Modelling shocks and adjustment mechanisms in EMU

EMU study by Dr Peter Westaway
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This study has been prepared by Dr Peter Westaway to inform the assessment of the five economic tests
This study has been prepared by Dr Peter Westaway, while on secondment to HM Treasury from the Bank of England. Dr Westaway would like to acknowledge helpful advice provided on technical aspects of the modelling work by Karen Dury, Vincent Labhard and Laura Piscitelli of the Bank of England. All content, conclusions, errors and omissions in this study are, however, the responsibility of HM Treasury alone and do not in any way reflect the position or views of the Bank of England.

This is one of a set of detailed studies accompanying HM Treasury’s assessment of the five economic tests. The tests provide the framework for analysing the UK Government’s decision on membership of Economic and Monetary Union (EMU). The studies have been undertaken and commissioned by the Treasury.

These studies and the five economic tests assessment are available on the Treasury website at:

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This study looks at the macroeconomic implications of the UK joining Economic and Monetary Union (EMU). It considers how the UK’s macroeconomic costs of adjustment to economic shocks compare inside and outside of EMU. The study focuses on the current policy environment where UK interest rates are available to respond to economic shocks and the bilateral nominal sterling-euro exchange rate is free to vary. It compares this with the alternative inside EMU where UK interest rates would be determined by the European Central Bank (ECB)’s single monetary policy and the bilateral sterling-euro exchange rate would be irrevocably fixed.

The major contribution of this study is the application of a new stylised model specifically designed to analyse adjustment processes in and out of EMU with possible UK entry into EMU in mind. As such, this model offers advantages over models adopted in previous work and allows several relevant policy questions to be addressed.

Different empirical evidence and analytical tools have typically been used in the academic literature on the desirability of monetary unions. One approach analyses the correlation between business cycles in the UK and euro area. Whatever the methodology – straightforward growth rate correlations, correlations of business cycle turning points or output gaps – this approach suggests that, historically, UK and euro area business cycles have differed significantly.

This analysis does not, however, indicate why such differences exist. So another strand of empirical work develops modelling techniques to disentangle the influence of asymmetries in shocks and structures on business cycles in different countries. An example using an approach pioneered by Bayoumi and Eichengreen (1993) suggests different responses to demand and supply shocks in the UK and the euro area.

However, both these approaches relate to the past, and so are of limited use when considering the question of possible UK entry to EMU. In EMU, it would be likely that the UK response to shocks would change; for example, due to the different monetary policy regime or to changes in trade patterns. Moreover, the nature of shocks could also change, perhaps due to changes in production structures or due to the loss of an independent exchange rate (which some argue is itself a source of shocks).

To analyse the UK response to shocks in EMU, it is necessary to use different tools: structural macroeconomic models. These allow researchers to control explicitly for changes in the monetary policy regime, as well as the private sector responses to the different policy environment. This study considers the National Institute Global Macroeconometric Model (NiGEM) and the IMF Multimod model.

Although these models are empirically estimated, they predict some differences in how the UK economy might respond to shocks compared to the euro area. Since these models are fairly large and complex, it is difficult to disentangle all the causes of these differences.

To address this, a simple stylised macroeconomic model is used in this study as a diagnostic tool. One of the key advantages of this approach in the policy context is that the results are transparent and easier to interpret. The model adopted has very conventional properties in the spirit of recent models used in the analysis of monetary policy in a single-country context (see Clarida et al., 1999, for example). But it is specifically tailored to reveal the key aspects of the possible interactions between the UK and euro area economies.
This systematic analysis of the possible response of the UK economy to shocks inside EMU compared to outside is similar in motivation to analysis carried out in the original ‘One Market, One Money’ study (see European Commission, 1990). And it addresses many of the same issues highlighted in recent work, for example by Blanchard (2001), which considers the extent to which macroeconomic divergences within EMU since 1999 can be explained by these intra-EMU adjustment mechanisms being played out.

