Interpreting sterling exchange rate movements

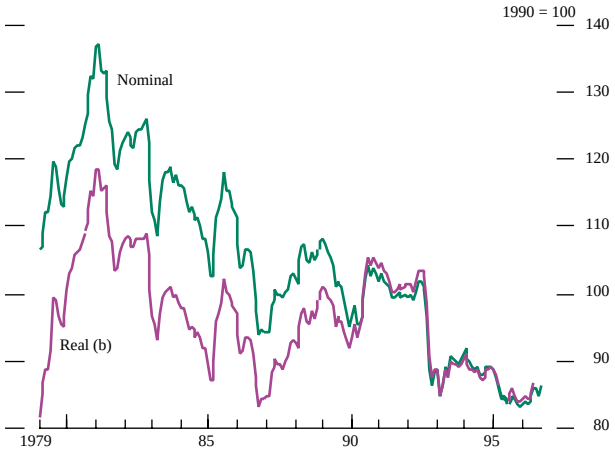
By Mark S Astley and Anthony Garratt of the Bank's Monetary Assessment and Strategy Division.

This article considers the analysis and interpretation of exchange rate fluctuations. It stresses the importance of identifying the sources of exchange rate movements, and recognising the many channels through which they can affect consumer prices. It reports empirical results which confirm that there is no simple relationship between the exchange rate and inflation. Sterling exchange rate depreciations are not necessarily associated with rises in UK consumer prices relative to prices overseas. In particular, UK prices may fall relative to those overseas if the depreciation is caused by increases in aggregate supply or falls in real spending, but rise if it is caused by increases in the money supply.

Introduction

Sterling exchange rate movements have long attracted intense discussion and analysis. Several factors have contributed to this. First, sterling nominal and real(1) exchange rates have fluctuated markedly since the break-up of the Bretton Woods fixed exchange rate system in early 1973 (see Chart 1). Second, the exchange rate plays several important roles in an open economy like the United Kingdom. In particular, sterling exchange rates provide a channel through which overseas developments may be transmitted to the UK economy and vice versa. And *real* exchange rates determine the terms on which UK companies compete in international markets.(2) Finally, the exchange rate plays an important role in the transmission of domestic shocks, including shifts in monetary policy, through the UK economy.

Chart 1
Sterling real and nominal effective(a) exchange rates



(a) Trade-weighted indices.
(b) Based on relative consumer prices.

These factors help to explain the importance that successive UK monetary policy frameworks have attached to the exchange rate.(3) Indeed, the United Kingdom has a long, intermittent, history of formal exchange rate targeting—from the international Gold Standard, through Bretton Woods to the European exchange rate mechanism (ERM). In the current policy framework, sterling's external value is one of several indicators monitored by the authorities when assessing progress towards the Government's inflation target. It is in this context that Section 2 of the *Inflation Report* analyses movements in sterling.

This article discusses the factors that are central to the analysis and interpretation of exchange rate movements. A key issue when interpreting an exchange rate movement is to identify the *source* of its change so that informed inferences can be made about the price movements that are likely to accompany it. The article outlines recent Bank research that attempts to quantify these considerations.

Some considerations in analysing exchange rates

In analysing and interpreting exchange rate movements, it is important to recognise that exchange rates are *endogenous* macroeconomic variables. Their value is determined within the economic system, by the interaction of domestic and foreign macroeconomic (real and financial) variables. Many other macroeconomic variables—such as consumer prices or GDP—that typically concern policy-makers are also endogenous. Movements of endogenous variables are caused by changes in—or shocks to— the structural parameters of the economy. But shocks can affect any endogenous variable both directly and via their impact on other endogenous variables.

(1) This article analyses the real exchange rate defined as the nominal exchange rate deflated by the ratio of domestic to foreign prices. They thus represent a common-currency measure of the price of domestic goods relative to their foreign equivalents. Of the various price indices that can be used, this article analyses real exchange rates based on relative consumer prices. But a different real exchange rate can be defined as the ratio of tradable goods prices to non-tradable goods prices. Real exchange rates calculated in this way aim to reflect the relative incentives for producers to operate in the tradables and non-tradables sectors of the economy.
(2) Authors such as Buiter and Miller (1983) and Bean (1987) have commented on the large effects that pronounced sterling real exchange rate movements have had on UK industry.
(3) George (1994, 1996) discusses sterling's role in past and current UK monetary policy frameworks. King (1994) outlines the current policy framework.

