of long-run restrictions on the sum of the polynomial lags in C(1). From equation (23) it follows that C(1)=E(1)S, and hence, placing zero restrictions on the long-run impact C(1) of the structural shocks on x is useful in identifying elements in S given the estimate of E(1). Open economy applications of such long-run restrictions to real exchange rate modelling are contained in the work of Clarida and Galí (1994) and Canzoneri, Vallés and Vinals (1996).

4. Empirical evidence

In this section we represent our empirical results, with which we seek to answer a number of questions: first, what were the sources of intra-European and transatlantic real and nominal exchange rate movements after the collapse of the Bretton Woods system, and, in particular, did nominal shocks play a major role? We also want to challenge the results derived by Clarida and Galí (1994), who find that demand shocks explain the majority of both real and nominal exchange rate movements, whilst supply shocks explain very little. Is this result robust with respect to our extension of their model? Does this result still hold if we look at the

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[3] This normalization ensures that the vector of shocks is measured in terms of one standard deviation of the corresponding variable in the vector x

European economies rather than just bilateral relationships vis-a-vis the United States? But before discussing our findings, we take a brief look at the data.

4.1 The data

In the econometric work we limit ourselves to seasonally-adjusted monthly data beginning in 1971.VIII and ending in 1994.XII. Our starting date stems from the beginning of the more freely floating exchange rate period, which can be dated back to the closing of the gold window by the U.S. Federal Reserve in August 1971. Owing to the use of six-month lags in estimating the VARs, our estimates cover only the years 1972 through 1994, or 276 observations.

4.2. Unit root and cointegration properties of the data

This paper aims at estimating the system $x=[\Delta l_t, \Delta y_t, \Delta s_t - \Delta p_t, \Delta m_t - \Delta p_t, \Delta p_t]$, whereby the variables in x are defined as follows: Δl_t is the first difference in the logarithm of the employment ratio, Δy_t is the first difference in the logarithm of industrial production ratio, $\Delta s_t - \Delta p_t$ is the logarithm of the bilateral real exchange rate, with Δs_t as the change in the nominal bilateral exchange rate and Δp_t as consumer price inflation, and $\Delta m_t - \Delta p_t$ corresponds to the change in real money balances, where Δm_t is the change in the logarithm of the ratio of broad monetary aggregates (M2). By appropriate transformation these five variables also uniquely determine the ratio of money growth rates Δm_t, the nominal exchange rate Δs_t, and average labour productivity $\Delta y_t - \Delta l_t$.

The specification of the degree of time differencing and drift or trend adjustment of the variables in x is outlined in detail in Table 1, which reports the results of prior unit-root tests for the bilateral variables of the United States and Germany, whilst Table 2 summarizes the time series properties for all EC economies relative to Germany. Amongst the countries under study all bilateral output ratios were found to be integrated of order one, I(1). The employment ratios where also in general found to be I(1) with two exceptions: for France an I(1)+trend process seems more appropriate, whilst for the United Kingdom there are indications of a stationary employment ratio relative to Germany. The ratios of price levels are integrated of order one with a trend, I(1)+trend,. The same tends to apply for nominal exchange rates. Real exchange rates are typically also I(1), which in turn implies that relative price ratios and nominal exchange rates are not cointegrated. This statement is supported by the formal evidence from cointegration tests based on the procedure of Johansen and Juselius (1990), which is reported in Table 3. A similar statement holds for the price ratios and nominal and real money ratios for France, Italy, Belgium and the UK, where again nominal money ratios and price ratios are not found to be cointegrated. However, for the Netherlands, Denmark and the United States there is some indication that nominal money ratios relative to Germany are stationary, implying that real money ratios and price ratios could be cointegrated. Formal cointegration tests do indeed suggest that for these three cases the cointegration rank is greater than zero. However, if we disregard either the price ratios or the real money balance ratios in the cointegration tests we find no cointegration between the remaining four variables, which is an encouraging result. To obtain estimates compatible with the results for the remaining countries, we therefore proceed by estimating an unrestricted VAR in first differences for these three countries as well, but the results should be interpreted with somewhat more caution. Since the ratios of all variables employed in our VAR were integrated of order one, we adjusted for drifts and trends in the growth rates accordingly before estimating the unrestricted VAR using a lag window of length four.[4]

4.3 Impulse responses

[4] Our results were not very sensitive with respect to the length of the lag window. Similar results were obtained by using alternative lag windows of length six or nine, but in these cases the impulse response functions indicated a overparameterization of the VAR.

Figures 3 to 5 display the impulse responses of the bilateral price ratios, real and nominal exchange rates to a one-standard deviation disturbance for each type of shock. Both in qualitative and quantitative terms, these results closely resemble those of Clarida and Galí (1994). The major impulse response of the price ratios is found with respect to money supply shocks, followed by aggregate demand shocks. Both shocks are found to have a significant inflationary impact in all bilateral cases. The deflationary impact of money demand, labour supply and aggregate supply shocks is in many cases not found to be significant, but if they are significant these impulse responses have the right sign. There are two interesting exceptions: for Italy and Belgium relative labour supply shocks have an inflationary instead of deflationary impact, and this may result from the systems of wage indexation in operation in these countries during the period under study.

Figure 4 shows that relative demand shocks have a significant impact on all bilateral real exchange rates over all time horizons. Money demand and money supply shocks by construction only have short-run real exchange rate effects, which tend to become insignificant over 2 to 6 months time horizons. As in Clarida and Galí (1994), aggregate supply shocks have no impact on U.S. dollar real exchange rates, but produce a quite persistent and significant appreciation of the German mark real exchange rates of France, Italy and the United Kingdom. For France and the United Kingdom relative labour supply shocks also result in a significant real appreciation which, however, is less long-lived.

The above results are interesting, because they point towards an important asymmetry between intra-European and transatlantic exchange rates. Figure 5 suggests that the behaviour of the nominal U.S. dollar exchange rate is difficult to explain in terms of a significant propagation of any of the five fundamental shocks considered in this paper. All intra-European nominal exchange rates, on the other hand, appear to be significantly driven by relative money supply and relative demand shocks. For the larger European economies, in particular for France, the nominal German mark exchange rates also appear to respond significantly and consistently to relative supply shocks on goods and labour markets. These estimation results confirm the visual impression from above that for the European nominal exchange rates fundamentals appear to matter more than for the U.S. dollar real exchange rates. Will losing the bilateral exchange rate as a shock absorber for these shocks therefore imply major macroeconomic costs under Economic and Monetary Union (EMU)? The results from the SVAR decomposition suggest that this is not the case: intra-European nominal exchange rates are predominantly driven by differential monetary policy shocks, and the common monetary policy under EMU will eliminate the very source for these asymmetric shocks. What about transatlantic exchange rate arrangements? The results for Germany versus the United States suggest that it is impossible to identify any significant source of transatlantic exchange rate movements, thus a formal exchange rate arrangement is much less likely to have a stabilizing impact.

4.4 Variance decomposition

Table 4 reports the variance decomposition for price ratios, real and nominal exchange rates relative to the German mark, whilst Table 5 displays the same information for the U.S. dollar. As can be clearly seen from Table 4, most of the short-term conditional variance in the level of DM real exchange rates can be attributed to demand shocks (70-100 percent) and a much smaller proportion is due to supply shocks (0-23 %) or monetary shocks (1-7%), whilst relative labour supply and money demand shocks play virtually no role. Table 4 also suggests that price variability relative to Germany in the short-run reflects a combination of relative monetary policy shocks (50-75%) and relative demand disturbances (15-41%), whilst in the long-term relative monetary policy clearly dominates. Relative price variability in the long-run is predominantly a monetary phenomenon. The same conclusions in principle also apply for the bilateral relationships with the United States in Table 5, but the importance of relative demand shocks for real exchange rate variability and relative monetary policy shocks for relative price variability is even more pronounced.

A major difference between Tables 4 and 5 can be found for intra-European and transatlantic nominal exchange rate variability. For Europe most of the short-term conditional variance in the level of DM nominal exchange rates can be attributed to demand shocks (50-70%), money supply shocks(20-30%) and aggregate supply shocks (0-23 %), whilst in the long-term relative monetary policy gains importance and supply side factors lose some of their impact. For the United States only relative demand shocks matter (93-97%), and other nominal or real shocks do not contribute much to nominal exchange rate variability. This again suggests that the variability of the intra-European nominal exchange rates is more due to fundamentals than that of the U.S. dollar exchange rates. A common monetary policy will therefore eliminate some of the sources of exchange rate variability, but asymmetric fiscal policy aimed at stabilizing relative demand shocks may be required to prevent major current account imbalances under irrevocably fixed exchange rates.

4.5 Historical decomposition into shock components

Figure 6 displays the components of German mark real exchange rates due to the various shocks, whilst the corresponding U.S. dollar real exchange rates are contained in Figure 7. For the larger European economies the real exchange rates display a small business cycle and labour market component, but the bulk of real exchange rate movements is captured by relative demand shocks. For the smaller EC economies these relative demand shocks map almost one-for-one into real exchange rate movements. The same holds for all bilateral real rates relative to the United States in Figure 7. Similar results are obtained in Clarida and Galí (1994), Canzoneri, Vallés and Vinals (1996) and Weber (1997a). However, in Weber (1997a) it is shown that the identification strategy proposed by Clarida and Galí (1994) tends to produce this result, since any long-run effects of monetary shocks on real exchange rate are ruled out by definition and supply side factors frequently turn out not to be statistically significant. This only leaves aggregate demand shocks to be associated with long-run real exchange rate movements, and Weber (1997a) argues that the labelling of these shocks as being “demand shocks“ is at least questionable: they could equally well be interpreted as a measure of our ignorance as to the sources of real exchange rate movements.

Finally, Figure 8 looks at the stochastic trend deviations of European nominal German mark exchange rates. Interestingly, the money supply shock components account for most of these intra-European exchange rate movements, whilst relative labour market and goods market supply shocks are of minor importance. Note that the aggregate demand shock component of intra-European nominal exchange rates is also relatively small. This is not true for the nominal U.S. dollar exchange rates in Figure 9, where the components of nominal exchange rate rates closely resemble those of real exchange rates depicted in Figure 7. This again suggests that a common monetary policy under EMU will eliminate the very source of intra-European nominal exchange rate movements, that is differential monetary policy. The results for Germany versus the United States indicate that monetary policy coordination or even a formal exchange rate arrangement at the transatlantic level is likely to have much less of an effect, since differential monetary policy is not at the roots of transatlantic exchange rate movements.

