Decomposing exchange rate movements according to the uncovered interest rate parity condition

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This article discusses the relationship between the exchange rate and monetary policy. It sets out some of the difficulties in identifying the underlying causes of exchange rate movements, and outlines one approach, based on the uncovered interest rate parity condition, that can be used to assess how far news about monetary policy has contributed to an exchange rate change.

Introduction

The monetary authorities of a country with a floating exchange rate, such as the United Kingdom, face the important and difficult issue of how to respond to exchange rate changes. As the price of one country's money in terms of another country's money, a floating exchange rate may change in response to developments either at home or abroad. The implications for monetary conditions, and so for the setting of national monetary policies, depend on the underlying causes. This article describes one approach, based on the uncovered interest rate parity (UIP) condition, used by the Bank to assess the contribution of monetary policy news to exchange rate developments.

The first section of the article discusses the relationship between the exchange rate and monetary policy in more detail. The second section describes techniques that have been used in the past to try to identify the underlying causes of exchange rate developments. The third section sets out in detail how the UIP condition can be adapted to provide an estimate of the contribution of news about monetary policy to exchange rate changes. The fourth section illustrates the potential use of this UIP decomposition with some case studies. The article concludes by assessing this technique, including some of its potential pitfalls.

Exchange rates and monetary policy

How monetary authorities with inflation targets react to economic developments depends on how the prospects for inflation are affected. This is as true for the exchange rate as for other economic factors—see King (1997).[1]

This section provides three hypothetical illustrations of why the link between exchange rate changes and monetary policy is not straightforward. The examples are: the impact of a temporary shock to foreign monetary policy; a permanent positive demand shock; and a reassessment by financial markets of the objectives of UK policy-makers.

Imagine first that the sterling exchange rate appreciated because markets correctly came to believe that overseas monetary policy would be loosened. The initial direct effect would be to lower domestic inflation, as the sterling price of imports fell. But after a time this would wear off as the foreign price of these imported goods rose (reflecting the looser monetary conditions abroad), and so their sterling price would return to its initial level. Overall, there would be an initial temporary fall, followed by a temporary rise in UK price inflation, with no net effect in the long run on the overall price level in the economy. These direct price-level effects would be unrelated to trends in domestically generated inflationary pressure.

But there could also be important indirect effects. In particular, following an overseas monetary expansion, domestic demand might be boosted by an increase in UK residents' real incomes and wealth (resulting from temporarily lower prices). But at the same time, demand for UK exports could fall if our exports became relatively more expensive (exporters did not change the sterling prices of their exports). Depending on the size and persistence of these indirect effects, expectations of inflation might change, requiring offsetting monetary policy action.

Now consider a real shock: for example, a change in overseas tastes that made UK domestically produced goods and services more popular abroad than before. The relative price of domestically produced goods would increase, through a real (and nominal) exchange rate appreciation, leaving domestic prices in the respective countries unchanged. If permanent, this might lead ultimately to a re-balancing of resources between the exporting and import competing sectors of the economy. The shorter-term indirect effects on net trade and GDP would largely depend on the immediate reaction of the exporting sectors to the increased popularity of their products. Again, any knock-on effect on the short-run path of demand and activity might require a monetary policy response.

(1) 'Monetary Policy and the Exchange Rate', speech to the Governors of the National Institute of Economic and Social Research, 27 February 1997, reprinted in the May 1997 *Quarterly Bulletin*, pages 225–27.

Finally, suppose sterling were to appreciate because financial markets changed their assessment of UK policy objectives, and concluded that official interest rates would need to be higher temporarily to satisfy these new objectives. In this case, the underlying shock would be news about domestic monetary policy. If the markets were correct, then there would be both a nominal and real exchange rate appreciation, which would be a consequence of the change in monetary policy objectives. The appreciation would be associated with falling prices (relative to the baseline case of no change in policy objectives) and would contribute to the monetary authorities' pursuit of the revised objective. The real exchange rate would ultimately return to its initial level, but there would be a permanent effect on the nominal exchange rate, reflecting the change in relative prices. Alternatively, if the markets were incorrect and policy objectives had not in fact changed, the exchange rate would probably fall back, other things being equal, as markets reassessed their views about likely monetary policy.

Many other factors can lead to exchange rate movements, but the hypothetical examples above illustrate why there is no simple link between the exchange rate and interest rates when the policy target is inflation. The appropriate policy response will depend on an analysis of the causes of the exchange rate change.

Identifying shocks

Given that the nature of the shock matters for policy, it is essential to try to identify the shocks underlying particular exchange rate movements. Though simple in theory, this is very difficult to do in practice.

Previous studies offer little consensus on which type of shock has been the predominant source of volatility in exchange rates since they were floated in the early 1970s.(1) Some argue that unexpected changes in monetary policy ('monetary shocks') have been responsible for the bulk of observed exchange rate volatility.(2) Others argue that real disturbances to the supply of and demand for goods, which require relative price adjustment, have been responsible for most of the volatility in exchange rates.(3)

Evaluating these views is difficult, because the underlying shocks are not directly observable. For this reason, it is necessary to rely on indirect evidence. A variety of techniques have been developed to do this. One approach, previously discussed in the *Bulletin*,(4) is to examine the relationship between two countries' output (as measured by GDP), inflation and the real exchange rate to identify the contribution of permanent real shocks, temporary real shocks and monetary shocks.(5) This technique assumes that only real (demand or supply) shocks can affect the permanent component of changes in real variables, and that only supply shocks affect output in the long run.

An alternative approach is to split changes in the real exchange rate into permanent and temporary changes using statistical tools, and to take the relative variance of these permanent and temporary elements as a measure of the

The real exchange rate

The nominal exchange rate is a relative money price. For example, the sterling/Deutsche Mark exchange rate, as quoted on the London market, is the price in Deutsche Marks of sterling currency. The real exchange rate is the relative price of (a representative sample of) two countries' output.

A country's price level is an index of the money price of a given basket of commodities. For example, in a consumer price index, the basket is a set of 'typical' household purchases. The real exchange rate is defined in this article as the relative cost of a common reference basket of goods in two countries, where the baskets' costs are compared after being converted into a common currency. For the United Kingdom and Germany, with price levels PUK and $PGER$, and nominal exchange rate S (defined as Deutsche Marks per pound sterling), the real exchange rate (Q) is $S \times PUK/PGER$. The United Kingdom experiences a real appreciation (and Germany a real depreciation) if Q rises. A real appreciation means that domestic goods become more expensive relative to foreign goods in common currency terms. The volume of exports of domestic goods might be expected to fall and the volume of imports of foreign goods to rise, so the volume of net trade (exports minus the volume of imports) is likely to decrease.

Aggregate demand is often split into domestic absorption, such as investment and consumption, and net trade. For a given level of domestic absorption, the equilibrium real exchange rate can be defined as the real exchange rate at which the net trade contribution to aggregate demand equates aggregate demand with the equilibrium rate of output in the economy.