The endogeneity of exchange rates and consumer prices means that any observed *correlations* between these two variables should not be interpreted as exchange rate changes *causing* price movements, or vice versa. Such correlations are likely to reflect an exogenous shock moving both these endogenous variables in the same direction. But several factors may weaken this conclusion. First, exchange rate changes can directly affect the imported goods, materials and services components of domestic consumer prices. The strength of this 'import price channel' may, however, be weaker than is commonly perceived: there is substantial evidence that foreign exporters 'price to market'—holding the sterling price of their exports steady in the face of exchange rate movements in order to maintain UK market share.(1) Second, exchange rate movements are likely to *cause* consumer price fluctuations if the authorities allow this 'first-round' effect to feed through to wage and price-setting behaviour.

The distinction between endogenous variables and exogenous shocks is especially important for exchange rates. Exchange rates are *asset prices*, whose value is determined by the *expectations* of the *future* path of the exogenous shocks, and their effects on the other endogenous variables.(2) This forward-looking characteristic means that exchange rates are likely to change by more following *unanticipated* than *anticipated* developments. This is because, to rule out unexploited profit opportunities, exchange rates can only move in discrete steps—'jump'—following an unanticipated development. If arbitrage opportunities are exploited fully, any development which is expected beforehand will have been preceded by an exchange rate change at the moment when a piece of information first caused a revision of expectations. Expected trend movements in relevant economic variables can, however, produce smooth exchange rate movements.(3)

It is also important to recognise that the shocks that produce exchange rate movements can affect relative consumer prices(4) through a number of channels. For example, consumer prices will be affected by a shock's impact on the level of excess supply or demand in the economy. And, depending on the type of shock, the impact via these channels can either reinforce or offset the impact via import prices. This will become clearer if, like the May 1995 *Inflation Report*, we consider how the relative consumer price movements associated with a sterling nominal exchange rate depreciation may differ depending on its cause.

Three broad classes of shock underlie movements in macroeconomic variables such as the exchange rate, consumer prices and GDP. First, *real* aggregate supply shocks. These are developments—such as productivity movements—that shift the potential output of an economy. Second, *real* spending shocks, such as shifts in fiscal policy, consumption, investment and changes in tastes between home and foreign goods. Third, shifts in money supply or money demand schedules—money shocks.(5)

Consider each of these in turn:

- First, if a positive aggregate supply shock(6)—such as an improvement in UK productivity relative to its foreign equivalent—underlies the depreciation, it may be associated with a *fall* in UK relative consumer prices. The increase in potential—and actual—output generated by the supply shock is likely to be less than fully matched by an increase in UK aggregate demand.(7) The supply shock therefore creates an excess supply of UK goods, which is eliminated by an increase in foreign demand for UK goods. The *real* exchange rate depreciation required to stimulate foreign demand is, for a broad range of parameter values in the economy,(8) achieved partly through a nominal depreciation. And the excess supply also exerts downward price pressure, producing a *fall* in UK relative consumer prices,(9) which is partly offset by the rise in sterling import prices.

- Second, if a negative real spending shock—such as a shift in tastes away from UK goods—underlies the depreciation, it is again likely to be associated with a *fall* in UK relative consumer prices. The negative real spending shock will temporarily decrease output below its long-run supply-determined potential, putting *downward* pressure on UK relative consumer prices. But the shock also causes UK nominal interest rates to fall below their foreign equivalents. This generates a capital outflow and hence a sterling nominal exchange rate *depreciation*.(10) This depreciation, together with the fall in UK interest rates, eventually raises output back to its unchanged equilibrium level.

- Third, if a positive money shock—such as a one-off increase in the United Kingdom's money supply relative to that abroad—underlies the depreciation, it will eventually be associated with a *rise* in UK relative consumer prices. Consumer prices increase because the money shock stimulates aggregate demand.(11) And the increase in aggregate demand also raises the demand for

(1) See *inter alia* Hooper and Mann (1989), Krugman (1987,1989) and Mann (1987,1989).
(2) Black (1973) is an early example of the asset price approach to exchange rate. Empirical papers attempting to quantify these responses include Dornbusch (1978, 1980), Frenkel (1981), Eichenbaum and Evans (1993), Grilli and Roubini (1993) and Clarida and Gali (1994). Frankel and Rose (1995) provide an overview.
(3) But these movements must be accompanied by compensating cross-country interest rate differentials.
(4) Defined in the empirical work as the log of UK consumer prices minus the log of an index of foreign consumer prices.
(5) Real spending shocks and money shocks are often combined into aggregate demand shocks.
(6) The aggregate supply shocks we consider are ones which have roughly equal effects on all sectors of the economy and whose direct supply effects are not exceeded by any wealth effects that may be associated with them. Our analysis differs from that in the May 1995 *Inflation Report* by allowing for permanent real exchange rate changes.
(7) For example, if the marginal propensity to consume is less than one.
(8) See Astley and Garratt (1996) for details of the relevant parameters.
(9) That is, relative consumer price movements also play a role in achieving the required real depreciation. But the 'stickiness' of prices means that nominal exchange rates are likely to change by more than relative consumer prices in the short run.
(10) The associated rise in sterling import prices again partly offsets the fall in relative consumer prices.
(11) This occurs through several channels. First, through the fall in nominal interest rates attendant on the money supply expansion. Second, while goods market prices remain sticky, the nominal depreciation is also a real depreciation, making UK goods more competitive on international markets. And, of course, the rise in the sterling price of imported goods and materials following the nominal depreciation directly raises consumer prices.