5. Summary and policy conclusions

Recent research into the sources of real and nominal exchange rate movements has produced some surprising new results. Clarida and Galí (1994) report that demand shocks, such as shocks to national savings or investment, explain most of the variance in real exchange rate fluctuations for the U.S. dollar exchange rates of major industrialised economies, whilst supply shocks and monetary shocks do not appear to matter much, except perhaps over very short time horizons. They argue that the fact that real demand shocks instead of nominal shocks dominate short-term real exchange rate movements in the face of short-term sluggish price adjustment may explain why deviations from PPP die out at such a low rate. These findings are furthermore consistent with the view that real disturbances, rather than nominal shocks, must be important for real exchange rates in the medium to long run. But it is surprising that aggregate demand shocks rather than supply or productivity shocks should play the key role for long-term real exchange rate movements. The present paper reconsiders this evidence in an extended version of the Clarida and Galí (1994) model by splitting supply shocks into labour supply and productivity shocks, and by viewing monetary shocks to be composed of money demand and money supply shocks. However, this does not overturn the results of Clarida and Galí (1994) for the U.S. dollar exchange rates. But when we consider evidence from intra-European real exchange rates we find that labour market disturbances and differential productivity movements play at least some role and have a significant impact on international competitiveness.

The policy implications of this exercise are threefold: firstly, the empirical results do not suggest any obvious policy choice with respect to maintaining stable transatlantic exchange rates for the Euro-area. Transatlantic real and nominal exchange rate movements are difficult to link to any of the fundamentals analysed here, and monetary policy coordination does not seem to be an obvious first-best choice before 'benign neglect' for the U.S. dollar exchange rates of the Euro-area. Secondly, it has been shown that intra-European nominal exchange rate movements respond partly to asymmetric labour and goods market supply shocks. Moving to an irrevocable peg will eliminate the shock absorbing capacity of nominal exchange rates, and this may involve some macroeconomic costs. But these costs are likely to be small, because differential monetary policy is found to have been the key driving force behind intra-European nominal exchange rate movements, and moving to EMU will eliminate this key source of exchange rate movements. Finally, PPP has been shown to be quite compatible with the European data. Misalignments have been much smaller (by a factor 3) in Europe as compared to the United States. One explanation for this is higher goods market integration and lower transportation costs within Europe. Alternatively, one may argue that the ERM realignments were designed such that they have used PPP as a benchmark to which nominal exchange rates are re-set in order to restore competitiveness. If the tendency towards PPP in Europe reflects the effects of monetary policy rather than goods market arbitrage, then irrevocably pegging intra-European exchange rates may increase persistent real exchange rate misalignments rather than reduce them. This has important implications for the 'ins' and the 'outs' in the first few years of EMU. For the countries participating from the beginning in EMU the common monetary policy will ensure that the driving source behind exchange rate and relative price movements, that is, differential monetary policy shocks, are eliminated. For the countries initially outside EMU such differential monetary policy shocks may still occur, and they are likely to distort competitiveness persistently if their nominal Euro exchange rates are pegged irrevocably. Thus, a mechanism has to be created that prevents this degree of freedom from being used for independent monetary policy. To ensure this, special institutional arrangements, such as a currency board between the 'ins' and the 'outs', have be designed.

Appendix A: Time series and data sources

All data are monthly, seasonally adjusted data. In case the original data were not seasonally adjusted, seasonal adjustment was carried out using the GAUSSX procedure SAMA. The time series and data sources used were:

Output (industrial production, index):

IMF, International Financial Statistics, various issues

Employment: Inverse of Number of Registered Unemployed

COMMISSION OF THE EUROPEAN ECONOMIES, Cronos, various issues.

OECD, Main Economic Indicators, various issues.

IMF, International Financial Statistics, various issues.

Consumer price indices:

IMF, International Financial Statistics, various issues, line 64.

Monetary base M0, national definition:

IMF, International Financial Statistics, various issues, line 24 or national definition for

the United Kingdom.

Nominal exchange rates :

IMF, International Financial Statistics, various issues.

Appendix B: Solving the model

To solve the model, we begin with deriving an expression for the real exchange rate that would prevail in the flexible-price rational expectations equilibrium in which output, employment and the money stock are supply determined. By substituting the equilibrium real wage rate and real interest rate together with the laws of motion for w_t, into (7) the long-run solution for the relative employment level in the flexible-price rational expections equilibrium is given by:

$$l_t^e = l_t = \frac{b}{b+g}\left(w_{t-1} + e_t^w\right), \tag{B1}$$

and the corresponding solution for the output ratio is obtained by inserting (6) and (B1) into (5):

$$y_t^e = y_t^s = \frac{\left(A_{t-1} + e_t^z\right)}{a} + \frac{b}{b+g}\left(w_{t-1} + e_t^w\right). \tag{B2}$$

Note that in the long run both employment and output are independent of aggregate demand shocks and nominal shocks such as money supply or money demand shocks.

Substituting the equilibrium real wage and real interest rate together with the laws of motion for A_t, d_t, and w_t into (1), solving for q_t^e, and carrying out the conditional expectation projections results in:

$$q_t^e = \frac{1}{h}\left(\frac{\left(A_{t-1} + e_t^z\right)}{a} - \left(d_{t-1} + e_t^d\right)\right) + \frac{s+f}{h\left(b+g\right)}\left(w_{t-1} + e_t^w\right). \tag{B3}$$

The flexible-price real exchange rate depreciates in response to both a relative technology shock and a relative labour supply shock. As in Clarida and Galí (1994) the real exchange rates appreciates in response to a relative demand disturbance.

In order to derive an expression for the relative price level p_t^e in the flexible-price rational expectations equilibrium we solve (11) for p_t^e, and using (12) and (13) we obtain:

$$p_t^e = \left(\left(m_{t-1} + \varepsilon_t^m\right) - \frac{\left(A_{t-1} + \varepsilon_t^z\right)}{\alpha} + \left(d_{t-1} + \varepsilon_t^d\right) \right) + \frac{\beta}{\beta + \gamma}\left(\omega_{t-1} + \varepsilon_t^w\right) - \frac{1}{\left(1 + \lambda\right)} \varepsilon_t^m . \quad \text{(B4)}$$

All six shocks influence the relative price level in the flexible-price solution: the relative price level rises equiproportionally to the relative money supply shocks and falls in response to relative money demand shocks. Relative prices also decline as a result of a relative supply shock (technology shocks or labour supply shocks), and they rise in response to the temporary component of the relative demand shock. Note that a solely permanent relative demand shock pushes up the common world level of nominal and real interest rates in the flexible price equilibrium, and for given labour, output and money supplies this must drive up home and foreign prices in proportion, leaving the relative price level unchanged.

Comparing equations (B1) and (B2) yields an equation for the nominal exchange rate:

$$s_t^e = \left(m_{t-1} + \varepsilon_t^m\right) - \frac{\left(1-\eta\right)}{\eta}\left[\frac{\left(A_{t-1} + \varepsilon_t^z\right)}{\alpha} - \left(d_{t-1} + \varepsilon_t^d\right)\right] + \left(\frac{\beta + \varphi - \eta\beta}{\eta\left(\beta + \gamma\right)}\right)\left(\omega_{t-1} + \varepsilon_t^w\right)_t - \left(\frac{1}{\left(1 + \lambda\right)}\right)\varepsilon_t^m .$$

This is not an independent reduced form solution, but simply the linear combination of the above two reduced forms. It therefore contains no additional information useful for identification. However, it reveals that in the flexible-price solution both money supply shocks and money demand shocks have an identical impact on both the price ratio and the nominal exchange rate. Also notice that without order conditions (i.e. $1 - \eta > 0$) the effect of productivity shocks, labour supply shocks and aggregate demand shocks on the nominal exchange rate is uncertain.

The flexible-rate solution for the ex ante nominal interest rate differential i_t can simply be obtained by carrying out the rational expectation projections of the expected rate of exchange rate change based on the exchange rate equation above:

$$i_t^e = \left(\frac{1}{(1+l)}\right) e_t^m .$$

Inserting this expression into the money demand equation yields the long-run flexible price solution for level of real money balances as:

$$m_t^e - p_t^e = \frac{\left(A_{t-1} + e_t^z\right)}{a} - \left(d_{t-1} + e_t^d\right) + \frac{b}{(b+g)}\left(w_{t-1} + e_t^w\right)_t + \left(\frac{1}{(1+l)}\right) e_t^m , \qquad \text{(B5)}$$

Real money balances rises in response to relative money demand shocks, whilst money supply shocks have no effect on real money balances in the flexible price solution. Furthermore, real money balances increases in response to relative technology shocks and relative labour supply shocks, whilst relative aggregate demand shocks reduce the demand for real money balances.

The dynamic response of our five key variables to the various shocks in the "long-run" flexible-price solution can be summarized as:

$$\begin{bmatrix} l_t \\ y_t \\ s_t - p_t \\ m_t - p_t \\ p_t \end{bmatrix} = \begin{bmatrix} l_{11} & 0 & 0 & 0 & 0 \\ l_{21} & l_{22} & 0 & 0 & 0 \\ l_{31} & l_{32} & l_{33} & 0 & 0 \\ l_{41} & l_{42} & l_{43} & l_{44} & 0 \\ l_{51} & l_{52} & l_{53} & l_{54} & l_{55} \end{bmatrix} \begin{bmatrix} e_t^w \\ e_t^z \\ e_t^d \\ e_t^m \\ e_t^m \end{bmatrix}, \qquad \text{(B6)}$$

which corresponds to equation (14) in the main text.

The short-run sluggish-price-adjustment solution of our model may be derived by viewing quantities as being demand rather than supply determined. By substituting (B4) into the price setting rule (10) and carrying out the conditional expectations projection, we derive that the ratio of home to foreign price levels, p_t, is given by:

$$\mathrm{p_t} = \mathrm{p_t^e} - (1-q)\left\{e_{\mathrm{t}}^{m} - \frac{e_{\mathrm{t}}^{z}}{a} - e_{\mathrm{t}}^{d} + \frac{be_{\mathrm{t}}^{w}}{(b+g)} - \frac{e_{\mathrm{t}}^{\mathrm{m}}}{(1+l)}\right\}. \qquad \text{(B7)}$$

As in the long-run flexible-price solution, the ratio of the price levels in the short-run sluggish-price-adjustment solution is a function of all five shocks. In response to a money supply or aggregate demand shock the price level rises in the short-run, but by less than in the long-run. Furthermore, the price level falls in the sticky-price solution as a result of money demand, aggregate supply or labour supply shocks, again by less than in the flexible-price solution. The degree of "sluggishness" is thereby indexed by ($1-\theta$).