(1) Rogoff, K (1996), 'The purchasing power parity puzzle', *Journal of Economic Literature*, June 1996, pages 647–68.
(2) Mussa, M (1982), 'Nominal exchange rate regimes and the behaviour of real exchange rates, evidence and implications', *Carnegie-Rochester Conference series on public policy*, 26.
(3) For a well-known statement of this position see Stockman, A (1987), 'The equilibrium approach to exchange rates', *Federal Reserve Bank of Richmond Quarterly Review*, March/April.
(4) Astley, M and Garratt, A (1996), 'Interpreting sterling exchange rate movements', *Quarterly Bulletin*, November 1996, pages 394–404, which was based on Clarida, R and Gali, J (1994), 'Sources of real exchange rate fluctuations; how important are nominal shocks?', *Carnegie-Rochester Conference series on public policy*, 41, pages 1–56.
(5) The shocks to monetary equilibrium identified in this approach capture the effects of shocks to both money supply and money demand (see Astley and Garratt, *Quarterly Bulletin*, November 1996 for more detail).

relative importance of real and monetary factors.[1] The underlying assumption is that only real shocks affect the permanent component of changes in real variables. So the variance of the temporary component of real exchange rate changes gives an upper bound to the contribution of monetary shocks to (the variance of) real exchange rate changes. It is an upper bound because some real shocks are themselves temporary (for example, a temporary fiscal boost) and so may affect the real exchange rate only temporarily.

The approach that this article presents also distinguishes between shocks that have permanent and temporary effects on the real exchange rate. But it does not use the same statistical tools. Instead, it uses the UIP condition to focus on the interaction between interest rates and exchange rates. It provides an alternative measure of the contribution of different types of shock to the exchange rate, which is important given the uncertainties implicit in exchange rate analysis. In general, the UIP method will permit timely analysis, since market interest rate and exchange rate data are available daily.

Using the UIP condition to help interpret exchange rate movements

The UIP condition can be written as:

$$E_t s_{t+1} - s_t = i_t^* - i_t + \rho_t \qquad \textbf{(1)}$$

where s_t is the spot exchange rate (defined as the foreign currency price of domestic currency); $E_t s_{t+1}$ is the market's one-step-ahead forecast for the spot exchange rate made at time t;[2] i_t is the domestic one-period nominal interest rate; i_t^* is the foreign one-period nominal interest rate; and ρ_t is a currency risk premium. Equation **(1)** says that, after adjusting for expected exchange rate movements, the one-period return on holding assets denominated in different currencies, allowing for any risk premium, must be equal.

Many authors question the empirical validity of UIP. But these tests invariably invoke additional assumptions that the decomposition set out below does not embody (see the box on page 380).

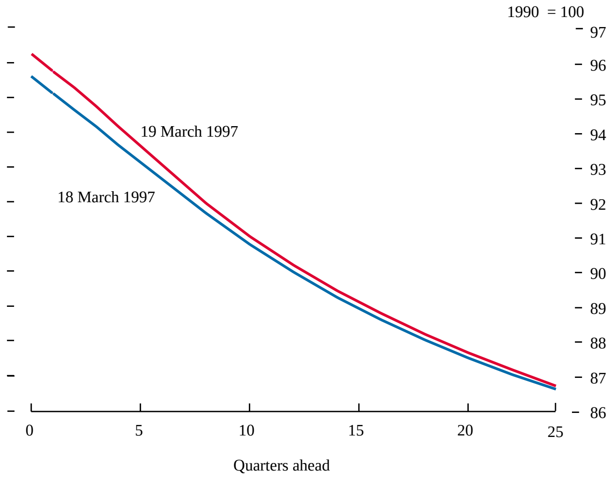
We illustrate the uses that can be made of UIP analysis with reference to the change in the sterling exchange rate between close of business on 18 March and close of business on 19 March 1997. Labour market statistics published on 19 March recorded a fall in claimant count unemployment to its lowest level since 1990, and a rise in measured average earnings growth to its highest since November 1992. At the time, commentators regarded these data as significant news about the need for further monetary tightening.[3]

The steps are broadly as follows. First, a measure of 'news' is derived, as the extent to which a change in the nominal exchange rate during a short period differed from the change implied by the differential between domestic and overseas interest rates for that period. Second, the factors lying behind the news are split into (i) changes in the differential between expected domestic and overseas interest rates up to some arbitrary terminal point, and (ii) a residual term that includes changes in the expected value of the nominal exchange rate at that terminal point and changes in currency risk premia. Third, using various assumptions about the influence that the monetary authorities can have on expected interest rates at different maturities, the news is attributed to 'monetary policy' and 'other' factors. As explained below, this final step also requires a judgment about the reasons for any changes in relatively short maturity interest rates; that is why the example chosen to illustrate the technique is a day when statistical releases caused market commentators to change their stated expectations about the path of official interest rates.

(a) Deriving a measure of news

The first step is to derive a measure of news. As an extension of the one-period example in **(1)**, it is assumed that UIP holds for every day into the future. Given the current spot exchange rate and information on domestic and foreign interest rates, an expected profile for the exchange rate can then be traced out. Chart 1 provides an example[4] for an effective index where sterling is measured against a basket of currencies from other G7 countries.[5]

Chart 1
UK effective exchange rate profiles



The line labelled 18 March shows how the exchange rate was expected to evolve from its level of 95.7, given the

(1) Beveridge, S and Nelson, C (1981), 'A new approach to the decomposition of economic time series into permanent and transitory components', *Journal of Monetary Economics*, 7, pages 151–74.
(2) The exchange rates in **(1)** are expressed as logs, and though **(1)** is the most commonly used representation of UIP, it is actually an approximation of the true UIP condition. See the mathematical appendix for details.
(3) See for example, 'Earning a Rise', *The Lex Column*, *Financial Times*, page 32, 20 March 1997.
(4) For simplicity, this chart is drawn on the assumption that the current and expected future currency risk premia are both zero. This assumption is not crucial to results that follow.
(5) The Bank calculates forward interest rates for these countries on a daily basis, and these data are needed to apply the UIP decomposition. The box on page 381 compares the G7 ERI with the official ERI, which is measured against a basket of 20 currencies.

Uncovered interest parity in practice

The method described in this article is based on the UIP condition. Economic models typically assume that it holds and that if markets are efficient and investors are risk-neutral, then the excess return on domestic assets, defined as the interest differential net of the observed exchange rate movement, should be unforecastable. Otherwise, investors would be systematically ignoring profit opportunities.

Much research has been directed into examining whether or not UIP holds in practice. The UIP condition cannot be estimated directly, since neither market expectations of the spot rate nor the currency risk premium are observable. Most empirical work has therefore tested the joint hypothesis that UIP holds together with market efficiency (investors are rational and use all available information to construct their forecasts) and risk neutrality. This joint hypothesis is frequently rejected. For example, using weekly data for the US dollar against six other major currencies, Cumby and Obstfeld (1981)[(1)] find that a significant portion of the excess return on each currency can be explained by previous excess returns. So excess returns appear persistent, and not random as predicted. But since Cumby and Obstfeld test a joint hypothesis, it cannot be concluded that UIP itself does not hold.