foreign goods and hence for the foreign currency. This leads to a rise in the price of the foreign currency—a nominal sterling *depreciation*. The rise in relative prices and nominal exchange rate will eventually completely offset each other, ensuring that purchasing power parity—an unchanged real exchange rate—is maintained in the long run.(1) This occurs because nothing 'real' has happened to change the relative price of the two countries' goods.

These considerations imply that, as the May 1995 *Inflation Report* stated, 'there is no simple relationship between exchange rate changes and subsequent inflation'. The *Report's* analysis was framed on a model where purchasing power parity held in the long run. The present analysis, which is based in a richer model, has confirmed the *Report's* conclusion. In particular, we have shown that a nominal depreciation may be associated with a *fall* in relative consumer prices if it is caused by aggregate supply or real spending shocks, but a *rise* in relative prices if it is caused by a money shock.

As such, the common assertion that depreciations are unambiguously associated with rises in consumer prices is flawed. Of course, if monetary policy allows wage and price-setting behaviour to be revised upwards following depreciations, 'second-round' effects are generated. These add to the ('first-round') effect of exchange rates on import prices. Monetary accommodation therefore increases the monetary element of *any*—real or money—shock, making relative price rises more likely.

In summary, an exchange rate analysis should take place in a framework that takes account of two factors. First, the framework needs to be able to identify the type of shock underlying an exchange rate movement. Second, it needs to be able to recognise the many channels through which these shocks can affect prices. We now turn to an empirical approach that does both of these things.

Quantifying these considerations

This section outlines a method for estimating the relative importance of the three types of exogenous shocks described above as *sources* of movements of sterling bilateral exchange rates, UK relative consumer prices and UK relative GDP.(2) The relative formulation is employed because the bilateral exchange rates examined are relative prices linking two economies. This means that only the effects of asymmetric shocks—hitting one country but not the other—are considered. The approach also generates empirical estimates of the dynamic effects of each of the three types of shock on exchange rates, relative consumer prices and relative GDP. This allows a quantification of the relative price (and output) movements which have, on average, been associated with exchange rate movements in the past. In reporting these results, we concentrate on the exchange rate and relative price interactions.

Empirical method

A Structural Vector AutoRegression (SVAR) approach is used to explore these interactions. SVARs are dynamic simultaneous equation systems that allow a quantification of the dynamic impact of exogenous shocks on endogenous variables. Unfortunately, the exogenous shocks—and their dynamic effects on the endogenous variables—are unobservable. But the data allow movements in each endogenous variable to be represented as responses to past movements in all the endogenous variables. And by applying assumptions, or restrictions, to this representation we can obtain estimates of—or identify—the dynamic effects of the unobservable exogenous shocks. These identification issues are familiar from the Vector AutoRegression (VAR) methodology.(3) The advantage of the SVAR approach is that the identifying restrictions employed are explicitly grounded in economic theory.(4)

In our case these restrictions are formulated in terms of the *long-run* effects of shocks on endogenous variables. In particular, we impose the conditions that neither real spending shocks nor money shocks have long-run effects on the level of relative output. These two restrictions mean that long-run relative output fluctuations are attributed entirely to aggregate supply shocks. Finally, we restrict money shocks to have zero long-run effects on the level of the real exchange rate. The advantage of these restrictions is their generality. This means that the empirical quantification is not tied to one particular theoretical model. The technical appendix discusses these issues in more detail.