The real exchange rate solution under partial price adjustment may be obtained by substituting (1) and (12) into (11) and using (B7) to obtain:

$$\mathrm{q_t} = \mathrm{q_t^e} + \left[\frac{(1-q)(1+l)(b+g)}{(s+h+l)(b+g)+jf}\right]\left\{e_{\mathrm{t}}^{m} - \frac{e_{\mathrm{t}}^{z}}{a} - e_{\mathrm{t}}^{d} + \frac{be_{\mathrm{t}}^{w}}{(b+g)} - \frac{e_{\mathrm{t}}^{\mathrm{m}}}{(1+l)}\right\}. \qquad \text{(B8)}$$

An interesting feature of this solution is that both money supply and money demand shocks influence the real exchange rate in the sticky-price solution, whilst in the flexible-price solution they do not. Furthermore, in the flexible-price solution monetary shocks had an identical impact on both the price level and the nominal exchange, but in the sluggish-price-adjustment solution for the nominal exchange rate:

$$\mathrm{s_t} = \mathrm{s_t^e} + \left[\frac{(1-q)[(1-s-h)(b+g)-jf]}{(s+h+l)(b+g)+jf}\right]\left\{e_{\mathrm{t}}^{m} - \frac{e_{\mathrm{t}}^{z}}{a} - e_{\mathrm{t}}^{d} + \frac{be_{\mathrm{t}}^{w}}{(b+g)} - \frac{e_{\mathrm{t}}^{\mathrm{m}}}{(1+l)}\right\}$$

the famous Dornbusch (1976) "overshooting-effect" in response to money supply shocks (e_{t}^{m}) can be generated for $(1-s-h)(b+g)-jf>0$. Note that this order condition also implies an undershooting-effect in response to money demand shocks ($e_{\mathrm{t}}^{\mathrm{m}}$), aggregate demand shocks (e_{t}^{d}) and productivity shocks (e_{t}^{z}).

Using (B7) and the IS equation (1) to solve for the demand-determined level of output under sluggish price adjustment results in:

$$y_t = y_t^e + \left[\frac{(1-q)(1+l)[(s+h)(b+g)+jf]}{(s+h+l)(b+g)+jf} \right] \left\{ e_t^m - \frac{e_t^z}{a} - e_t^d + \frac{b e_t^w}{(b+g)} - \frac{e_t^m}{(1+l)} \right\}, \quad \text{(B9)}$$

whilst using (B7) and the labour demand equation (8) to solve for the demand-determined relative employment level under sluggish price adjustment yields:

$$l_t = l_t^e + \left[\frac{(1-q)(1+l)bj}{(s+h+l)(b+g)+jf} \right] \left\{ e_t^m - \frac{e_t^z}{a} - e_t^d + \frac{b e_t^w}{(b+g)} - \frac{e_t^m}{(1+l)} \right\}. \quad \text{(B10)}$$

Both the output ratio and the employment ratio are now functions of all five shocks, and not only of technology or labour supply shocks. Home relative to foreign output and employment only partially rises in response to technology and labour supply shocks under the short-run sticky-price solution. Furthermore, relative money supply and aggregate demand shocks boost home relative to foreign output and employment in the "short-run" under partial price adjustment, whilst relative money demand shocks depress the output and employment ratios temporarily under sluggish price adjustment.

Finally, using (B5) and (B6) to solve for the demand-determined level of nominal interest rate differentials results in:

$$i_t = i_t^e - \left[\frac{(1-q)[(1-s-h)(b+g)-jf]}{(s+h+l)(b+g)+jf} \right] \left\{ e_t^m - \frac{e_t^z}{a} - e_t^d + \frac{b e_t^w}{(b+g)} - \frac{e_t^m}{(1+l)} \right\},$$

which inserted in (11) jointly with (B9) yields the demand determined level of real balances:

$$m_t - p_t = m_t^e - p_t^e + (1-q) \left\{ e_t^m - \frac{e_t^z}{a} - e_t^d + \frac{b e_t^w}{(b+g)} - \frac{e_t^m}{(1+l)} \right\}, \quad \text{(B11)}$$

which again is a function of all five shocks.

The dynamic response of our five key variables to the various shocks in the "short-run" sluggish-price-adjustment solution can be summarized as:

$$\begin{bmatrix} \mathrm{l_t} \\ \mathrm{y_t} \\ \mathrm{s_t - p_t} \\ \mathrm{m_t - p_t} \\ \mathrm{p_t} \end{bmatrix} = \begin{bmatrix} f_{11} & f_{12} & f_{13} & f_{14} & f_{15} \\ f_{21} & f_{22} & f_{23} & f_{24} & f_{25} \\ f_{31} & f_{32} & f_{33} & f_{34} & f_{35} \\ f_{41} & f_{42} & f_{43} & f_{44} & f_{45} \\ f_{51} & f_{52} & f_{53} & f_{54} & f_{55} \end{bmatrix} \begin{bmatrix} e_{\mathrm{t}}^{w} \\ e_{\mathrm{t}}^{\mathrm{z}} \\ e_{\mathrm{t}}^{d} \\ e_{\mathrm{t}}^{\mathrm{m}} \\ e_{\mathrm{t}}^{m} \end{bmatrix}, \qquad \text{(B12)}$$

which correspond to equation (15) in the main text.

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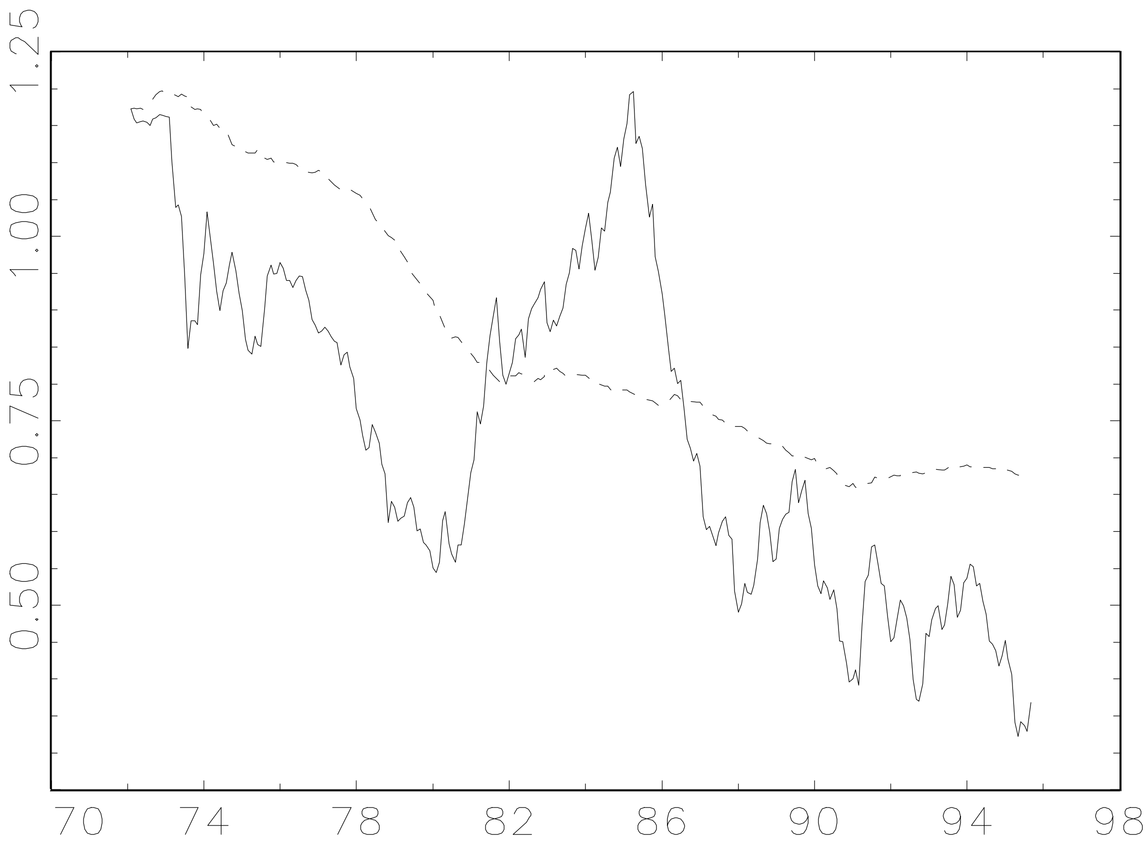
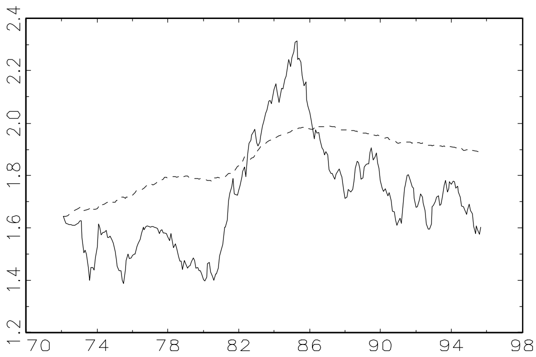
Figure 1: Nominal Exchange Rates and Price Ratios for the United States versus Germany, 1972-1996



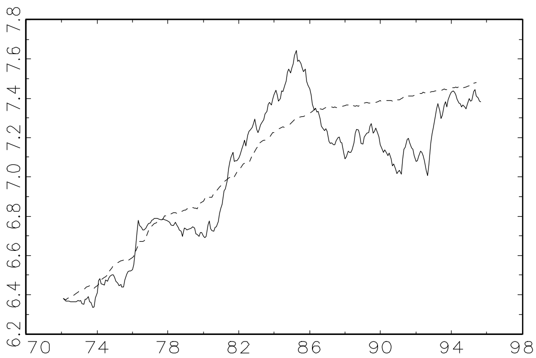
Key to Figure: ______ Log of Real Exchange Rate - - - - - Log of Price Level Ratio

Figure 2: Nominal Exchange Rates and Price Ratios of European Economies versus the United States and Germany, 1972-1996