The decomposition described in this article is valid even when neither of the conditions of rational expectations and risk neutrality hold. The decomposition attempts to identify the contribution of interest rate expectations—as distinct from the risk premium or expected terminal exchange rate—to a change in the current spot rate. It is important for the decomposition that nominal interest rate differentials feed through one-for-one to expected changes in the price of domestic currency. To put it another way, the coefficient for i_t^*-i_t must be one. This can be tested econometrically.

Fisher *et al* (1990)[(2)] test to see if real interest differentials feed through one-for-one to the expected change in the real dollar/sterling exchange rate. To test this, they have to make some auxiliary assumptions: that expectations are rational, and that the current account/GDP ratio can be used as a proxy for currency risk. They find that the model works, in the sense that the coefficient on the current real interest rate differential equals one, and that previous lags of the exchange rate or interest rates have no explanatory power. Moreover, the model gives a better prediction of real exchange rate changes out of sample[(3)] than a simple random walk hypothesis—contrasting with the famous result in Meese and Rogoff (1983)[(4)] that simple random walk models predict exchange rate changes more accurately than theoretical models of the exchange rate.

But though the expected exchange rate movement may vary one-for-one with the interest rate differential, real interest rate differentials together with the current account/GDP ratio explain just 3% of the quarterly movement in the actual real sterling/US dollar exchange rate. This finding does not invalidate UIP, but merely implies that a large amount of the variation in spot exchange rates is driven by random innovations ('news' as defined by equation **(2)** on page 382) arriving each period.

In summary, a number of authors have found that excess returns in foreign currency markets are predictable. This is not in itself evidence against UIP; instead it means that UIP probably does not hold jointly with rational expectations and risk neutrality. Forecasts of the next period's spot exchange rate might well be biased and inefficient and risk premia might well be non-zero, but this would not affect the decomposition described in the article. All that matters is that interest rate differentials feed through one-for-one to expected exchange rate movements, which seems plausible.

(1) Cumby, R and Obstfeld M, (1981) 'A note on exchange rate expectations and nominal interest differentials: a test of the Fisher hypothesis', *Journal of Finance*, Vol 36, No 3 June, pages 1,231–44.
(2) Fisher, P, Tanna, S, Turner, D, Wallis, K and Whitley, J 'Econometric evaluation of the exchange rate', *Economic Journal*, 100, December 1990, pages 1,230–44.
(3) These out-of-sample tests used (National Institute) forecasts of the exchange rate as proxies for the markets' expectations for the exchange rate.
(4) Meese, R, and Rogoff, K, (1983) 'Empirical exchange rate models of the seventies', *Journal of International Economics*, No 14, pages 3–24.

A comparison of the full and G7 sterling ERIs

The Bank publishes an official effective exchange rate index, which measures the value of sterling against a basket of 20 other currencies. It is a weighted geometric average of exchange rates, expressed as an index. The weights are taken by the Bank from trade flows data published by the IMF and measure the relative importance of other countries as competitors to the UK manufacturing sector.[1]

Country weights in the official and G7 ERIs

Country	Weight (full ERI)	Weight (G7 ERI)	Country	Weight (Full ERI)	Weight (G7 ERI)
Germany	22.49	32.97	Republic of Ireland	3.08	n.a.
United States	16.49	24.17	Finland	1.41	n.a.
France	12.59	18.45	Canada	1.38	2.02
Italy	8.27	12.12	Denmark	1.38	n.a.
Japan	7.00	10.26	Austria	1.19	n.a.
Netherlands	5.71	n.a.	Norway	1.19	n.a.
Belgium and		n.a.	Portugal	0.84	n.a.
Luxembourg	5.39	n.a.	Australia	0.48	n.a.
Spain	3.85	n.a.	Greece	0.31	n.a.
Sweden	3.45	n.a.	New Zealand	0.21	n.a.
Switzerland	3.27	n.a.			

n.a. = not applicable.

In the UIP decomposition described here, a weighted average of the other G7 currencies (the United States, Germany, France, Italy, Japan and Canada) is used, rather than the full ERI. The weights attributed to these six countries account for just over 68% of the total. Chart A compares the levels of these two indices since September 1992 (re-based to September 1992 = 100), and Chart B compares the monthly growth rates. The two series are very similar, especially in growth rate terms, possibly because the currencies excluded from the G7 effective measure move closely with the major currencies included. For example, ERM members excluded from the G7 ERI, accounting for a further 23% of the full ERI, might be expected to move quite closely with the Deutsche Mark.

Chart A
Comparison of G7 and full ERIs (levels)

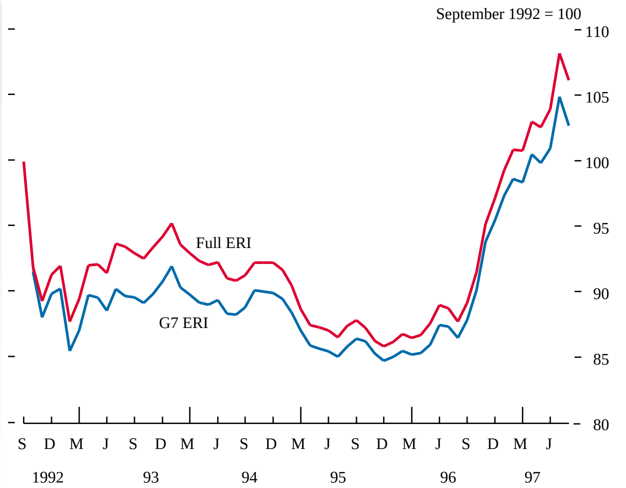
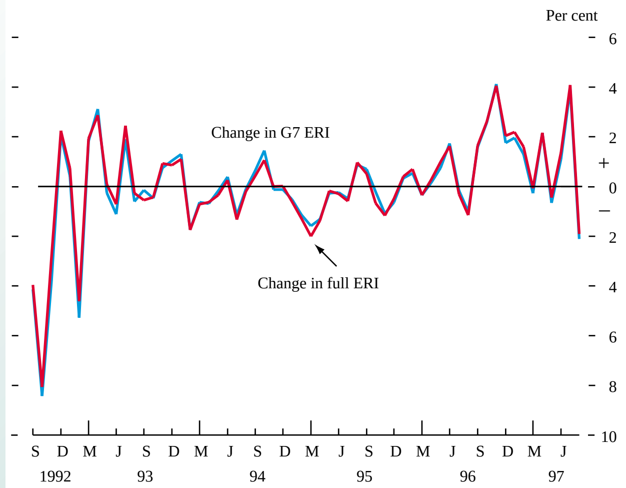


Chart B
Comparison of G7 and full ERIs (changes)



(1) See *Bank of England Quarterly Bulletin*, February 1995, pages 24–25.

differential on that date between domestic and foreign market interest rates. Thus between 18 March 1997 and 17 March 1998, the exchange rate was expected to depreciate in line with the differential between one-year domestic and overseas interest rates. And between 18 March 1998 and 17 March 1999, sterling was expected to depreciate in line with the one-year forward interest rate differential.[1]

During the next day sterling did not depreciate at all; it appreciated to 96.3, and the 19 March line shows how the exchange rate was expected to evolve, given the new starting-point and the new set of market interest rates at home and abroad. Domestic interest rates had risen in the 24-hour period, relative to those of other members of the G7, so the UIP condition implied that sterling was expected to depreciate more quickly on 19 than on 18 March, from the higher starting level.