SVAR models were estimated for the United Kingdom relative to four major countries—France, Germany, Japan and the United States—on quarterly data between 1973 and 1994. This sample period was chosen to cover the post Bretton Woods era. As there was little qualitative variation in the results across country pairs, only the results from the UK-German system are reported below.(5)

Sources of sterling exchange rate and UK relative consumer price movements

This section outlines the estimates of the relative importance of the three shocks as sources of movements in sterling bilateral exchange rates and in UK relative consumer prices. They are determined by the proportion of the movements of each of the endogenous variables between 1973 and 1994 which can be attributed to each of the exogenous shocks. And these proportions can be calculated at various time periods—or horizons—after the impact of the shock.(6) We

(1) Dornbusch (1976) showed that the presence of slowly adjusting goods market prices means that in the short run the nominal exchange rate will depreciate by more than it does in the long run; the exchange rate 'overshoots' in the short run. The overshooting reflects the fall in UK interest rates below their foreign equivalents following the money supply expansion, which must be offset by an expectation of an *appreciation* of sterling. This is only consistent with the long-run sterling depreciation if the currency over-depreciates in the short run.
(2) This approach is based upon the Clarida and Gali (1994) analysis of US dollar exchange rates.
(3) See Dale and Haldane (1993) and Henry and Pesaran (1993) for overviews of the VAR approach.
(4) The restrictions employed in VARs are more restrictive and are often difficult to reconcile with structural economic models—see Cooley and LeRoy (1985).
(5) More detailed results are presented in Astley and Garratt (1996).
(6) These proportions relate to the endogenous variable movements *directly* due to the initial shock.

report both the central—or point—estimate of the relative importance of the shocks and, in parentheses, the 95% confidence intervals surrounding these point estimates. These confidence intervals allow us to test whether the contribution of a particular shock is significantly different from zero.(1)

Table A presents the results for the *real* DM/£ exchange rate (similar results were obtained for the nominal DM/£ rate). According to those estimates, real spending shocks—such as shifts in consumers' tastes or fiscal policy—accounted for the majority of real (and nominal) DM/£ exchange rate movements between 1973 and 1994. Real aggregate supply shocks, such as cross-country productivity differentials, were usually the second most important source of those movements, while money shocks were usually the least important.

Table A
Percentage of real DM/£ exchange rate variation accounted for by each of the shocks; 95% confidence intervals in parentheses

Quarters after shock	Aggregate supply shock		Real spending shock		Money shock	
1	9.3	(1.3–17.3)	72.0	(55.7–88.3)	18.7	(4.2–33.2)
2	11.2	(2.4–20.0)	74.9	(59.9–89.9)	13.9	(2.3–25.5)
4	13.6	(2.9–24.4)	78.2	(64.2–92.2)	8.2	(0.0–25.5)
8	15.7	(2.9–28.5)	80.3	(66.4–94.2)	4.0	(0.5–7.5)
12	16.7	(3.0–30.4)	80.9	(66.6–95.2)	2.5	(0.4–4.6)
16	17.1	(2.8–31.4)	81.1	(66.5–95.7)	1.8	(0.4–3.2)
20	17.4	(2.8–32.0)	81.2	(66.4–96.0)	1.4	(0.3–2.5)
40	17.9	(2.9–32.9)	81.4	(66.8–96.0)	0.7	(0.2–1.2)
60	18.1	(13.1–33.1)	81.4	(66.9–95.9)	0.5	(0.2–0.8)

It is interesting to set these results against the predictions of alternative approaches to (real) exchange rate determination. We consider two mainstream approaches. First, the 'sticky price' approach.(2) That approach focuses on the slow adjustment of goods market prices. This means that nominal exchange rate movements also constitute real exchange rate changes. And since money shocks affect nominal exchange rates, they should play a role in real exchange rate movements, at least in the short run when prices are 'sticky'. Second, the 'equilibrium' approach.(3) That approach focuses on *real* shocks, which are largely permanent, as determinants of real exchange rate changes. Such a predominance of *permanent* real shocks implies that a high proportion of real exchange rate changes represent permanent shifts in the equilibrium real exchange rate.

On balance, our results that *real* spending and aggregate supply shocks were the most important sources of sterling exchange rate fluctuations—particularly in the long run—are more *consistent*(4) with the 'equilibrium' approach. And the roles that our results that indicate real shocks played in relative price and output movements suggest that they may indeed have had large permanent components. But the 'sticky price' approach also receives some support. In particular, our finding that the role of money shocks was largest in the first few quarters following the shock, before declining thereafter, is consistent with that approach. And the estimated dynamic responses (discussed below) indicate that relative prices respond comparatively slowly to shocks.

Table B reports the results for UK-German consumer prices. According to these estimates, most of the movements in UK-German consumer prices between 1973 and 1994 were accounted for by money shocks. This is consistent with the view that inflation is essentially a monetary phenomenon.