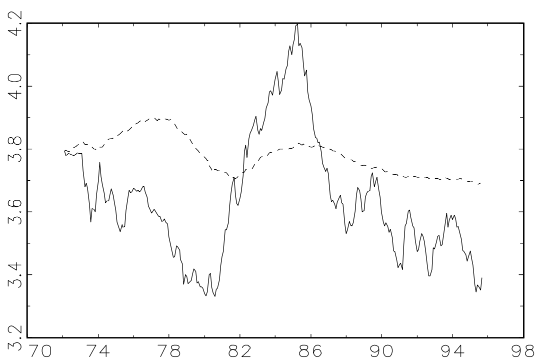
(a) France-USA



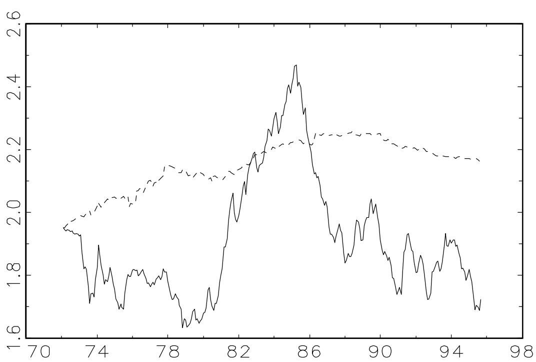
(b) Italy-USA



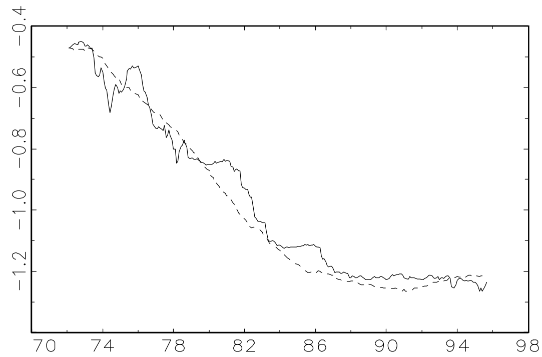
(c) Belgium-USA



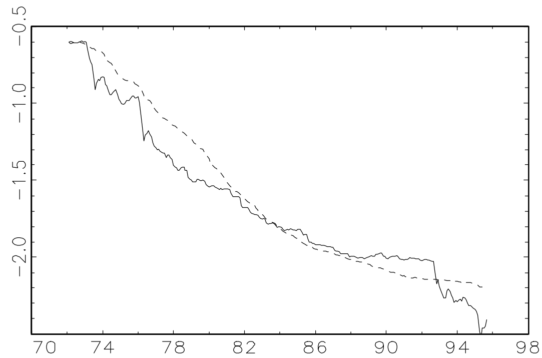
(d) United Kingdom-USA



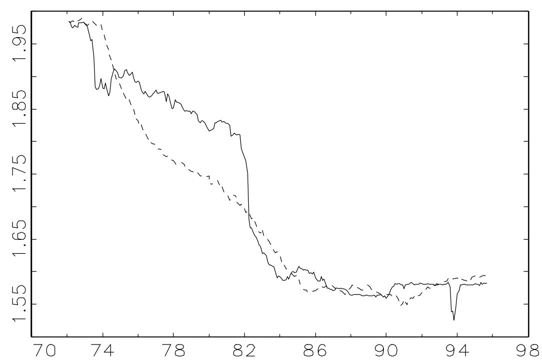
(e) France-Germany



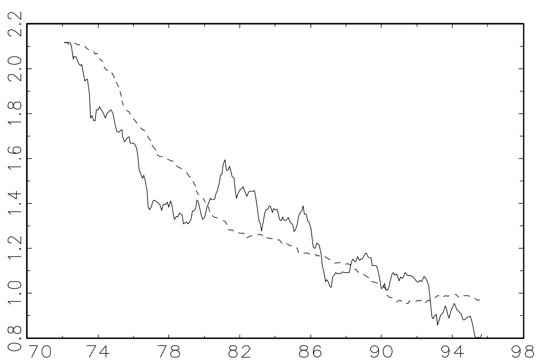
(f) Italy-Germany



(g) Belgium-Germany

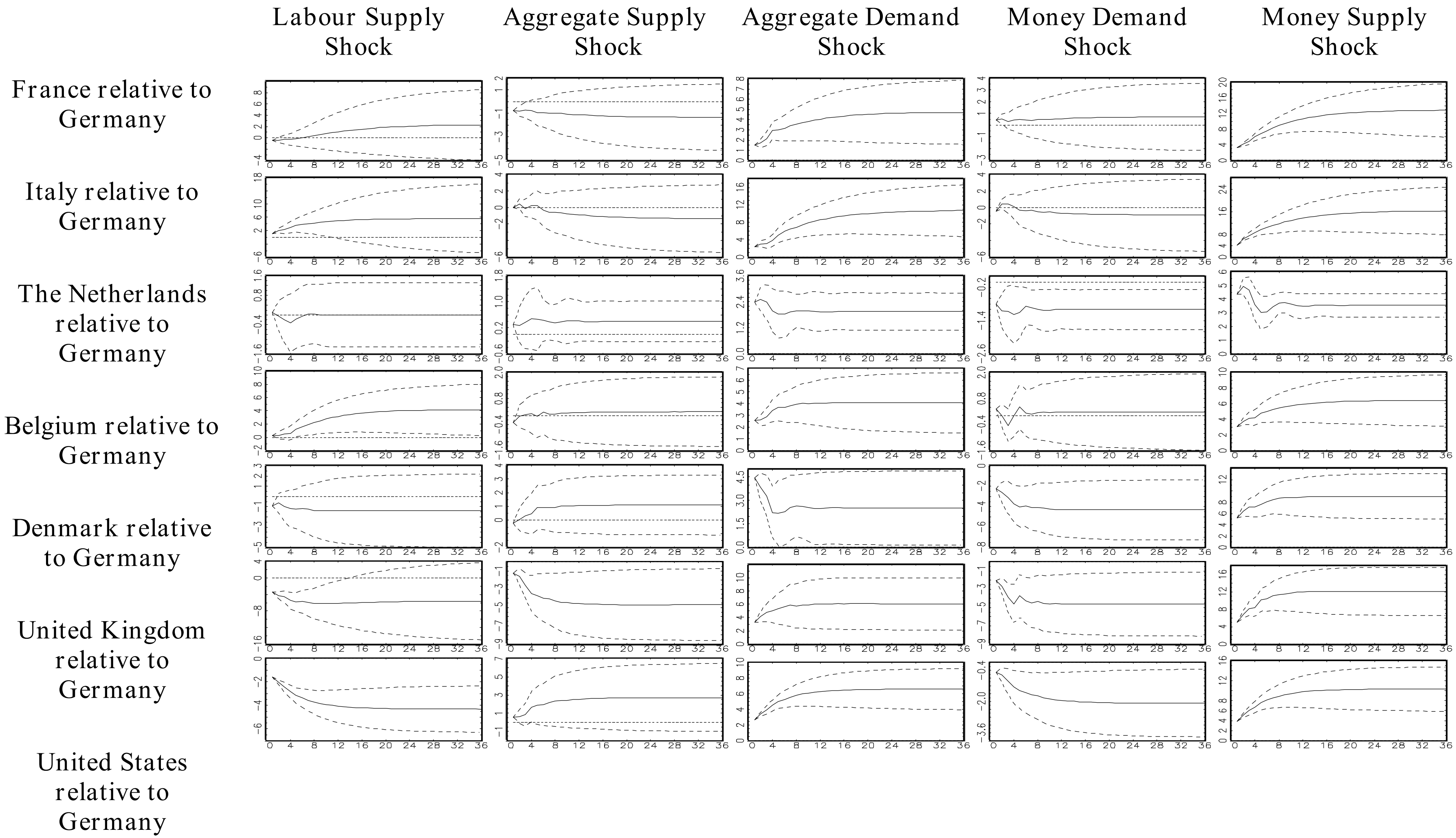


(h) United Kingdom-Germany



Key to Figure: ________ Log of Nominal Exchange Rate - - - - - - Log of Price Ratio

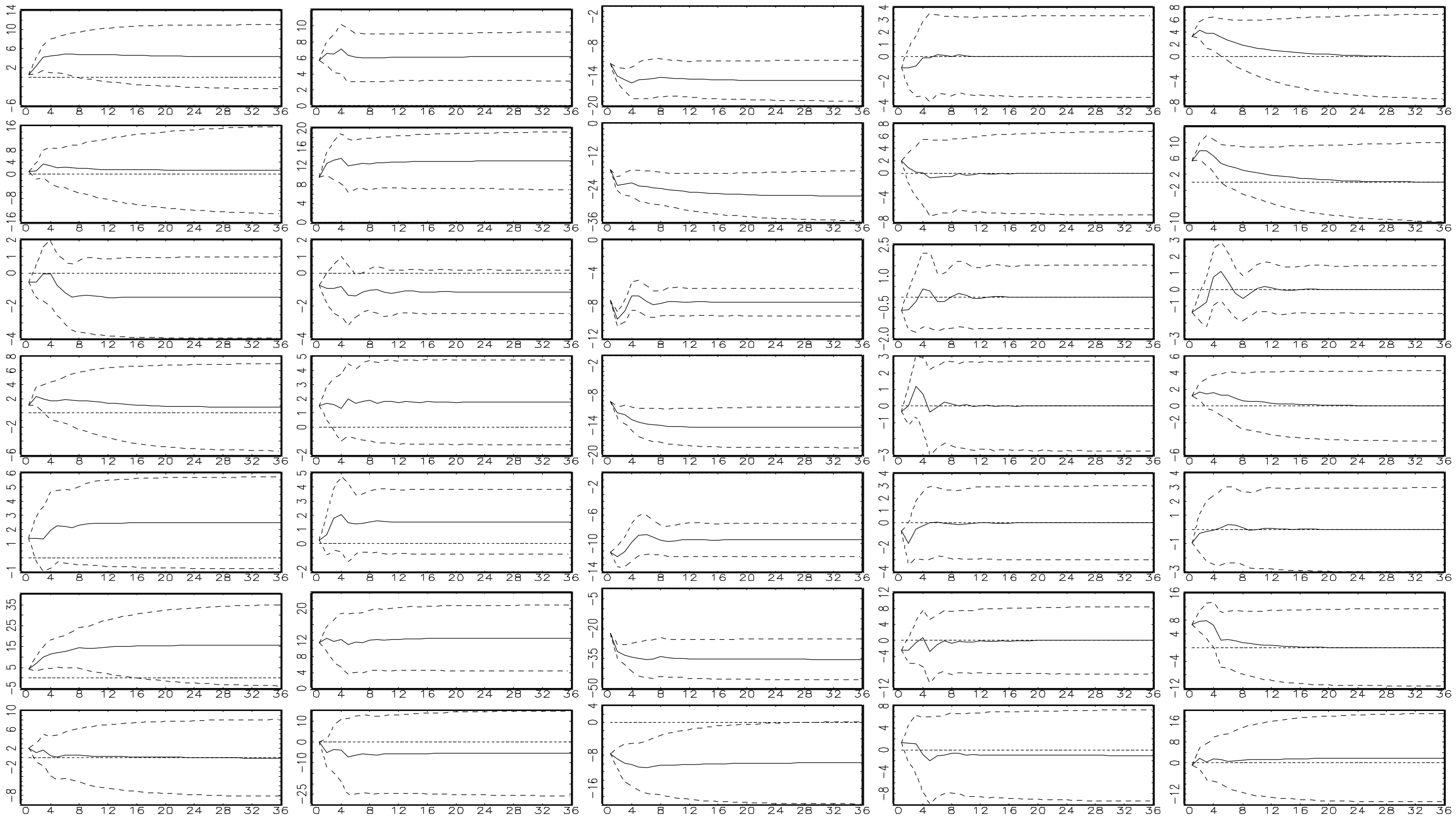
Figure 3: Impulse Response of the Price Ratios of EC-Countries and the United States Relative to Germany to Various Types of Shocks, Monthly Data, 1972.I-1994.XII



Key: The solid lines are the mean response of the ratio of log levels of consumer prices to a one standard deviation shock. The dashed lines are the 2 standard error bands obtained by Monte Carlo simulation.