The diagnostic model developed here has three stylised country blocks: the UK, the euro area economies and the rest of the world. Since these country blocks can be characterised as small, medium and large, the model is known as the ‘Three Bears’ model. It incorporates forward-looking and lagged behavioural responses and features:

- a simple IS curve where aggregate demand depends on the real interest rate and the real exchange rate (separating out influences from the real exchange rates of the different trading partners for each country);
- a simple Phillips curve where changes in inflation are driven by the output gap augmented by an influence from the real exchange rate to incorporate effects from overseas prices;
- bilateral nominal exchange rates assumed to be determined by the appropriate uncovered interest parity (UIP) condition; and
- a simple policy rule for determining the path of nominal interest rates.

One of the key insights is the different way that the UK adjusts to shocks in EMU compared to when it is outside, particularly in the face of shocks that are specific to the UK. Outside EMU, with an independent monetary authority targeting UK inflation, the UK price level is allowed to ‘slip’ in the face of shocks, with the nominal exchange rate playing a role in facilitating re-adjustments in the real exchange rate between the UK and the euro area.

Inside EMU, the monetary policy authority targets euro area inflation, so would take account of UK inflation only in as much as it contributed to the aggregate euro area inflation rate (where the contribution would be roughly a fifth, based on the UK’s weight in euro area GDP). So UK real interest rates would no longer play the primary adjustment role and may sometimes even be destabilising. This would occur when the ECB’s nominal interest rate response to a shock is less than the effect of the shock on UK inflation itself. So for inflationary shocks that are specific to the UK, real interest rates in the UK will fall, potentially reinforcing the effects of the original shock.

Instead, without an independent monetary policy or a nominal exchange rate between the UK and the euro area, the burden of adjustment would be on the real exchange rate (i.e. the relative price between the UK and the euro area.). In this case, the euro area price level would act as a nominal anchor for the UK price level with little slippage. So UK inflation would need to differ from inflation in the euro area for as long as necessary to bring about the required relative price change. This would necessitate greater fluctuations in UK output relative to potential as a consequence.

Because of these changes to the adjustment mechanisms inside EMU compared to outside, the model suggests that, inside EMU, the UK real exchange rate adjustment would not be as smooth but would follow a more oscillatory path compared to outside. This tendency may be moderated if firms and households respond more to long-term measures of real interest rates. But the destabilising tendency may be aggravated if firms and consumers respond slowly to interest rate changes.
Although the independent interest rate and variable nominal exchange rate would be lost on EMU entry, other adjustment mechanisms would still be available. The model shows that fiscal policy can be designed to stabilise the response of the economy to shocks when the UK is in EMU. In practice there are of course problems with designing effective discretionary fiscal policies. The stylised analysis of fiscal policy in this study does not attempt to address the practical questions that would need to be addressed if effective discretionary fiscal policy were to be implemented.

Ultimately wage-price flexibility might offer the most effective means of avoiding output costs inside EMU, though inflation variability may be higher as a result. The basic model in this study assumes a reasonable degree of wage and price rigidity. Wage contracts, menu costs and backward-looking inflation expectations prevent immediate adjustment to a shock. If this assumption were relaxed, so that prices were assumed to be fully flexible, then in the face of symmetric demand shocks, inflation would remain on target with no adverse implications for output stability in both the UK and the euro area.

The ‘Three Bears’ model builds in structural asymmetries associated with different degrees of international openness and patterns of trade between the UK and the euro area. But it assumes no behavioural asymmetries. This is a simplifying assumption, partly motivated by the empirical literature, partly by the argument that any differences that do exist may diminish in EMU through the process of endogenous convergence; that is the process whereby UK behavioural responses become more similar to those in the rest of the euro area.