Table B
Percentage of UK-German consumer price variation accounted for by each of the shocks; 95% confidence intervals in parentheses

Quarters after shock	Aggregate supply shock		Real spending shock		Money shock	
1	32.7	(11.7–53.7)	16.4	(0.0–33.5)	50.9	(31.2–70.6)
2	27.0	(17.8–46.2)	16.3	(0.0–32.8)	56.7	(37.8–75.6)
4	22.3	(4.3–40.3)	16.0	(0.0–32.4)	61.7	(43.1–80.3)
8	19.6	(2.2–37.0)	15.6	(0.0–32.0)	64.8	(46.1–83.5)
12	18.7	(1.4–36.0)	15.5	(0.0–31.9)	65.8	(47.0–84.6)
16	18.3	(1.1–35.5)	15.5	(0.0–31.9)	66.2	(47.4–85.0)
20	18.1	(0.9–35.3)	15.4	(0.0–31.8)	66.5	(47.7–85.3)
40	17.8	(0.6–35.0)	15.4	(0.0–31.8)	66.8	(47.9–85.7)
60	17.7	(0.6–34.8)	15.4	(0.0–31.8)	66.9	(48.0–85.8)

And the increasing dominance of money shocks at longer time periods following the shock is consistent with this being a long-run theory of price determination. But, importantly, real (aggregate supply and spending) shocks also played a significant role in explaining UK relative price movements. This is most apparent in the first few quarters after the shock—especially for aggregate supply shocks—but is also present a considerable period thereafter. For example, real shocks are estimated to account for nearly a third of the UK-German consumer price movements due to the shocks fifteen years after their impact.

A comparison of the results from Table A with those from Table B suggests that different types of shocks were the sources of the movements in sterling exchange rates and UK relative consumer prices between 1973 and 1994. The real spending shocks that accounted for most of the sterling exchange rate fluctuations over that period played a much smaller role in the associated UK relative consumer price movements. This suggests that sterling exchange rate fluctuations did not constitute an important channel through which exogenous shocks eventually fed through to changes in UK relative prices over this period. UK relative consumer price movements were instead accounted for primarily by money shocks that were unimportant sources of sterling exchange rate movements.

The theoretical considerations discussed above suggested that sterling depreciations (appreciations) were likely to be associated with falls (rises) in UK relative consumer prices if aggregate supply or real spending shocks were the primary source of the exchange rate fluctuations. And,

(1) This was first proposed by Runkle (1987). But many practitioners do not strictly apply this test, because VARs are not meant to be parsimonious representations. As such, the degree of uncertainty associated with the point estimates could easily be reduced.
(2) Due to Dornbusch (1976), the approach usually only considers money shocks.
(3) Due to Stockman (1987, 1988).
(4) Our empirical results cannot be used to formally discriminate between alternative exchange rate theories.

according to our results, such real shocks were the main source of sterling exchange rate movements between 1973 and 1994.(1) But this does not necessarily imply that sterling depreciations (appreciations) were in the past associated with falling (rising) UK relative consumer prices. This is because such inferences relate to the dynamic interactions between exchange rates and relative prices.(2) We turn to this issue next.

Dynamic relationships between sterling exchange rate and UK relative consumer price movements

The estimated systems allow us to trace out the dynamic effects of each of the three exogenous shocks on each of the endogenous variables. From these we can infer the stylised dynamic interactions between sterling exchange rate and UK relative price movements between 1973 and 1994.

Chart 2 plots the response (in per cent) of each of the variables in the UK-German system to a 1.0 percentage point *positive* innovation in each of the exogenous shocks. The real and nominal exchange rates are defined so that a rise represents an appreciation. The point estimates are represented by the dark lines, while the lighter lines represent the 95% confidence intervals (error bands).(3)

The dynamic responses of each of the endogenous variables following each of the shocks are consistent with the theory outlined above. This, importantly, suggests that the SVARs are more than statistical representations of the data; they also have considerable economic content. For example, a *positive* real spending shock produces a temporary rise in UK-German GDP, an *appreciation* of the (real and nominal) DM/£ exchange rate and a *rise* in UK-German consumer prices. Thus nominal DM/£ *depreciations* are associated with *falling* UK-German prices following *negative* real spending shocks. Likewise, nominal DM/£ depreciations are found to be associated with *falling* UK-German consumer prices following *positive* aggregate supply shocks. In contrast, and as expected, nominal DM/£ depreciations were found to be associated with *rising* UK-German consumer prices following *positive* money shocks.

Combined with the result that real spending and aggregate supply shocks were the primary sources of sterling fluctuations, these point estimate responses suggest that sterling depreciations were largely associated with *decreases* in UK relative consumer prices between 1973 and 1994.

But taking account of the error bands associated with the point estimates in Chart 2 considerably weakens that conclusion. In particular, the error bands suggest that the relative consumer price responses to real spending and aggregate supply shocks are not significantly different from zero. The relative consumer price responses following money shocks are, however, significantly different from zero. So if a sterling exchange rate depreciation was caused by real spending or aggregate supply shocks—which the results indicate was the case for most of sterling's movements between 1973 and 1994—it was unlikely to be associated with any significant change in UK relative consumer prices. But if the sterling depreciation was caused by a money shock—which the results indicate was the case for a small proportion of sterling's fluctuations over the past two decades—it was likely to be associated with a statistically significant rise in UK relative consumer prices.