Table A provides a breakdown of this analysis (and the decomposition into 'monetary policy' and 'non-monetary policy' factors that is described below). It reports results for the G7 effective rate and also changes in the bilateral dollar/sterling and Deutsche Mark/sterling rates. For the example used above, spot interest rates on 18 March implied no significant overnight change in sterling, so the news is broadly equal to the actual change of 0.7%.[2] Line 1 reports the actual change in each spot rate in the sample period.

(1) It is assumed that a forward interest rate is the interest rate expected in the future (eg the one-year rate expected next year). See Deacon, M and Derry, A (1994), 'Estimating market interest rate and inflation expectations from the prices of UK government bonds', *Quarterly Bulletin*, August, pages 232–40.
(2) This result is common for overnight changes. Annualised interest rate differentials would have to be very large to imply a significant overnight movement.

Line 2 reports the change predicted by UIP at the start of the period, and line 3 reports this definition of exchange rate news (line (1) – line (2)).

Table A
Sterling exchange rate movements between 18 and 19 March 1997

Per cent; *percentage points in italics*

		US$	DM	UK ERI
Actual change against	(1)	0.6	0.8	0.7
of which:				
Expected	(2)	0.0	0.0	0.0
'News'	(3) = (1) – (2)	0.6	0.8	0.7
Cumulative revision to nominal forward interest differentials (a)	(4)	*0.7 to 0.9*	*0.6 to 0.7*	*0.7 to 0.9*
of which:				
Estimated real component	(5)	*0.3*	*0.3*	*0.3*
Sensitivity band (b)	(6)	*0.3 to 0.4*	*0.2 to 0.4*	*0.3 to 0.4*
Residual	(7) = (3) – (5)	*0.3*	*0.5*	*0.4*
Sensitivity band (b)	(8) = (3) – (6)	*0.2 to 0.3*	*0.4 to 0.6*	*0.3 to 0.4*

Sources: Bank of England, Bloomberg, LIFFE and Financial Times.

(a) Range as terminal horizon (n) varies from eight to twelve years.
(b) Estimated range as p-horizon varies from four to eight years.

(b) Estimating the proportion of news accounted for by changes in nominal interest rate differentials

The second step is to look at how the news—the unexpected change in the spot exchange rate—is related to changes in the differential between domestic and overseas forward interest rates up to some terminal point, and to changes in the nominal exchange rate expected at that terminal point. In terms of Chart 1, this amounts to relating the change in the starting-point to the change in the slope and the change in the end-point of the trajectory of the exchange rate. As explained in detail in the Appendix, this can be set out algebraically as follows:

$$s_{t+k} - E_t s_{t+k} = \sum_{j=k}^{n-1}(E_{t+k}\delta_{t+j} - E_t\delta_{t+j}) + (E_{t+k}s_{t+n} - E_t s_{t+n}) - \sum_{j=k}^{n-1}(E_{t+k}\rho_{t+j} - E_t\rho_{t+j}) \qquad \textbf{(2)}$$

where $\delta_{t+j} = (i_{t+j} - i_{t+j}*)$, the difference between domestic and overseas forward interest rates at a given maturity.

In our example, t is 18 March 1997; $t + k$ is 19 March 1997; and $t + n$ is the chosen terminal point (18 March 2007 for n = ten years), which is arbitrary.

The first term (on the right-hand side) is the cumulative change in the expected difference between domestic and overseas interest rates (the forward differential). This term shows how the expected rate of depreciation of sterling up to some horizon $t + n$ has changed between t and $t + k$. The second term is the change in the expected nominal value of sterling at the chosen terminal date. The third term is the net change in the sterling risk premium up to the chosen horizon. Only the first term can be directly measured. In what follows, no attempt is made to analyse separately changes implied by the second and third terms; instead, they are treated together as a residual.

Line 4 of Table A shows how much of the news can be accounted for by changes in the forward nominal differential (first bracketed term of **(2)**), conditional on the simplest possible assumption that changes in the forecast long-run nominal value of sterling and in the mass of risk premia (second and third bracketed terms) occur independently. From equation **(2)** it is clear that this will be sensitive to the choice of terminal date ($t + n$). Results are reported for terminal points eight to twelve years after the starting date for the decomposition.

For the case illustrated in Table A, changes in interest rate differentials account for between 0.7 and 0.9 percentage points of the appreciation of sterling against the basket of G7 currencies between 18 and 19 March.[1]

Chart 2 shows the forward curve movements that underpin this result. Panel A shows UK and overseas forward rates on these two dates. On both dates UK rates were higher than overseas rates, producing the implied depreciation paths for sterling shown in Chart 1. Panel A also shows that overseas forward rates did not change much from one day to the next. By contrast, UK forward rates rose at all maturities. Panel B shows the difference between UK and overseas forward rates—the interest rate differential—on the two dates; the impact of revision to UK forward rates is clear. Finally, Panel C shows how this differential changed between 18 and 19 March. The area under the curve in this final panel is the graphical representation of the first bracketed term in equation **(2)**, and of the results reported in line 4 of Table A.

This second stage of the decomposition reveals how much of the exchange rate movement can be explained by changes in interest rate differentials up to some arbitrarily chosen horizon. But it does not help to identify the underlying shock that caused either interest rates or the exchange rate to change. The third stage draws inferences about the nature of these shocks on the basis of some further assumptions.

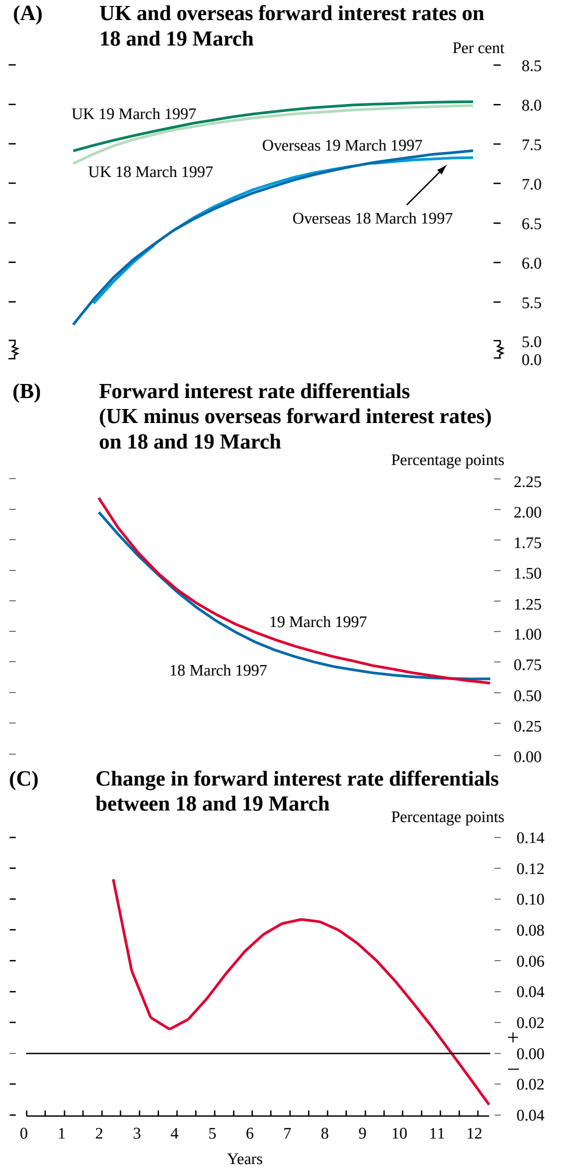
(c) Estimating the proportion of news accounted for by changes in expected monetary policy