But it can also be argued that behavioural asymmetries between the UK and the euro area would remain if the UK were to join EMU. So sensitivity analysis is undertaken on some of the key structural features of the model:

- for example, making demand more sensitive to interest rates in the UK than in the euro area (reflecting, for example, the importance of housing in the UK transmission mechanism) means that the real interest rate channel would be more pronounced for the UK in EMU, leading to more vigorous output responses inside EMU compared to outside; or
- making prices more flexible in the UK than in the euro area makes UK inflation volatility higher in the face of asymmetric shocks inside EMU. But this additional volatility would be less the more flexible is price setting in the euro area. This diagnostic exercise highlights the potential importance of the degree of flexibility in the UK and the euro area, not just in absolute terms but in relative terms too.

The implications of different modelling assumptions for expected macroeconomic outcomes highlight the importance of considering policymakers’ output-inflation preferences when examining possible entry to EMU. An explicit measure of the costs of macroeconomic volatility needs to be defined if the potential size of overall macroeconomic costs is to be compared with that associated with remaining outside. Moreover, if EMU entry does change the nature of macroeconomic volatility, this may have implications for the level of output in the UK, although this study does not attempt to quantify these long-run effects. All these influences need to be considered alongside the potential benefits from EMU entry, which are examined in detail in other EMU studies.

\[\text{For example, paragraph 2.2 of the 2002 Budget (HM Treasury, 2002) states that “Large and unpredictable fluctuations in output, employment and inflation impose significant economic and social costs and can hold back the economy’s long-term growth potential.”}\]
20 The potential macroeconomic costs of EMU entry are estimated in this study using a technique known as stochastic simulation analysis. This requires a model of the behaviour of the economies in question; and of the statistical distribution of all relevant shocks expected to hit those economies. Macroeconomic volatility is evaluated and compared across policy regimes by examining the implications for the variability of inflation from target and of output from potential. The question of the appropriate relative weighting to be placed on inflation and output variability is a policy choice beyond the scope of this study, as is the question of whether other objectives should be considered.

21 Two recent studies, using different models, evaluate the macroeconomic costs or benefits of UK membership. Barrell and Dury (2000) find that, under a range of assumptions, inflation variability is predicted to be lower inside EMU, while output volatility is estimated to be higher. By contrast, Minford (2001) predicts that both inflation variability and output volatility would increase inside EMU, markedly so in the case of inflation volatility.

22 There are many reasons for the divergence in results. One relates to the assumed properties of the adopted models. With more flexible prices, as in Minford (2001), more reliance is placed on inflation as the primary adjustment mechanism inside EMU. Another explanation lies in the treatment of exchange rate shocks and how they are assumed to evolve were the UK to join EMU. Overall macroeconomic volatility could fall if the shocks to the exchange rate were assumed to become more benign for the UK, for example because shocks to sterling as a separate currency would be absent. But volatility might rise if the shocks impinging on the euro (and hence on the UK’s exchange rate inside EMU) were more volatile than those sterling had experienced outside EMU.

23 Stochastic simulation exercises are also undertaken on the ‘Three Bears’ model. First, they are used to show how different types of shocks affect inflation and output volatility inside EMU compared to outside. Second, different calibrations of the model and of the estimated shocks to the model illustrate how overall macroeconomic volatility might be affected by UK membership in the face of plausible combinations of shocks inside and outside EMU.

24 The main conclusion is that, under a range of assumptions, UK inflation and output volatility is predicted to increase if the UK were to join EMU relative to staying outside. This increase can be modified if fiscal policy is used actively inside EMU as an additional adjustment mechanism. And the increase in volatility can be reversed altogether if exchange rate shocks outside EMU are estimated to have been particularly detrimental. So under that assumption, volatility could diminish if the UK were to join EMU.

25 Overall the analysis confirms the prediction that, on a priori grounds, it is not possible to say whether macroeconomic volatility in the UK would increase or decrease inside EMU compared to outside. But the analysis provides a conceptual framework which helps to explain how different assumptions about the workings of the macroeconomic environment can lead to different conclusions regarding the degree of macroeconomic volatility inside EMU compared to outside.

26 Again, it is important to emphasise that this study focuses on the likely scale of the ongoing costs associated with adjustment to shocks inside EMU compared to outside. It does not attempt to estimate how any such change in macroeconomic volatility might affect the long-run level of productive potential in the UK. Nor does it compare these costs with the potential benefits which EMU entry offers. The overall assessment of the economic case for UK entry to EMU makes this comparison.