Figure 4: Impulse Response of the Real Exchange Rates of EC-Countries and the United States Relative to Germany to Various Types of Shocks, Monthly Data, 1972.I-1994.XII

	Labour Supply Shock	Aggregate Supply Shock	Aggregate Demand Shock	Money Demand Shock	Money Supply Shock
France relative to Germany					
Italy relative to Germany					
The Netherlands relative to Germany					
Belgium relative to Germany					
Denmark relative to Germany					
United Kingdom relative to Germany					
United States relative to Germany					



Key: The solid lines are the mean response of the log levels of the real exchange rate (measured as the log level of the nominal exchange rate minus the ratio of the log levels of consumer prices) to a one standard deviation shock. The dashed lines are the 2 standard error bands obtained by Monte Carlo simulation.

Figure 5: Impulse Response of the Nominal Exchange Rates of EC-Countries and the United States Relative to Germany to Various Types of Shocks, Monthly Data, 1972.I-1994.XII

Labour Supply Shock	Aggregate Supply Shock	Aggregate Demand Shock	Money Demand Shock	Money Supply Shock

France relative to Germany

Italy relative to Germany

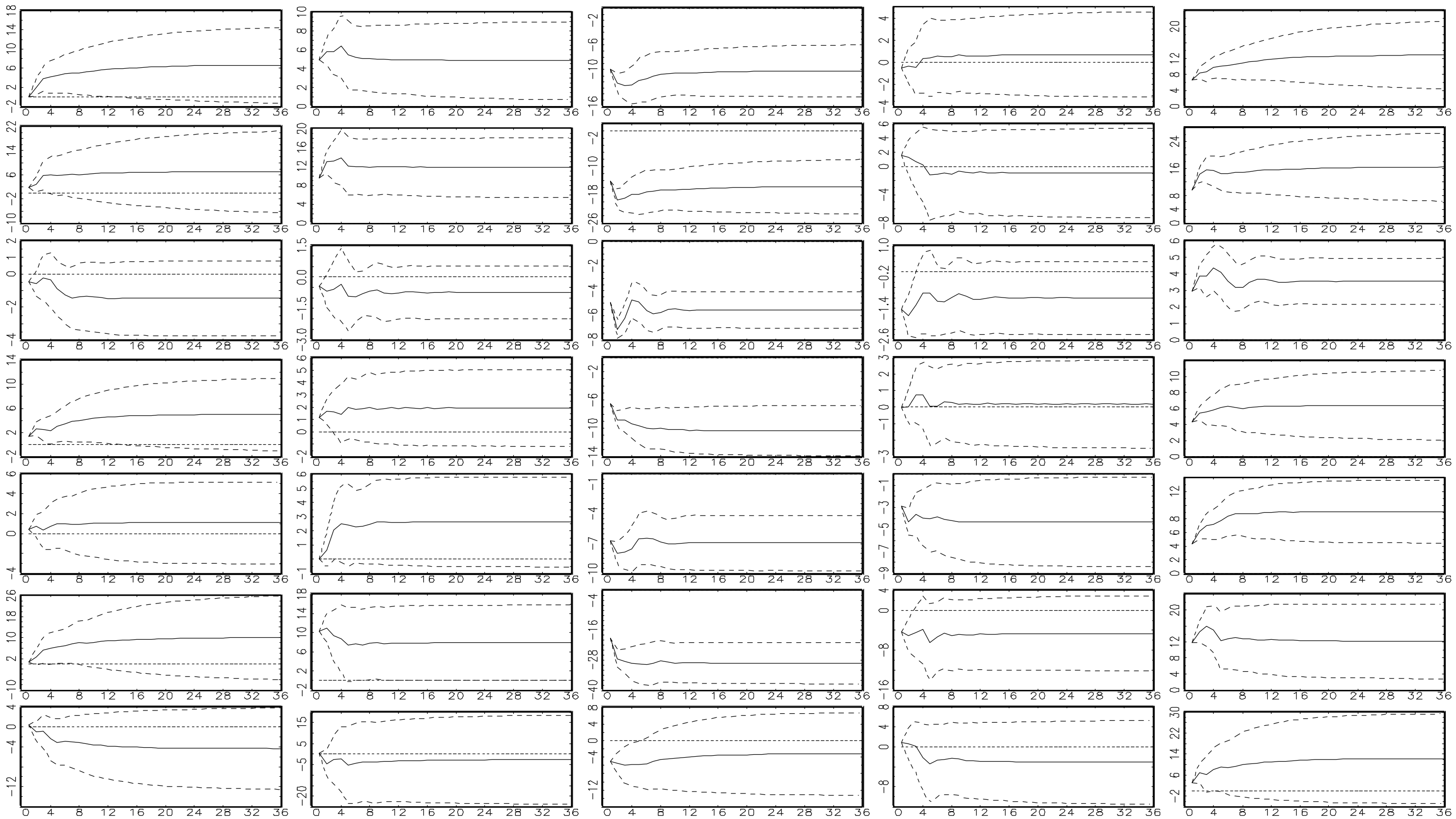
The Netherlands relative to Germany

Belgium relative to Germany

Denmark relative to Germany

United Kingdom relative to Germany

United States relative to Germany

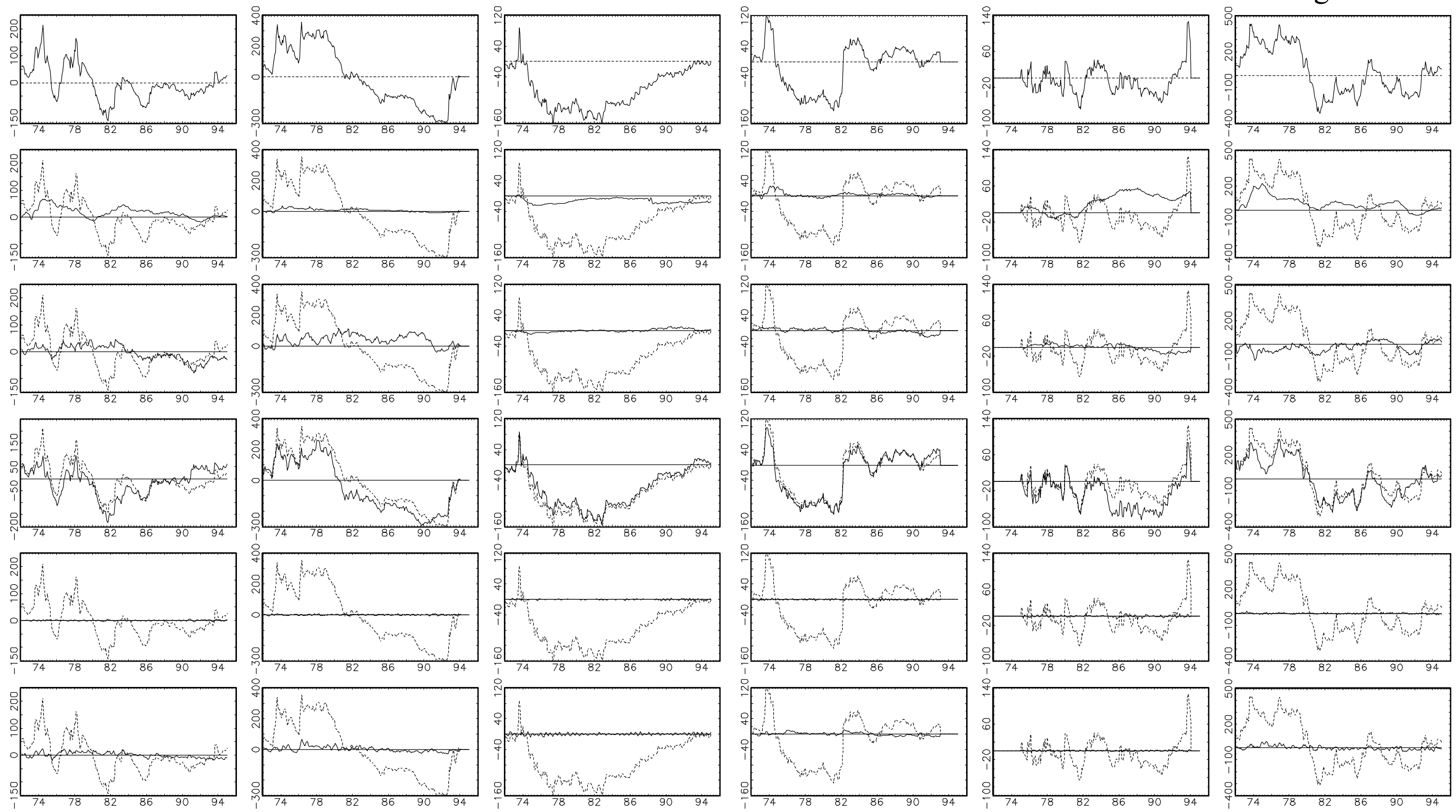


Key: The solid lines are the mean response of the ratio of log levels of the exchange rate to a one standard deviation shock. The dashed lines are the 2 standard error bands obtained by Monte Carlo simulation.