Economic theory suggests that monetary authorities can influence real interest rates in the short run because goods prices are sticky, but in the long run prices will adjust, so monetary authorities can influence only nominal rates via inflation expectations. This theory also suggests that monetary policy is neutral in the long run: changes in nominal interest rates will have no long-term effect on real activity. This implies that the real exchange rate is independent of monetary policy in the long run, but that the

(1) Line 4 of the table shows the maximum and minimum change in the current exchange rate that the change in interest rate differentials predict, as the horizon up to which the change in the differential is cumulated varies from eight to twelve years.

expected nominal exchange rate will change in line with changes in the prospects for inflation.[1]

Chart 2
Deriving the news in UK forward interest rates relative to other countries[(a)]



(a) The overseas economies here are the M6. Their forward interest rates are weighted together using ERI weights to give the rate on a benchmark overseas asset.

The decomposition presented here embodies these features by assuming that when there is news about monetary policy (i) changes in near-term nominal interest rate expectations relative to overseas rates reflect a reassessment of future relative real interest rates (over which the monetary authorities have some influence), but in the longer term they reflect a reassessment of relative inflation prospects,[2] and (ii) any changes in expected prices (relative to overseas prices) have no impact on the real exchange rate expected in the long run. As monetary policy is not the only influence on interest rates, these assumptions are clearly valid only when monetary policy shocks are the main cause of interest rate movements.

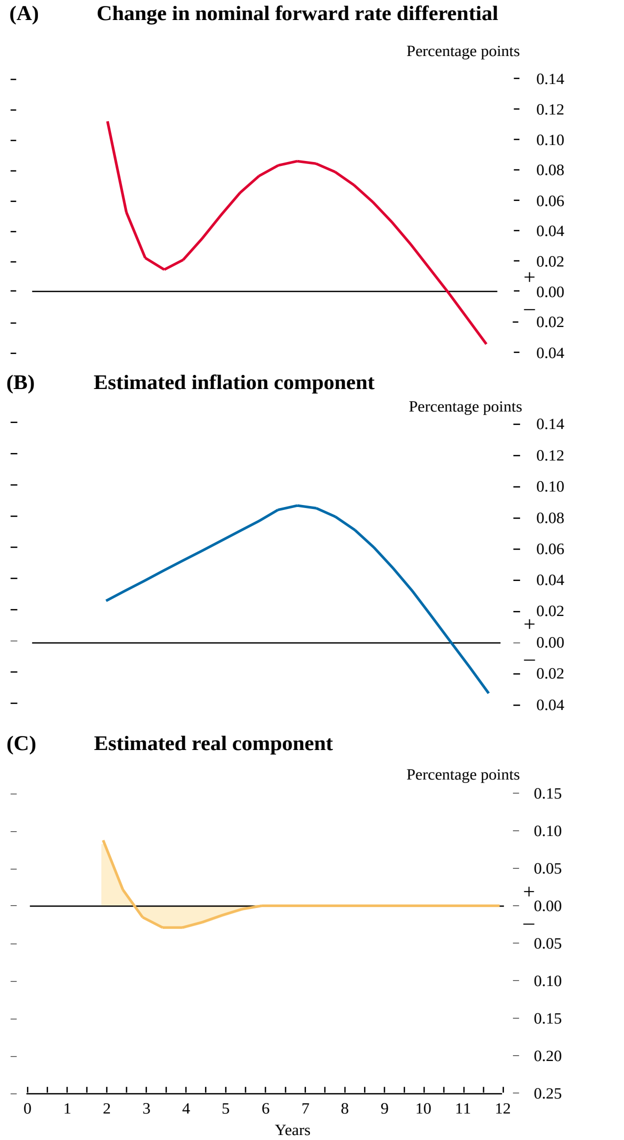
To put these assumptions into practice, a working definition of the short run is needed. Though the lags in the transmission mechanism are uncertain, many economists would probably agree that monetary policy does not have an effect on prices in modern low-inflation economies straightaway.[3] In addition, markets are unlikely to revise their views about relative monetary policies (as captured by the real rate differential) at maturities longer than a typical cycle, which is around six years.[4] One solution would be to assume that all movements in forward nominal interest rates up to some given maturity are driven by the real component, and thereafter all are driven by the inflation component. Though simple, this discrete switch approach would be unrealistic, as the impact of monetary policy changes on inflation builds up gradually. Instead, stage three embodies a smooth transition: it is assumed that news about relative inflation prospects runs from zero in the immediate period to equal the entire change in the nominal forward interest differential at some policy threshold point (p). Thereafter, all changes in the nominal forward interest differential are driven by the inflation component—relative real interest rates do not vary beyond the p-horizon. In the central case, p is set equal to 6 years. It may help to give a numerical example: imagine that the forward differential at six years has widened by 150 basis points. The assumption employed would imply that expected UK inflation six years hence has risen by 150 basis points relative to other countries, but by only 50 basis points after two years and by 25 basis points after one year. If the forward differential has in fact widened by 150 basis points at all horizons up to six years, a further implication would be that expected real rates had risen by 150 basis points in the immediate period, 125 basis points after one year, 100 basis points after two years, and so on down to zero at the six-year horizon. In practice, the p-horizon is varied from four to eight years to reflect the uncertainties about the speed of pass-through, and to provide a sensitivity test.