27 This study informs the assessment of the convergence test, the first of the Government’s five economic tests for EMU entry; the flexibility test, the second test; and the growth, stability and jobs test, the fifth test.
This study considers the macroeconomic implications if the UK were to join Economic and Monetary Union (EMU). It focuses on the consequences of moving from the current policy environment where, outside EMU, UK interest rates are available to respond to shocks and the bilateral nominal sterling-euro exchange rate is free to vary. It compares this with the alternative inside EMU where UK interest rates would be determined by the European Central Bank (ECB)'s single monetary policy and the bilateral sterling-euro exchange rate would be irrevocably fixed.

The study deliberately restricts its focus to those macroeconomic implications of EMU that would arise from changes in the UK's ability to respond to shocks. It does not attempt to evaluate any possible change in productive potential that might arise from any change in the degree of macroeconomic volatility. It also ignores whether EMU membership would be potentially beneficial for other reasons, for example relating to falls in transaction costs and exchange rate uncertainty, and possible associated increases in trade. These issues are considered in other EMU studies and in the assessment itself. Neither does this study examine the question of how, if the UK economy were to join EMU, it might optimally enter in terms of timing and conditions. The issues raised by this question are tackled from a modelling perspective in the companion EMU study by Dr Peter Westaway *Modelling the transition to EMU.*

In considering how EMU affects the ability of an economy to respond to shocks, some broad principles apply:

- for any country entering a monetary union, the loss of the domestic interest rate as an instrument of monetary policy and the loss of the nominal exchange rate as a ‘shock absorber’ would compromise the ability of the economy to respond to shocks;
- but there may be other adjustment mechanisms available that partially or fully compensate for the absence of an independent monetary policy;
- and the nature of the transmission mechanism for the country entering monetary union might alter so as to lessen this problem; or
- the shocks impinging on the economy, in particular emanating from the exchange rate itself, might become more benign, offering a further potential mechanism acting to lessen or even outweigh the costs of monetary union.

These conclusions are generic for any country considering entry to a monetary union. Importantly, they imply that, on *a priori* grounds, it is not possible to conclude whether macroeconomic volatility would increase or decrease inside EMU compared to outside.

The purpose of this study is to explain how these different influences on macroeconomic volatility inside and outside EMU can be understood and evaluated.

In attempting to understand how macroeconomic volatility in the UK might be affected by EMU membership, a range of analytical tools are considered. To differing degrees, they all draw on the insights of optimal currency area (OCA) theory. The main principles of this approach are described in more detail in the EMU study by HM Treasury *The five tests framework.*
1.7 One of the central considerations is how the capacity of the UK economy to cope with shocks would be affected by membership of EMU. The relevant prediction of OCA theory is that the advantages of having an independent monetary policy would be small:

- if the structure of the UK economy were similar to that of the euro area, i.e. if the macroeconomic response of the UK economy to a given shock is similar to the response of the euro area; and
- if the shocks hitting the UK economy were similar to those hitting the euro area as a whole.

1.8 Empirical evidence can be brought to bear on these issues in different ways:

- indirect outcome-based approaches can be used to analyse the historical macroeconomic performance of the UK outside EMU compared to the euro area. However, their usefulness may be limited by the fact that focusing on outcomes alone may provide limited information about the causes of past differences;
- more sophisticated outcome-based approaches can be adopted which allow, again on the basis of historical experience outside EMU, the influence of different shocks on macroeconomic behaviour to be disentangled, and the relative frequency of these different types of shocks to be calculated; and
- direct model-based approaches can attempt to address the ‘what if’ question more explicitly by examining the response of econometrically estimated models of the UK economy to different shocks. This involves examining the estimated responses outside EMU, when interest rates are set independently and the sterling-euro exchange rate is free to vary; and comparing these with the responses which would arise inside EMU, when interest rates are set by the ECB and the sterling-euro exchange rate is irrevocably fixed.