Figure 6: Shock Components of the Real Exchange Rates of EC-Countries Relative to Germany, Monthly Data, 1972.I-1994.XII

Columns: France | Italy | The Netherlands | Belgium | Denmark | United Kingdom

Rows: Stochastic Trend Deviations | Labour Supply Shock Component | Supply Shock Component | Demand Shock Component | Money Demand Shock Component | Money Supply Shock Component



Key: In order to indicate the proportion of real exchange rate movements due to the various shock components they are dispayed against the stochastic trend deviations of the real exchange rate (dashed lines).

Figure 7: Shock Components of the Real Exchange Rates of EC-Countries Relative to the United States, Monthly Data, 1972.I-1994.XII

France | Italy | The Netherlands | Belgium | Denmark | United Kingdom

Stochastic Trend Deviations

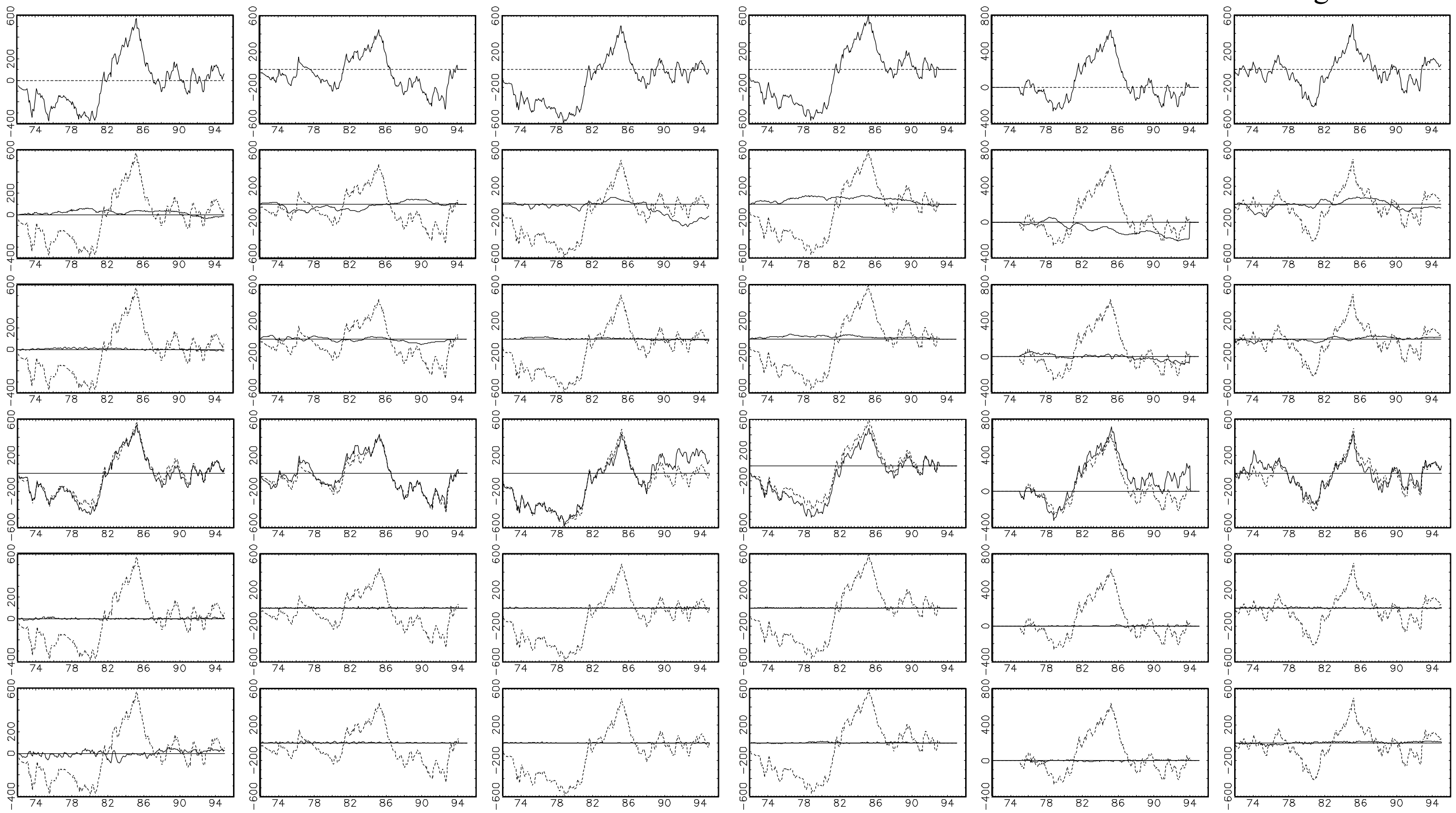
Labour Supply Shock Component

Supply Shock Component

Demand Shock Component

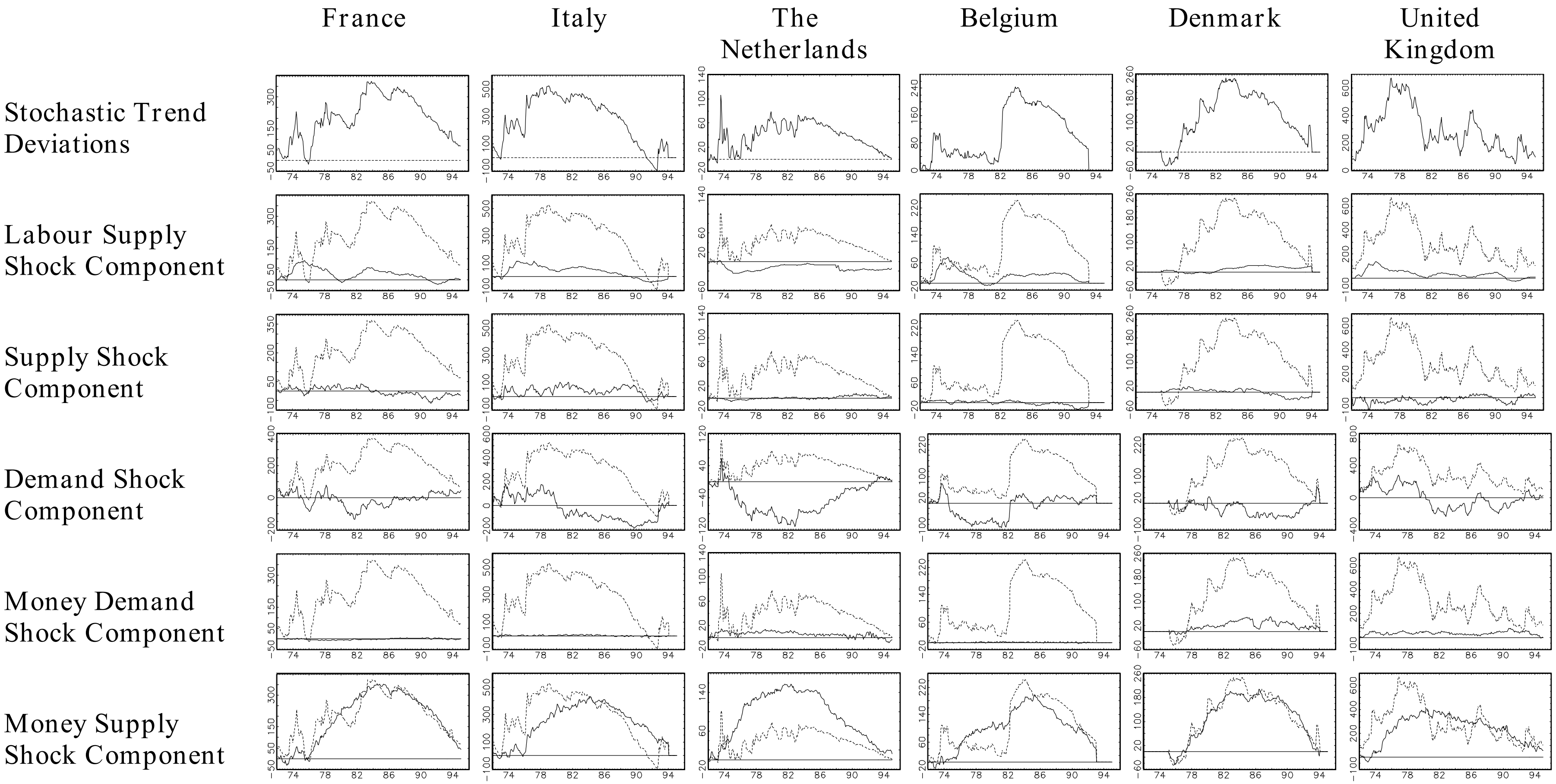
Money Demand Shock Component

Money Supply Shock Component



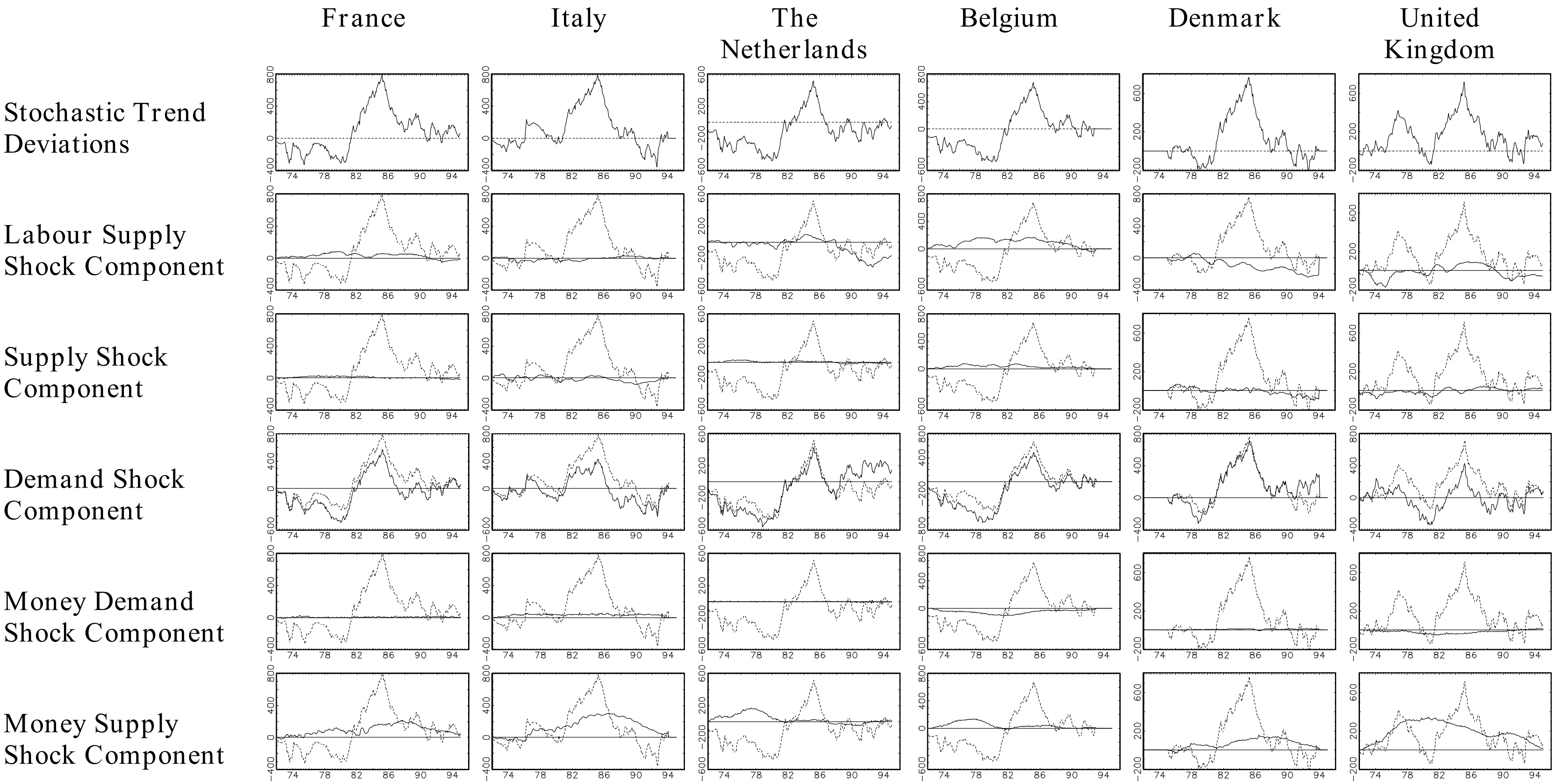
Key: In order to indicate the proportion of real exchange rate movements due to the various shock components they are dispayed against the stochastic trend deviations of the real exchange rate (dashed lines).

Figure 8: Shock Components of the Nominal Exchange Rates of EC-Countries Relative to Germany, Monthly Data, 1972.I-1994.XII



Key: In order to indicate the proportion of rnominal exchange rate movements due to the various shock components they are dispayed against the stochastic trend deviations of the nominal exchange rate (dashed lines).

Figure 9: Shock Components of the Nominal Exchange Rates of EC-Countries Relative to the United States, Monthly Data, 1972.I-1994.XII



Key: In order to indicate the proportion of real exchange rate movements due to the various shock components they are dispayed against the stochastic trend deviations of the real exchange rate (dashed lines).

Table 1: Summary of Unit Root Test Statistics for the Key Macroeconomic Variables in all Bilateral Relationships of EC-Countries and the United States Relative to Germany

Country Variable	France	Italy	Netherlands	Belgium	Denmark	UK	United States
Employment Ratio	I(1)+trend	I(1)	I(1)	I(1)	I(1)	I(0)+trend or I(1)	I(1)+drift
Output Ratio	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Nominal Money Ratio	I(1)	I(1)+trend	I(0)+trend or I(1)	I(1)	I(0)+trend or I(1)	I(1)	I(0)+trend or I(1)
Real Money Ratio	I(1)+drift	I(1)	I(1)+drift	I(1)+drift	I(1)	I(1)+drift	I(1)
Price Level Ratio	I(1)+trend	I(1)+trend	I(1)+trend	I(1)+trend	I(1)+trend	I(1)+trend	I(1)+drift
Nominal Exchange Rate	I(1)+trend	I(1)+trend	I(1)	I(1)+trend	I(1)+trend	I(1)	I(1)
Real Exchange Rate	I(1)	I(1)	I(1)+trend	I(1)	I(1)	I(1)	I(1)
Nominal Interest Rate Differential	I(1)	I(1)	I(0)	I(0)	I(0)	I(1)	I(1)
Real Interest Rate Differential	I(0)+trend	I(0)+trend	I(0)+trend	I(0)+trend	I(0)+trend	I(0)+trend	I(0) or I(1)

Key: Own calculations using GAUSS386. The unit root properties indicated here are based on the test statistics and decision process outlined in Weber (1977) for the United States versus Germany. The full set of tables with the detailed results is available on request.

Table 1: Detailed Unit-Root Test Statistics of Macroeconomic Variables for the United States versus Germany

Variable/ Ratio of	Symbol / Period		$t^{\tau}(z)$	sig. level	$\bar{\rho}$	Stock's ρ intervals	$t^{\mu}(z)$	sig. level	$\bar{\rho}$	Stock's ρ intervals	$Z(t_{\bar{\alpha}})$	$Z(t_{\alpha^*})$	$Z(t_{\tilde{\alpha}})$	Decision
			Augmented Dickey-Fuller Tests, Detrended Data				Augmented Dickey-Fuller Tests, Demeaned Data				Phillips-Perron Tests			
Employ-ment	l	72:1-94:12	-2.73	-	0.99	(- , -)	-0.52	(-)	1.00	(0.99,1.02)	-4.14(***)	-0.95 (-)	-1.71 -	I(1)+drift
	Δl		-3.03	(***)	0.79	(- , -)	-3.07	***	0.79	(0.89,1.00)	-8.37(***)	-11.8***	-11.8(***)	
Output	y	72:1-94:12	-2.37	-	0.94	(- , -)	-1.30	(-)	0.99	(0.97,1.02)	-1.85 -	-1.43 (-)	-2.98 (-)	I(1)