Using these results

The estimated interactions between shocks and endogenous variables should not be applied mechanically to each movement in sterling exchange rates. But they constitute a useful way of quantifying the theoretical considerations central to exchange rate analysis. And the stylised results have several potential uses.

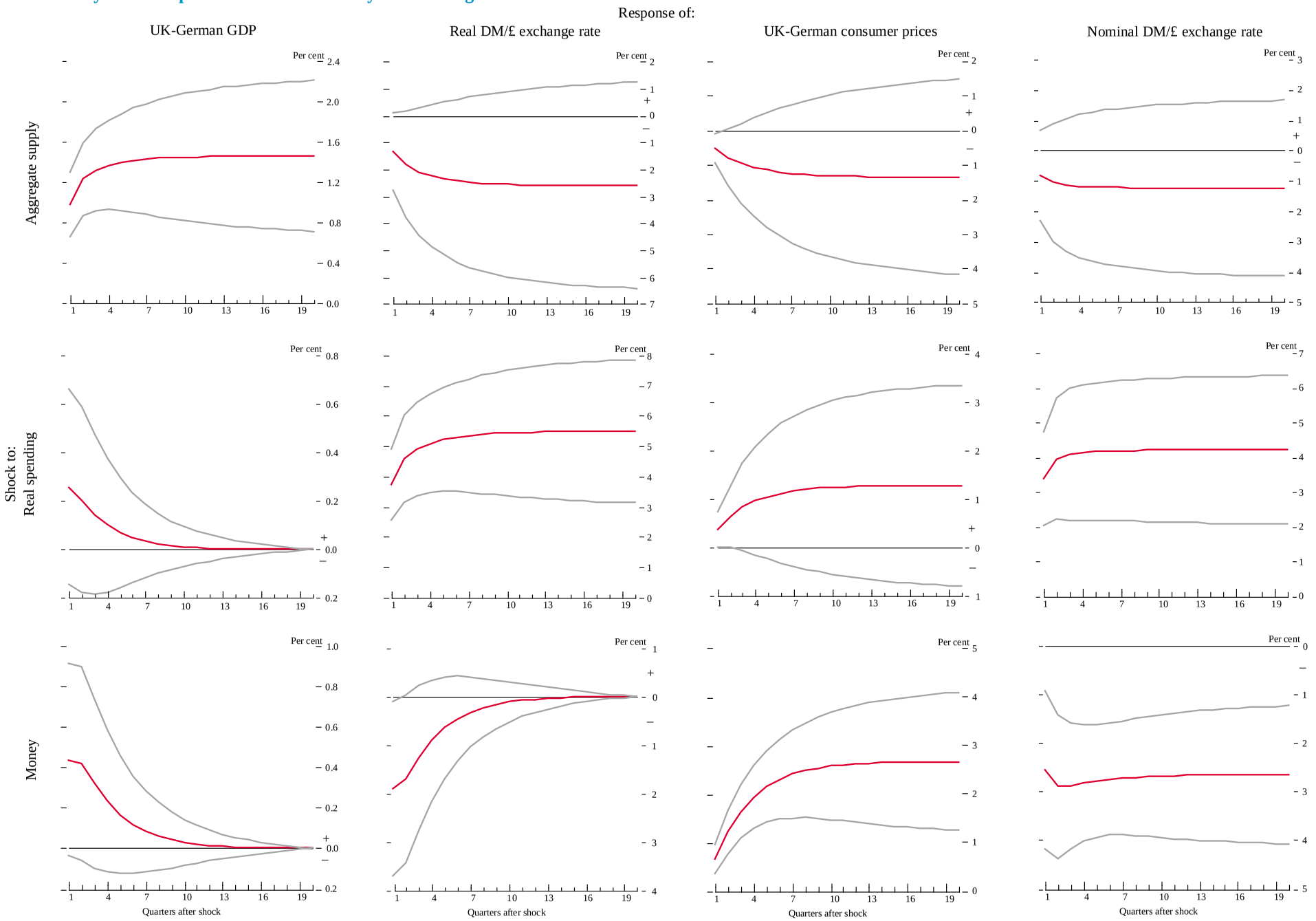
First, the results can help us to understand past exchange rate, relative consumer price and relative output fluctuations. SVARs are particularly useful in this respect because they allow the decomposition of endogenous variable movements over distinct historical episodes into that attributable to each of the shocks. In general, we find that the historical periods during which the estimated SVARs indicate that a particular shock was most important correspond sensibly to observed macroeconomic developments. This again indicates that the SVARs have considerable economic content.