To capture the money neutrality notion, it is assumed that agents revise their expectation of the spot nominal rate at the terminal horizon one-for-one with the changes in expected relative prices identified from interest rates. For example, if changes in forward interest rates between two dates implied that, using the real/inflation split outlined above, expected UK prices relative to those abroad had been revised up by 10%, then, other things being equal, it is assumed that markets would revise down their expectation for the nominal

(1) Though this is a standard conclusion embedded in many economic models, some models do not have this neutrality. For example, Obstfeld, M and Rogoff, K (1995), 'Exchange Rate Dynamics Redux', *Journal of Political Economy*, 1995, Vol 103, No 3, pages 624–60, develop a model in which monetary shocks lead to permanent changes in wealth and the long-run real exchange rate.
(2) In the United Kingdom, estimates of real interest rates and inflation expectations can be derived by comparing changes in conventional and index-linked gilts. If index-linked bonds were common overseas, then it would be possible to measure changes in domestic real interest rates relative to overseas rates directly.
(3) Dale, S and Haldane, A (1995) 'Interest rates and the channels of monetary transmission: some sectoral estimates', *European Economic Review*, 39, pages 1,611–26.
(4) Cooley and Prescott describe methods used to extract data of business cycle frequency. They eliminate data of frequency less than three years and greater than eight years, which guides the choice of six years as an estimate for the central case (Cooley, T and Prescott, E (1995) 'Economic growth and business cycles' pages 1–39 in Cooley (Ed) *Frontiers of business cycle research*, Princeton).

value of sterling by 10%. This would imply that the expected value of the real exchange rate would be unchanged in the long run by the change in inflation expectations.[1] So the effect of monetary policy on the exchange rate is identified as the cumulative change in estimated real interest rate differentials.

Chart 3
Splitting the change in nominal forward differentials into real and inflation components



Line 5 of Table A reports the central, six-year, estimate for the case study. It suggests that the estimated change in relative real interest rates implied an appreciation of 0.3% between 18 and 19 March 1997. Line 6 shows that this estimate does not change much if the horizon up to which it is assumed that policy can influence real interest rates is shortened or lengthened. Overall, the decomposition suggests that monetary factors—as captured by estimated changes in real interest rate expectations—did play a significant role in explaining the appreciation of sterling on 19 March. But equally, it suggests that these monetary factors were not the only influence on sterling on that day. Lines (7) and (8) provide estimates of the influence of these other 'residual' factors.

Chart 3 provides a graphical representation of these results. Panel A shows the change in the nominal interest rate differential; Panels B and C show how the technique decomposes this into changes in relative inflation expectations (Panel B), and relative real interest rates (Panel C), with the pass-through parameter, p, set equal to six years. Line 5 in Table A shows the exchange rate shift implied by the shaded area in Panel C.

It is important to recognise that the assumptions underpinning this decomposition are highly stylised; it can provide only an approximate measure of the change in real interest rate expectations. And as monetary policy is not the only influence on these rates, care must be taken in linking real interest rate changes to monetary policy. Thus the prudent interpretation of results for this case study would be that monetary policy news can probably explain a significant proportion of the increase in sterling on 19 March, but that the method cannot support more precise conclusions.

Further case studies

This section reports some further case studies that illustrate the type of results that the decomposition gives. Another two one-day studies are presented: for the 25 basis point interest rate cut on 13 December 1995, and for the 25 basis point interest rate rise on 30 October 1996. These are the two most recent turning-points in official interest rates. Previous studies suggest that turning-points in official interest rates have a larger-than-average impact on market expectations.[2] The decomposition is also applied to two longer time periods in which sterling moved significantly: first, the four months after the suspension of sterling's membership of the ERM, when sterling depreciated by around 13%; and second, the period from August last year to May this year, in which sterling appreciated by around 17%.

Table B shows the UIP decomposition between 12 and 13 December 1995. The decomposition suggests that the rate cut did lead to a revision to the expected relative path of monetary policy, which is consistent with past studies: it implies that sterling should have depreciated by around 0.5 percentage points, other things being equal. In fact, the G7 ERI appreciated by 0.2% on 12 December, suggesting that other shocks more than offset any downward pressure from the rate cut.[3]

(1) In terms of equation **(2)**, a change in forward differentials relates to the spot rate directly (term 1) and also indirectly via the change in the expected nominal value of sterling at the chosen horizon (term 2). This is because changes in longer-term nominal differentials are assumed to be revisions to longer-term inflation expectations, and therefore the expected nominal value of sterling is revised down. The monetary news is identified as the sum of the changes in these two terms. A corollary of this assumption is that the estimate of the 'monetary' news is independent of the choice of terminal horizon in **(2).**
(2) Dale, S (1993) 'The effect of official interest rate changes on market rates since 1987', *The Manchester School*, Vol 61, supplement, June 1993, pages 76–94.
(3) These shocks are measured by the residual in lines (7) and (8) of Table B and will include some combination of a change in the forecast long-run real exchange rate and a change in currency risk premia.

Table B
Sterling exchange rate movements between 12 and 13 December 1995

Per cent; *percentage points in italics*

		US$	DM	UK ERI
Actual change against	(1)	0.1	0.2	0.2
of which:				
Expected	(2)	0.0	0.0	0.0
'News'	(3) = (1) – (2)	0.1	0.2	0.2
Cumulative revision to nominal forward interest differentials (a)	(4)	*-0.8 to -0.2*	*0.5 to 2.8*	*-0.1 to 0.6*
of which:				
Estimated real component	(5)	*0.0*	*-0.5*	*-0.5*
Sensitivity band (b)	(6)	*-0.2 to 0.2*	*-1.1 to 0.0*	*-0.7 to -0.3*
Residual	(7) = (3) – (5)	*0.1*	*0.7*	*0.7*
Sensitivity band (b)	(8) = (3) – (6)	*-0.1 to 0.2*	*0.2 to 1.3*	*0.4 to 0.9*

Sources: Bank of England, Bloomberg, LIFFE and Financial Times.

(a) Range as terminal horizon (*n*) varies from eight to twelve years.
(b) Estimated range as *p*-horizon varies from four to eight years.

Table C shows the UIP decomposition between 29 and 30 October 1996. There is a similar impact on forward interest rates, and by extension on expected relative monetary policy. But this time there were no apparent offsetting factors, and the exchange rate moved in a direction consistent with monetary news. Monetary news explained around half of the appreciation against the G7 ERI.

Table C
Sterling exchange rate movements between 29 and 30 October 1996

Per cent; *percentage points in italics*

		US$	DM	UK ERI
Actual change against	(1)	1.4	1.2	1.2
of which:				
Expected	(2)	0.0	0.0	0.0
'News'	(3) = (1) – (2)	1.4	1.2	1.2
Cumulative revision to nominal forward interest differentials (a)	(4)	*-0.4 to 0.1*	*-0.7 to -0.6*	*-0.8 to 0.0*
of which:				
Estimated real component	(5)	*0.4*	*0.1*	*0.6*
Sensitivity band (b)	(6)	*0.3 to 0.5*	*-0.3 to 0.4*	*0.4 to 0.7*
Residual	(7) = (3) – (5)	*0.9*	*1.1*	*0.6*
Sensitivity band (b)	(8) = (3) – (6)	*0.9 to 1.0*	*0.9 to 1.5*	*0.5 to 0.8*

Sources: Bank of England, Bloomberg, LIFFE and Financial Times.