	Δy		-7.18	(***)	-0.44	(- , -)	-7.19	***	-0.43	(- , -)	-21.35***	-21.6(***)	-21.6(***)	
Real Ex.-Rate	q	72:1-94:12	-1.87	(-)	0.98	(- , -)	-1.81	-	0.98	(0.95,1.01)	-0.15(-)	-1.93 -	-2.0 (-)	I(1)
	Δq		-6.57	(***)	0.15	(- , -)	-6.58	***	0.15	(- , -)	-11.9***	-11.9(***)	-11.9(***)	
Real Money	m-p	72:1-94:12	-1.57	(-)	0.99	(- , -)	-0.31	-	1.00	(0,95,1.02)	-2.29***	0.34 (-)	-1.08 (-)	I(1)
	Δ(m-p)		-4.42	(***)	0.50	(- , -)	-4.42	***	0.51	(- ,0.93)	-12.7***	13.0(***)	-13.0(***)	
Consumer Prices	p	72:1-94:12	-0.37	(-)	1.00	(- , -)	-1.31	-	1.00	(0.97,1.02)	-4.26(***)	-1.47 -	0.24 (-)	I(1)+drift
	Δ(i-Δp)		-4.53	(***)	0.59	(- , -)	-4.37	***	0.61	(- ,0.94)	-10.1(***)	-11.2***	-11.3(***)	

Produc-tivity	y-l	72:1-94:12	-2.45	-	0.94	(- , -)	-1.34	(-)	0.98	(0.92,1.02)	-0.88 (-)	-1.50 -	-3.15 (-)	I(1)
	Δ(y-l)		-7.31	(***)	-0.47	(- , -)	-7.32	***	-0.47	(- , -)	-21.4***	-21.6(***)	-21.6(***)	
Velocity	m-p-y	72:1-94:12	-1.66	-	0.98	(- , -)	-0.12	(-)	1.00	(1.00,1.02)	-2.68(***)	-0.13 -	-1.67 (-)	I(1)+drift
	Δ(m-p-y)		-5.90	(***)	0.03	(- , -)	-5.86	***	0.05	(- , -)	-17.9(***)	-18.4***	-18.4(***)	

Table 1 continued

Key to Table: $t^{\tau}(z)$ in column 3 and $t^{\tau}(z)$ in column 7 are the augmented Dickey-Fuller tests for detrended data and demeaned data respectively. Their significance levels are taken from Table 8.5.2. of Fuller (1976), p. 373. A rejection of the null hypothesis of a unit root at the 1% significance level is marked with ***, at the 5% level with **, and at the 10% level with *. Significance levels in brackets indicate that the corresponding coefficient of the deterministic trend in column 3 (drift in column 7) was not significantly different from zero at the 5% level. Stock's (1991) 95% confidence intervals for the largest unit root ρ were calculated from the ADF statistics using Stock's Tables A1 and A2 and the procedure described in Appendix B of his paper. In addition to the confidence belts for ρ the estimated roots $\hat{\rho}$ are displayed. The three Phillips-Perron unit root tests reported are discussed in Perron (1988). $Z(t_{\hat{\alpha}})$ tests the null hypothesis of a unit root against an AR(1) regression without deterministic drift or trend, while $Z(t_{\alpha^*})$ includes a drift and $Z(t_{\tilde{\alpha}})$ both a drift and trend. Estimates were obtained using the Newey-West estimator. A rejection of the null hypothesis of a unit root at the 1% significance level is marked with ***, at the 5% level with **, and at the 10% level with *. Significance levels in brackets indicate that the Phillips-Perron test $Z(\Phi_{\mu^*})$ for a drift and $Z(\Phi_{\tilde{\beta}})$ for a trend were not significant at the 5% level. Critical values for the Phillips-Perron tests are taken from Tabele 8.5.2. in Fuller (1976), p. 371, and Tables I to III in Dickey and Fuller (1981), p. 1062. All ADF statistics are based on regressions including six lagged differences of the variable, and the Newey-West estimators for the Phillips-Perron used a lag-window of order six.

Table 2: Summary of Unit Root Test Statistics for the Key Macroeconomic Variables in all Bilateral Relationships of EC-Countries and the United States Relative to Germany

Country / Variable	France	Italy	Netherlands	Belgium	Denmark	UK	United States
Employment Ratio	I(1)+trend	I(1)	I(1)	I(1)	I(1)	I(0)+trend or I(1)	I(1)+drift
Output Ratio	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Nominal Money Ratio	I(1)	I(1)+trend	I(0)+trend or I(1)	I(1)	I(0)+trend or I(1)	I(1)	I(0)+trend or I(1)
Real Money Ratio	I(1)+drift	I(1)	I(1)+drift	I(1)+drift	I(1)	I(1)+drift	I(1)
Price Level Ratio	I(1)+trend	I(1)+trend	I(1)+trend	I(1)+trend	I(1)+trend	I(1)+trend	I(1)+drift
Nominal Exchange Rate	I(1)+trend	I(1)+trend	I(1)	I(1)+trend	I(1)+trend	I(1)	I(1)
Real Exchange Rate	I(1)	I(1)	I(1)+trend	I(1)	I(1)	I(1)	I(1)

Key: Own calculations using GAUSS386. The unit root properties indicated here are based on the test statistics and decision process outlined in Table 1 for the United States versus Germany. The full set of tables with the detailed results is available on request.