1.9 This type of evidence is highly relevant to the first two of the Government’s five economic tests, relating to the extent to which business cycles have converged and the degree of flexibility of the UK economy. All of these approaches are reviewed briefly in this study but are examined in more detail elsewhere, for example in the EMU studies *EMU and the monetary transmission mechanism* by HM Treasury and *Analysis of European and UK business cycles and shocks* by Professor Michael Artis.

1.10 Even with such a wealth of empirical evidence, however, it is not straightforward to infer how macroeconomic volatility would be affected by EMU membership. Questions of interpretation of the empirical evidence remain. How well correlated do UK and euro area business cycles have to be before EMU membership is not too costly? How different does the transmission mechanism of monetary policy have to be before EMU membership would be destabilising? How prevalent do asymmetric shocks to the UK have to be before a single monetary policy would be too restrictive?

1.11 To address these questions, it is necessary to calculate more direct measures of the degree of macroeconomic volatility in the face of shocks, both inside and outside EMU. These can be provided by a model-based technique known as stochastic simulation analysis.1

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1 For an earlier application of this technique in the context of the analysis of the implications for the original members of EMU, see the ‘One Market, One Money’ study (European Commission, 1990).
1.12 Stochastic simulation results are generated by repeatedly applying plausible shocks to a chosen model of the UK, first under the assumption that the UK remains outside EMU, then under the assumption that it joins. This allows a measure of expected macroeconomic volatility to be calculated in and out of EMU. In principle, such studies are designed to capture all the relevant considerations relating to asymmetries between the UK and the euro area in structures and shocks. So this type of approach should be able to provide a reasonable estimate of the net macroeconomic costs that would arise from entering EMU.

1.13 In practice, of course, as with any empirical study, the conclusions reached will depend on the model used and on the particular assumptions adopted. This is demonstrated later in this study where two sets of model-based stochastic simulation exercises are found to arrive at different conclusions regarding the macroeconomic costs of EMU for the UK. Since these results emerge from complex and highly technical modelling exercises, this highlights the need to disentangle the different possible influences on these results. Only then is it possible to understand why these conflicting findings emerge.

1.14 Above all other influences, the key to interpreting these findings is through understanding which shocks might impinge on an economy inside EMU compared to outside; and in understanding the different mechanisms by which an economy would respond to shocks inside EMU compared to outside.

1.15 This study therefore develops and systematically analyses a stylised model of the UK and the euro area economies specifically designed with the issue of UK entry into EMU in mind.

1.16 This focus on a simple tractable model:

- facilitates greater understanding of the key adjustment channels of monetary policy when interest rates are set independently, and clarifies how those adjustment channels would be eliminated or modified inside EMU;
- addresses which might be the most important asymmetries between the UK and the euro area in terms of their implications for macroeconomic volatility;
- allows a sensitivity analysis of how the adjustment processes might differ when different assumptions are made about the workings of the UK and the euro area economies. This is informative, not only because of inherent model uncertainty, but more particularly because some parameters might be expected to evolve or converge towards euro area levels once EMU membership were established; the notion of endogenous convergence; 3
- allows a stylised examination of the extent to which fiscal policy might be used more actively to compensate for the absence of an independent monetary policy; and
- with particular reference to the flexibility test, allows an examination of how greater price flexibility in the UK might change the nature of macroeconomic adjustment inside EMU.

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1 See Barrell and Dury (2000); Barrell et al. (2003); and Minford (2001), discussed in detail in Section 7.
2 See Frankel and Rose (1998), and the discussion in the EMU study by HM Treasury EMU and the monetary transmission mechanism.
1.17 The investigation of this stylised model of the adjustment process forms the analytical heart of this study. As such, its main role is to provide a qualitative guide to how these processes work and to the key assumptions affecting these processes. The predictions of the stylised model should not be taken too literally, and they are not intended to provide a definitive empirically-based estimate of the net macroeconomic costs of joining EMU. Nevertheless, by making different assumptions about how the UK economy might respond to the range of possible shocks, the model can be used to suggest a range of empirical estimates of the possible macroeconomic costs. And the analysis can be used to provide a guide for those types of calculation carried out by other researchers.