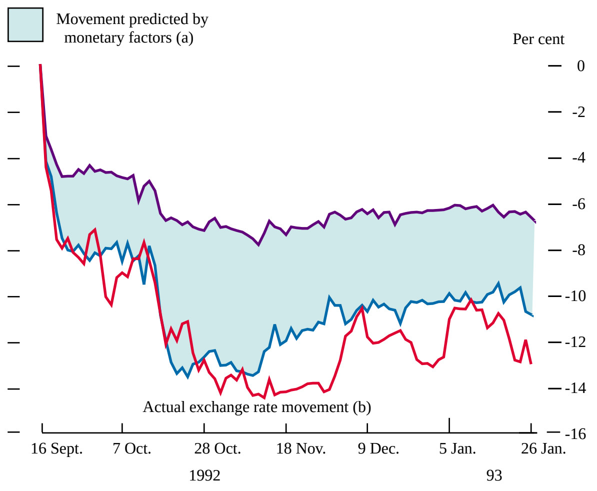
(a) Range as terminal horizon (*n*) varies from eight to twelve years.
(b) Estimated range as *p*-horizon varies from four to eight years.

Tables B and C also illustrate that bilateral exchange rate developments can be quite diverse. For instance, on 12/13 December 1995, the decomposition indicates that there was little monetary news relative to the United States, implying that expectations about monetary policy softened in the United States as well as in the United Kingdom. And on 29/30 October 1996, monetary factors can account for less of the appreciation against the Deutsche Mark than against either the dollar or the weighted basket of other G7 currencies. The implication is that expected monetary policy also tightened in Germany.

Sometimes the full implications of a given event for monetary policy do not become evident in a single day. Rather, market sentiment moves slowly in the same direction over a period of time. In these circumstances, it is possible to go a stage further and add up the identified real interest rate components to obtain a measure of cumulative news. There are two important caveats to this use of the decomposition—first, the assumption of unchanged relative prices, necessary to identify the movement in the terminal nominal exchange rate consistent with an unchanged terminal real exchange rate, becomes less plausible when the decomposition is conducted for a longer period. And second, it is increasingly likely that other factors will have caused relative interest rate movements as longer periods of time are considered.(1)

Sterling's membership of the ERM was suspended after trading hours on 16 September 1992. On 17 September, UK official rates were cut by 2 percentage points from 12% to 10%. UK forward interest rates fell at maturities up to four years by as much as 4 percentage points, and rose at longer maturities by as much as 1 percentage point. The UIP decomposition interprets this as a fall in real interest rate expectations in the short term and a rise in inflation expectations thereafter. As Chart 4 shows, the decomposition implies that almost all of the entire sterling depreciation on that day, of some 4.5%, can be accounted for by news about the expected future conduct of UK monetary policy relative to that in other countries.

Chart 4
News about monetary policy: from 16 September 1992 to 26 January 1993



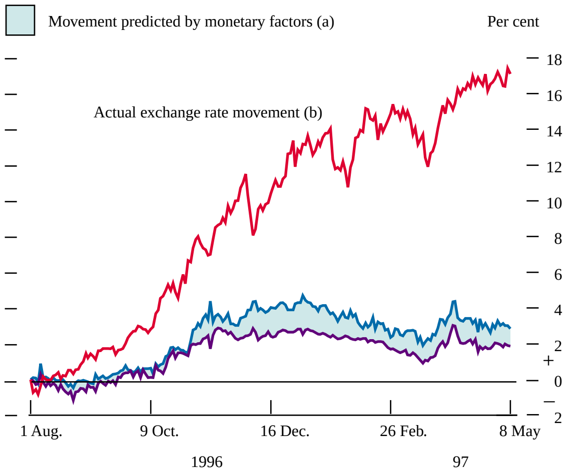
(a) Band shows estimated range as *p*-horizon varies from four to eight years, cumulated from 16 September 1992.
(b) In G7 effective index, cumulated from 16 September 1992.

In the subsequent period to 26 January 1993, the last date on Chart 4, official rates were reduced further, in four steps of 1 percentage point, to 6%. The short end of the UK nominal forward curve continued to fall and the long end continued to rise, with the result that, according to the decomposition, estimated monetary policy factors still accounted for most of the depreciation of sterling—by then 13% against G7 currencies—since the exit from the ERM.

(1) For such analysis, real interest data for other countries would therefore be especially informative.

Chart 5 shows how estimated news about UK monetary policy relative to other G7 countries has evolved since 1 August 1996. It suggests that until the end of September 1996, monetary factors had little net impact on the exchange rate, and so other factors were responsible for most of the 2% appreciation during that period. Market sentiment about the prospect for UK interest rates appeared to change from early October 1996: the identified contribution of monetary news began to rise quite sharply following the base rate change on 30 October, reaching a peak of around one half near the year end. It fell back a little by 7 February, when data for the February *Inflation Report* were finalised; according to the decomposition, news about relative monetary policies explained at most nearly one quarter of the cumulative sterling appreciation since August 1996.

Chart 5
News about monetary policy: from 1 August 1996 to 8 May 1997



(a) Band shows estimated range as *p*-horizon varies from four to eight years, cumulated from 1 August 1996.
(b) In G7 effective index, cumulated from 1 August 1996.

Assessment

The potential advantage of this decomposition is that it provides a cross-check on the interpretation of exchange rate developments that other models might provide, and gives an indication of broadly how much of a change can plausibly be explained by interest rate movements. Moreover, when it is believed that monetary policy factors have significantly influenced interest rates, it allows these rate changes to be used to identify whether the effect of expected monetary policy on the exchange rate has been significant.

The UIP decomposition should be able to distinguish the impact on the exchange rate of the three hypothetical events discussed in the first section. Consider first the example of a foreign monetary loosening. Other things being equal, short-term foreign real interest rates will have fallen relative to those in the United Kingdom (reflecting the easing of policy), but at longer maturities rates will only change to the extent that foreign inflationary prospects change. Assuming that UK interest rates remained unchanged, the decomposition would imply that an appreciation of sterling should occur (foreign interest rates fall relative to domestic rates). It would correctly ascribe the appreciation to foreign monetary factors. Conversely, in the third example (a perceived tightening of the domestic inflation objective), forward interest rates in the United Kingdom would rise relative to those overseas at short maturities, and fall at longer maturities as inflation expectations fell. The appreciation of sterling would again correctly be ascribed to domestic monetary news. By contrast, the second example—a shift in overseas tastes—has no obvious direct implications for foreign or domestic interest rates. And the appreciation of sterling would not be ascribed to monetary policy news at home or overseas, so long as forward interest rates did not change.

To make use of the UIP relationship, some quite strong assumptions are needed to derive a measure of real interest rate news. In particular, it is assumed that (i) short-term expectations of inflation are fairly rigid and (ii) after some threshold point, *p*, real interest rates move together across countries. It follows that the technique will give misleading results when presented with temporary nominal shocks that feed through rapidly to prices, or for example, a fiscal contraction overseas that has a sustained impact on real interest differentials due to, say, capital market imperfections. And of course, short-term relative real interest rates can vary for reasons other than monetary policy, which is why it is necessary to look for additional evidence of news about monetary policy when applying the decomposition.