For example, our results suggest that the real DM/£ appreciation in the late 1980s (see Chart 1) largely reflected real spending shocks. And this may be related to the observed shift in relative domestic demand towards the United Kingdom over that period. In contrast, our results suggest that real aggregate supply shocks played a large role in the real DM/£ depreciation following sterling's departure from the ERM. This may be linked to the improvement in UK relative productivity—partly reflecting the negative short-term effects of German reunification on German productivity—which occurred over that period. And these positive supply shocks also, according to our results, played a large role in the improvements in UK relative inflation witnessed over that period. This contrasts with previous experience; our results indicate that the rising UK-German consumer prices observed in the 1980s largely reflected money shocks. And this may be traced to UK monetary aggregates growing quicker than their foreign equivalents over that period.

Second, a better understanding of the past can aid the interpretation of current developments. For example, the result that real shocks underlay most of sterling's fluctuations between 1973 and 1994—and the implications for relative consumer price movements—might be

(1) The technique cannot easily detect if different shocks underlay exchange rate depreciations and appreciations.
(2) Moreover, it is possible that the association of *nominal* exchange rate depreciations with falling relative prices following (positive) aggregate supply shocks may not hold for some values of parameters in the economy.
(3) Chart 2 only plots the first 20 quarters of responses because the lines are flat thereafter.

Chart 2: Dynamic responses of UK-German system to exogenous shocks



extrapolated to more recent movements. But several caveats must be borne in mind. First, these stylised results are based upon past interactions between variables. It is well known that in general such past relationships will not necessarily hold outside the sample period, especially if policy-makers attempt to use these past relationships.(1) Moreover, this out-of-sample problem is especially pronounced in exchange rate modelling.(2) Second, these stylised results represent the *average* dynamic interactions over the sample period. So they will not necessarily apply to each and every exchange rate movement, either inside or outside the sample period.(3) Third, the results apply only to sustained exchange rate movements, rather than to erratic quarter-to-quarter changes. This is because non-macroeconomic factors—such as foreign exchange market participants' trading strategies—may have an impact on exchange rate movements, especially in the short run.(4) Fourth, the results reported above have been obtained in one of many potential empirical frameworks.(5) As such, they should not be regarded as definitive.

Conclusions

This article has emphasised the importance of identifying the sources of exchange rate movements and of taking account of the many channels through which such developments can affect consumer prices and activity. Both these tasks are extremely difficult. But analyses conducted without the discipline of this type of framework are more likely to be misleading. In particular, this article has demonstrated that, both theoretically and empirically, it should not be presumed that sterling exchange rate depreciations will necessarily be associated with rises in UK relative consumer prices. Relative consumer prices are likely to fall if either aggregate supply or real spending developments underlie the depreciation, but rise if monetary developments underlie it. The empirical approach outlined above represents one way of obtaining empirical information on the complex interactions between exogenous disturbances, exchange rates and the other endogenous variables in the economy.

(1) The Lucas (1976) critique of the use of econometric models to inform policy.
(2) Meese and Rogoff (1983a, b) demonstrated that a simple random-walk out-performed the out-of-sample forecasts of a number of mainstream economic models.
(3) This is, however, the best that we can do. Any average result will not, by definition, apply to every occasion.
(4) There is a large literature that suggests that exchange rate movements are little related to macroeconomic 'fundamentals'. See *inter alia* Kirman (1995), DeGrauwe (1994) and Rose (1994).
(5) The SVAR approach employed was chosen for its ability to obtain information on the links between shocks and endogenous variable movements. It also aimed to avoid the problems associated with traditional exchange rate modelling. The lack of problems uncovered by various diagnostic tests of the SVARs is reassuring in this respect. But SVARs employing different restrictions—based upon different theoretical models—could potentially uncover different stylised relationships.