Table 3: Cointegration Test Statistics for the Five Key Macroeconomic Variables in the Bilateral Relationships of EC-Countries and the United States Relative to Germany

Countries	Stationary Variables?	Specification	Eigenvalue	Likelihood Ratio, (Critical Values)	No. of Cointegration Equations	Variables in VAR-system
United States 1972.01-1994.12	Nominal Money Ratio is I(0)+trend or I(1)	linear deterministic trend, 6 lags	0.068831	39.37 (5%: 47.21) (1%: 54.46)	None	Employment (l), Output (y), Real Exchange Rate (q), Prices (p)
France 1972.01-1994.12	None	linear deterministic trend, 6 lags	0.096009	67.10 (5%: 68.52) (1%: 76.07)	None	Employment (l), Output (y), Real Exchange Rate (q), Real Money (m-p), Prices (p)
Italy 1972.01-1993.12	None	linear deterministic trend, 6 lags	0.084656	67.17 (5%: 68.52) (1%: 76.07)	None	Employment (l), Output (y), Real Exchange Rate (q), Real Money (m-p), Prices (p)
Netherlands 1972.01-1994.12	Nominal Money Ratio is I(0)+trend or I(1)	linear deterministic trend, 6 lags	0.067040	42.85 (5%: 47.21) (1%: 54.46)	None	Employment (l), Output (y), Real Exchange Rate (q), Real Money (m-p)
Belgium 1972.01-1994.12	None	linear deterministic trend, 6 lags	0.085745	60.38 (5%: 68.52) (1%: 76.07)	None	Employment (l), Output (y), Real Exchange Rate (q), Real Money (m-p), Prices (p)
Denmark 1972.01-1994.12	Nominal Money Ratio is I(0)+trend or I(1)	linear deterministic trend, 6 lags	0.073495	37.59 (5%: 47.21) (1%: 54.46)	None	Employment (l), Output (y), Real Exchange Rate (q), Prices (p)

United Kingdom 1972.01-1994.12	Employment Ratio is I(0)+trend or I(1)	linear deterministic trend, 6 lags	0.056403	40.90 (5%: 47.21) (1%: 54.46)	None	Output (y), Real Exchange Rate (q), Real Money (m-p), Prices (p)

Key: Cointegration analysis was carried out using EVIEWS

Table 4: Variance Decomposition of Price Ratios, Nominal and Real Exchange Rates of EC-Countries Relative to Germany, Monthly Data, 1972.I-1994.XII

REAL EXCHANGE RATE

Time	Labour Market Shock						Supply Shock						Demand Shock						Money Demand Shock						Money Supply Shock					
Period	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK
1	0	0	1	1	1	3	18	23	1	3	0	19	75	69	94	94	97	71	0	1	1	0	0	1	6	7	3	2	1	7
2	1	0	0	3	1	3	17	22	1	2	0	15	74	69	96	93	97	76	0	0	1	0	1	1	7	8	2	2	0	5
3	3	1	0	3	1	5	16	23	1	2	1	13	74	68	97	93	97	77	0	0	0	0	1	0	6	8	2	2	0	5
12	7	1	2	2	4	10	14	22	2	2	2	10	76	74	95	96	93	78	0	0	0	0	0	0	3	3	1	1	0	1
24	7	0	3	1	5	12	14	21	2	2	2	10	77	77	95	97	92	77	0	0	0	0	0	0	1	2	0	0	0	1
36	7	0	3	1	6	13	14	20	2	2	2	10	78	78	95	97	92	77	0	0	0	0	0	0	1	1	0	0	0	0
48	7	0	3	1	6	14	14	20	2	2	2	10	79	79	94	98	92	76	0	0	0	0	0	0	1	1	0	0	0	0

NOMINAL EXCHANGE RATE

Time	Labour Market Shock						Supply Shock						Demand Shock						Money Demand Shock						Money Supply Shock					
Period	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK
1	0	1	1	3	0	0	15	23	1	2	0	17	59	52	69	66	62	58	0	1	6	0	11	3	26	24	24	29	26	22
2	1	1	1	5	0	0	14	23	1	2	0	13	58	50	72	66	56	64	0	0	5	0	14	3	27	26	23	27	29	20
3	3	2	0	5	0	1	13	22	1	2	1	11	58	48	71	66	53	65	0	0	4	0	12	2	27	28	24	26	33	21
12	7	5	3	9	1	4	10	21	1	2	4	6	45	43	66	64	37	71	0	0	3	0	12	2	37	31	28	25	47	16
24	10	6	4	11	1	6	9	21	1	2	4	6	39	40	66	63	34	72	0	0	2	0	12	2	43	34	27	24	50	14
36	11	6	4	12	1	7	8	20	1	2	4	6	36	38	66	62	33	72	0	0	2	0	12	2	45	35	27	24	51	14
48	11	6	4	13	1	7	8	20	1	2	4	6	35	37	66	62	32	72	0	0	2	0	12	2	46	36	27	24	51	13

PRICE LEVEL

Time	Labour Market Shock						Supply Shock						Demand Shock						Money Demand Shock						Money Supply Shock					
Period	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK
1	2	4	0	0	2	22	4	0	0	1	0	3	16	24	22	41	37	20	1	1	3	1	9	8	77	72	75	58	52	48
2	1	6	0	0	1	20	3	0	0	0	0	3	15	19	21	36	30	19	1	0	3	0	10	8	79	74	76	63	59	50
3	1	7	0	1	1	18	3	0	0	0	0	4	15	16	21	35	24	18	1	0	3	0	11	10	81	76	76	64	63	50
12	0	9	0	9	2	16	1	0	1	0	1	7	14	23	21	31	9	15	0	0	5	0	16	9	84	68	73	59	72	53
24	1	8	0	16	2	14	1	0	1	0	1	8	12	25	22	27	7	14	0	0	5	0	17	8	85	66	72	57	73	55
36	2	8	0	19	2	14	1	0	1	0	1	8	12	26	22	25	7	14	0	0	5	0	17	8	85	65	72	56	74	56
48	2	8	0	20	2	13	1	0	1	0	1	8	12	27	22	24	7	14	0	0	5	0	17	8	85	65	72	56	74	56

Table 5: Variance Decomposition of Price Ratios, Nominal and Real Exchange Rates of EC-Countries Relative to the United States, Monthly Data, 1972.I-1994.XII

REAL EXCHANGE RATE

Time	Labour Market Shock						Supply Shock						Demand Shock						Money Demand Shock						Money Supply Shock					
Period	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK
1	0	1	2	0	0	0	0	1	0	0	2	2	86	96	98	99	95	96	2	1	0	0	0	0	11	1	0	0	2	2
2	0	2	3	0	1	0	0	1	0	0	3	2	87	96	97	99	95	97	1	1	0	0	0	0	11	0	0	0	1	1
3	0	2	4	0	1	0	0	1	0	0	3	1	88	96	95	99	95	98	1	0	0	0	0	0	10	0	0	0	1	1
12	1	4	7	1	4	4	0	3	0	1	3	2	96	94	93	98	93	94	0	0	0	0	0	0	4	0	0	0	0	0
24	1	4	7	2	5	7	0	3	0	1	3	2	97	93	93	97	92	91	0	0	0	0	0	0	2	0	0	0	0	0
36	1	4	7	2	5	8	0	3	0	1	3	2	98	93	92	97	92	90	0	0	0	0	0	0	1	0	0	0	0	0
48	1	4	7	2	5	9	0	3	0	1	3	2	98	93	92	97	92	89	0	0	0	0	0	0	1	0	0	0	0	0

NOMINAL EXCHANGE RATE

Time	Labour Market Shock						Supply Shock						Demand Shock						Money Demand Shock						Money Supply Shock					
Period	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK
1	0	0	3	0	1	1	0	1	0	1	3	3	93	97	93	97	95	95	1	1	1	0	0	1	5	0	4	2	1	0
2	0	1	4	1	2	1	0	1	0	0	4	2	93	96	92	97	92	96	1	0	0	1	0	1	5	1	3	1	2	1
3	0	1	6	1	2	1	0	2	0	1	4	2	95	95	90	97	93	95	1	0	0	0	0	0	4	3	3	1	2	2
12	1	1	10	4	5	8	0	4	0	1	4	3	98	89	88	93	89	86	0	0	0	1	0	0	1	5	2	1	2	3
24	1	1	11	5	6	11	0	5	0	2	4	4	97	88	87	90	88	81	0	0	0	1	0	0	1	6	2	2	2	4
36	2	1	11	6	6	13	0	5	0	2	4	4	97	98	86	89	87	79	0	0	0	1	0	0	2	6	2	3	2	4
48	2	1	11	6	6	13	0	5	0	2	4	4	97	88	86	89	87	78	0	0	0	1	0	0	2	6	2	3	2	4

PRICE LEVEL

Time	Labour Market Shock						Supply Shock						Demand Shock						Money Demand Shock						Money Supply Shock					
Period	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK	F	I	N	B	D	UK
1	7	2	2	24	5	24	0	0	0	1	0	0	5	1	9	4	2	8	5	0	4	18	10	11	83	96	84	52	83	57
2	7	4	4	23	5	23	0	0	0	1	1	1	7	0	7	3	2	5	4	1	4	17	12	14	82	94	85	55	81	57
3	6	4	4	22	5	20	0	2	0	2	1	2	9	0	8	2	2	4	3	2	3	17	12	14	83	92	85	57	79	59
12	4	9	11	21	4	14	1	5	1	4	3	5	17	1	4	1	1	2	1	4	2	17	10	8	77	81	83	57	81	72
24	5	12	14	23	4	13	1	5	1	5	4	5	20	1	3	1	0	1	1	4	1	16	10	6	74	78	81	55	82	74
36	5	12	15	23	4	12	1	5	1	5	4	6	21	1	3	1	0	1	0	4	1	16	10	6	73	78	81	55	82	75
48	5	13	15	24	4	12	1	5	1	5	4	6	21	1	2	1	0	1	0	4	1	16	10	6	72	77	80	55	82	75