1.18 The rest of the study is structured as follows. Section 2 summarises some of the empirical evidence that is typically examined to understand the likely costs of UK membership of EMU. Questions are raised as to how definitive such evidence can be in drawing conclusions regarding the desirability of EMU membership for the UK.

1.19 Section 3 introduces the stylised three-country model, providing the motivation for its specification and justifying the benchmark calibration intended to capture the key features of the UK relative to the euro area. Simulation properties of the model in the face of symmetric and asymmetric shocks are described both under autonomous monetary policy and in EMU. Section 4 examines the dynamic adjustment mechanisms available in and out of EMU.

1.20 Section 5 uses the stylised model to consider the extent to which other adjustment mechanisms might be able to compensate for the loss of a UK-specific monetary policy response inside EMU and for the loss of the bilateral euro-sterling nominal exchange rate. Two main mechanisms are considered:

- on policy adjustment, the implications of using fiscal policy as a discretionary stabilising mechanism are examined. The practical issues associated with this policy option are considered in more detail in the EMU study by HM Treasury *Fiscal stabilisation and EMU*; and

- on market-based adjustment, the implications of assuming a higher degree of price flexibility are examined.

1.21 Section 6 explores the robustness of the simulation properties derived from the benchmark calibration in the face of different assumptions about the degree of asymmetry between the behavioural responses of the UK and the euro area. This can arise either from the inherent model uncertainty, or more particularly because some parameters might not evolve or converge towards euro area levels as quickly as is implicitly assumed in the benchmark model, once EMU membership is established.

1.22 Section 7 brings together all the considerations about model specification and shocks in stochastic simulation exercises. These allow the macroeconomic costs of EMU membership to be evaluated in terms of a comparison of the predicted variability of macroeconomic variables inside EMU relative to outside. The results of previous empirically based studies of this nature are examined and an attempt is made to explain differences in their conclusions by examining some of the technical assumptions adopted.

1.23 Section 8 examines the issue more systematically by conducting stochastic simulation exercises on the model, first on a shock-by-shock basis, then by running stochastic simulations under a calibrated set of shocks. Macroeconomic volatility inside and outside EMU is compared for the benchmark model, and for a range of variants.

1.24 The final section draws some conclusions on how macroeconomic performance in the face of shocks might be affected if the UK were to join EMU and considers how other adjustment mechanisms might operate in those circumstances.
2.1 This section examines some of the empirical evidence that is frequently marshalled when quantifying the possible costs of EMU entry for the UK. In particular, it explains why certain analytical tools will provide valuable information on the likely implications of EMU membership for the UK. But it also explains how some of this empirical evidence can, at best, be difficult to interpret, and at worst, may give rise to misleading conclusions. This discussion motivates the structural modelling approach to the problem developed in later sections of the study.

2.2 In terms of the overall cost-benefit calculation relating to EMU entry, the costs associated with adjustment to shocks are primarily relevant in addressing the first two of the Government’s five economic tests, specifically:

“Are business cycles and economic structures compatible so that we and others could live comfortably with euro interest rates on a permanent basis?” and

“If problems emerge is there sufficient flexibility to deal with them?”

2.3 To answer these questions, it is necessary to look at the available evidence in the context of a well-understood theoretical framework. This is typically provided by the literature on optimal currency areas (OCAs) originally developed in the 1960s (see Mundell, 1961; McKinnon, 1963; Kenen, 1969). Since the original articulation of OCAs, the literature has developed considerably both in the scope of its coverage and in the range of empirical techniques which have been brought to bear on these questions.1

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1 See, for example, Tavlas (1993) for a survey of the more recent theoretical literature, as well as the contributions by Kenen, Tavlas and others in the EMU study Submissions on EMU from leading academics.
2.4 Nevertheless, the main message which emerges from this vast literature is simple, namely that two countries or regions might wish to adopt a single currency when the benefits from fixing the exchange rate exceed the rise in adjustment costs.