The monetary policy news identified by the decomposition reflects the markets' assessment of how various underlying shocks have altered the prospects for monetary policy. This captures the notion of an exogenous monetary shock (such as a change to policy), as well as a monetary policy reaction to other shocks (an 'endogenous' change to policy). For instance, if the financial markets revised up their (near-term) expectations of UK short-term real rates relative to other countries in response to a positive temporary demand shock in the United Kingdom, the technique would label the resulting appreciation 'monetary', even though the underlying cause is not an exogenous monetary shock. The key point is that the 'monetary' part of an appreciation reflects expectations about the future path of real interest rate at the short end of the maturity spectrum, where they can be influenced by central banks.

Appendix: a mathematical treatment of the UIP decomposition

The UIP condition states that:

$$\frac{E_t S_{t+1}}{S_t} = \frac{(1+i_t^*)}{(1+i_t)} R_t \qquad \textbf{(A1)}$$

Here, S_t is the foreign currency price of sterling; i_t is the one-period domestic interest rate, i_t* denotes the one-period foreign interest rate, and R_t is a risk premium.

It is standard to work with the log-linearised form of this equation,(1) making use of the Taylor series property that $\ln(1 + x) \cong x$ when x is small, and also ignoring Jensen's inequality (that the expressions $\ln E_t S_{t+n}$ and $E_t \ln S_{t+n}$ are not equal). This latter step simplifies the analysis considerably. The log-linearised version is:(2)

$$E_t s_{t+1} - s_t = (i_t^* - i_t) + \rho_t \qquad \textbf{(A2)}$$

That is, the expected change in the log of the exchange rate (s) between time t and t + 1 equals the interest rate differential on one-period foreign and domestic bonds plus ρ_t (= $\ln R_t$).

Forward substitution to period $t + n$ (n is typically set at ten years) gives the expression:

$$s_t = \sum_{j=0}^{n-1} E_t \delta_{t+j} - \sum_{j=0}^{n-1} E_t \rho_{t+j} + E_t s_{t+n} \qquad \textbf{(A3)}$$

where δ_{t+j}, the forward interest differential, equals $i_{t+j} - i_{t+j}$*.

Now suppose that the first date in the UIP projection is t (take 18 March 1997 as an example) and the second is k periods later at $t+k$ (say 19 March 1997) where $k < n$, then the exchange rate at that point is obtained by rolling **(A3)** forward k periods:

$$s_{t+k} = \sum_{j=0}^{n-1} E_{t+k} \delta_{t+k+j} - \sum_{j=0}^{n-1} E_{t+k} \rho_{t+k+j} + E_{t+k} s_{t+k+n} \qquad \textbf{(A4)}$$

To obtain the same end-point for the projection at time t and at $t + k$, the projection in **(A3)** is truncated by k periods so that the end-point is at $t + n$ (18 March 2007):

$$s_{t+k} = \sum_{j=k}^{n-1} E_{t+k} \delta_{t+j} - \sum_{j=k}^{n-1} E_{t+k} \rho_{t+j} + E_{t+k} s_{t+n} \qquad \textbf{(A5)}$$

The UIP decomposition calculates the news between t and $t + k$, defined mathematically as: $s_{t+k} - E_t s_{t+k}$. The next step is therefore to express the expectation at time t of the exchange rate at $t + k$ (the expectation formed on 18 March 1997 for the exchange rate on 19 March 1997):

By analogy with **(A3)** it is clear that:

$$s_t = \sum_{j=0}^{k-1} E_t \delta_{t+j} - \sum_{j=0}^{k-1} E_t \rho_{t+j} + E_t s_{t+k} \qquad \textbf{(A6)}$$

And rearranging gives:

$$E_t s_{t+k} = s_t - \sum_{j=0}^{k-1} E_t \delta_{t+j} + \sum_{j=0}^{k-1} E_t \rho_{t+j} \qquad \textbf{(A7)}$$

Substituting in the expression for s_t given by **(A3)** gives:

$$E_t s_{t+k} = \sum_{j=k}^{n-1} E_t \delta_{t+j} - \sum_{j=k}^{n-1} E_t \rho_{t+j} + E_t s_{t+n} \qquad \textbf{(A8)}$$

The news from time t to time $t + k$ is then given by subtracting **(A8)** from **(A5)**:

$$s_{t+k} - E_t s_{t+k} = \sum_{j=k}^{n-1} (E_{t+k} \delta_{t+j} - E_t \delta_{t+j}) + (E_{t+k} s_{t+n} - E_t s_{t+n}) - \sum_{j=k}^{n-1} (E_{t+k} \rho_{t+j} - E_t \rho_{t+j}) \qquad \textbf{(A9)}$$

The cumulative revision to nominal forward interest differentials is given by:

$$\sum_{j=k}^{n-1} (E_{t+k} \delta_{t+j} - E_t \delta_{t+j}) \qquad \textbf{(A10)}$$

This is reported in line 4 of Tables A, B and C, where a range is quoted as n varies from eight to twelve years.

The next step is to identify the 'monetary' component of observed news in the exchange rate at $t+k$, $s_{t+k} - E_t s_{t+k}$.

Assume that news about relative inflation performance feeds through to expectations of the long-run nominal exchange rate, but that the real exchange rate is unchanged by these changes in inflation expectations. As discussed in the third section, relative forward curve changes are decomposed into nominal and real components by assuming that near-term

(1) See, for example, Isard, P (1992), 'Uncovered Interest Parity' in the *New Palgrave Dictionary of Money and Finance*, Macmillan.
(2) All results presented in this article use the 'true' condition **(A1)** and not the log approximation **(A2)**.

changes predominately reflect real rate changes, but that the magnitude of country-specific real rate shocks falls to reach zero at some horizon $t + p$. After that point, changes in differentials reflect only changes in relative inflation rates. The central case for this cut-off point is six years, but results are also repeated with horizons ranging from four to eight years.

More precisely, the change in relative inflation expectations up to the p-horizon *(INF)* is defined as:

$$INF = \left(\frac{p}{2}\right)\left(E_{t+k}\,\delta_{t+k+p} - E_t\,\delta_{t+k+p}\right) \qquad \textbf{(A11)}$$

Expression **(A11)** represents the area of the triangle between the line and the axis in Panel B of Chart 3 up to the p-horizon (equals six years under the central case).

The change in relative real interest rates *(REAL)* is the total change in nominal interest differentials up to the p-horizon, minus the inflation component.

$$\begin{aligned} REAL = &\sum_{j=0}^{p-1}\left(E_{t+k}\,\delta_{t+k+j} - E_t\,\delta_{t+k+j}\right) \\ &-\left(\frac{p}{2}\right)\left(E_{t+k}\,\delta_{t+k+p} - E_t\,\delta_{t+k+p}\right) \end{aligned} \qquad \textbf{(A12)}$$

Note that **(A12)** does not sum at or beyond the p-horizon, since it is assumed that relative real interest rate expectations do not change at or beyond the p-horizon.

Expression **(A12)** represents the shaded area in Panel C of Chart 3.

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