Technical appendix

The endogeneity of macroeconomic variables such as exchange rates, consumer prices and GDP means that it is appropriate to think of them as fluctuating in response to unanticipated exogenous shocks. This may be represented as:[1]

$$y_t = C_0 \varepsilon_t + C_1 \varepsilon_{t-1} + C_2 \varepsilon_{t-2} + ... C_n \varepsilon_{t-n} . + ... \quad \textbf{(1)}$$

where y_t is a (3 by 1) vector of our endogenous economic variables (relative GDP, the real exchange rate and relative consumer prices), ε_t is a (3 by 1) vector of exogenous shocks and the *C*'s are (3 by 3) coefficient matrices which can be given economic interpretation. While the endogenous variables (y_t) are observable, the exogenous shocks (ε_t)—and their effects on the endogenous variables (C_i)—are not. Instead, movements in each of the endogenous variables can be modelled as a function of past movements in all of the endogenous variables:[2]

$$y_t = \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + ... + \Phi_p y_{t-p} + e_t \quad \textbf{(2)}$$

Where e_t is a vector of residuals and Φ are again parameter matrices, but with considerably less economic content than the *C*'s. The aim of the SVAR method is to move from the easily estimated form of **(2)** to an estimate of the form of **(1)**, which has considerably more economic content. The first stage in this is to notice that **(1)** may be inverted to obtain:

$$A_0 y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + \varepsilon_t \quad \textbf{(3)}$$

It is clear that **(2)** and **(3)** are of similar forms. In particular, $A_i = A_0 \Phi_i$, for i=1,..p, and $\varepsilon_t = A_0 e_t$. It can be shown that n^2 restrictions (n is the number of variables in y_t) are required to achieve a unique transformation from **(2)** to **(3)** (and hence back to **(1)**)—to 'identify' the model. Six of the nine restrictions required in our case are provided by the variances of the structural shocks (ε_t) being normalised to unity and the assumption that the structural shocks are uncorrelated with each other. This zero correlation means that each of the structural shocks is viewed as distinct economic phenomenon.

The final three restrictions are derived from economic theory. In our case this takes the form of specific shocks having zero *long-run* effects on the levels of certain endogenous variables. These *long-run* restrictions, which were first implemented by Shapiro and Watson (1988) and Blanchard and Quah (1989), have several strengths. First, they are grounded explicitly in economic theory. Second, they are usually very general. This means that the empirics are not tied to one particular theoretical model. Third, they avoid the need to impose restrictions on the short-run reaction of variables to shocks, which are often more contentious.

The three long-run restrictions we impose are derived from the Obstfeld (1985) stochastic two country version of the Dornbusch (1976) model. The first two of these are that both goods market shocks and money shocks have zero long-run effects on the level of relative output—which is entirely determined by aggregate supply shocks. Finally, we restrict money shocks to have zero long-run effects on the level of the real exchange rate.

Identifying the model—extracting an estimate of **(1)** from the data—allows us to extract several useful pieces of information on the dynamic interactions between shocks and movements in the endogenous variables.

First, we can determine the average *relative* importance of each of the shocks in accounting for movements in the endogenous variables over the estimation period. This information is obtained through what are known as *Forecast Error Variance Decompositions*. These test the relative importance of each of the shocks by considering their role in the h-step ahead forecast errors of the endogenous variables:

$$a_{t \setminus t-h} = y_t - y_{t \setminus t-h} \quad \textbf{(4)}$$

where $a_{t\setminus t\text{-}h}$ is the h-step-ahead forecast error of y_t and $y_{t\setminus t\text{-}h}$ is the h-step-ahead forecast of y_t made using information available at time t-h. For small (large) values of h, $a_{t\setminus t\text{-}h}$ can be interpreted as the short-run (long-run) movements in y_t. The relative importance of a shock is then determined by the fraction of the variance of the forecast error ($a_{t\setminus t\text{-}h}$) that it explains.

(1) This is known as the structural moving average representation.
(2) This is known as the Vector AutoRegression (VAR) representation.

These forecast errors are determined by both the exogenous shocks hitting the system and the response of the endogenous variables to these shocks (*C* matrices). A unique decomposition can only be obtained if, as is assumed, the exogenous shocks are uncorrelated with each other. It can be shown that the proportion of the variance of the *i*-th variable accounted for by the *j*-th shock at horizon *h* $\left(R^2_{ij,h}\right)$ is:

$$R^2_{ij,h} = \frac{\left[\sigma^2_j \sum_{k=0}^{h-1} c^2_{ij,k}\right]}{\sum_{m=1}^{n}\left[\sigma^2_m \sum_{k=0}^{h-1} c^2_{im,k}\right]} \qquad \textbf{(5)}$$

Where σ^2_j is the variance of the *j*-th structural shocks and $c_{ij,k}$ $(c_{im,k})$ are the individual elements in the *C* matrices—the response of the *i*-th variable following the *j*-th (*m*-th) shock after *k* periods.

Second, we can examine the dynamic responses of each of the endogenous variables to each of the exogenous shocks. These functions, which are known as *impulse responses*, are obtained from the sequence of $c_{ij,k}$ *s*.

Third, we can decompose movements in each of the endogenous variables over distinct historic periods into that attributable to each of the shocks. These functions, which are known as *historical decompositions*, are described in Burbridge and Harrison (1985).

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