2.5 The gains associated with joining EMU arise from a number of sources, and these are considered in other EMU studies and in the assessment itself. The focus here is on the costs associated with adjustment in the face of shocks. The literature on OCAs indicates that these costs can be attributed to three main sources:

- the extent to which the structure of the UK economy is similar to that of the euro area. This is important because if the macroeconomic response of the UK economy to a given shock is similar to the response of the euro area, then the warranted monetary policy response will be similar;

- the extent to which the shocks hitting the UK economy are similar to those hitting the euro area as a whole. This is important, again, because if the disturbances hitting the economy are similar, or ‘symmetric’ as this literature describes them, then the required monetary policy response will be identical in the UK and the euro area. But if the shocks are ‘asymmetric’, then the interest rate response in the UK may need to be different and the real exchange rate between the UK and the euro area may need to adjust; and

- the extent to which the UK economy has sufficient additional adjustment mechanisms in the absence of an independent stabilising monetary policy response. These adjustment mechanisms can take various forms:
  - adjustment in relative prices or wages;
  - adjustment in supply; for example labour mobility was deemed to be especially important in the original OCA literature; and
  - adjustment in demand, for example through an enhanced role for fiscal policy as an instrument of demand management.

2.6 Empirical evidence can be used to cast light on these different elements of the problem with varying degrees of sophistication ranging from the simple to the more complex. Broadly, however, two types of empirical evidence can be defined:

- indirect evidence: these outcome-based approaches analyse the historical macroeconomic performance of the UK outside EMU compared to the euro area and use this to draw conclusions about likely UK performance inside EMU. These approaches provide an indication of the degree of similarity between structures and shocks in the UK and the euro area in the past. However, their usefulness may be limited by the fact that focusing on outcomes alone may provide limited information about whether the causes of past differences could be expected to continue if the UK were to join EMU; and

- direct evidence: these approaches, which tend to be more technically demanding, attempt to derive direct estimates of the structural characteristics of the UK economy compared to the euro area, both in terms of shocks and the response of the economies to shocks. This type of approach lends itself to model-based scenario analysis where the net macroeconomic costs of entering EMU can be estimated directly.
2.7 Later in this study, the analysis will concentrate exclusively on the ‘direct’ approach by analysing a stylised model that allows the different aspects of the problem to be deconstructed and evaluated. The rest of this section examines some of the tools that have commonly been used to analyse the costs of EMU membership. Here the focus is on how informative different types of evidence are likely to be through the indirect or outcome-based approach.

**The measurement and comparison of business cycles**

2.8 Perhaps the most straightforward outcome-based measure of macroeconomic performance is provided by estimates of the ‘business cycle’. Since this concept is mentioned explicitly in the wording of the first of the Government’s five economic tests, it is important to be clear on how this is being defined. For a more complete discussion, see the EMU study *Analysis of European and UK business cycles and shocks* by Professor Michael Artis.

2.9 Business cycles can be defined in a number of different ways. In popular discussion, it is common to refer to the business cycle in terms of fluctuations in the annual growth rate of GDP around its long-run average. Chart 2.1 below compares this measure for the UK, the US and the euro area based on quarterly data. On this simple measure, cycles in growth rates are highly correlated between the major industrialised economies, but potentially significant differences do occur.

2.10 Another popular way to identify the business cycle also focuses on the growth rate of GDP but pays particular attention to periods when the growth rate falls below zero. This definition, sometimes referred to as the ‘classical business cycle’, draws a distinction between downswings when output is falling and upswings when it is rising.2 On this basis, the business cycles of two economies can be compared by calculating the proportion of time that two cycles are in the same phase. This measure of synchronisation is known as ‘concordance’ (see Harding and Pagan, 2002) though for a more complete comparison of two cycles, it is also necessary to take into account differences in the duration and amplitude of contractions and expansions. More details of this and other approaches are described in the EMU study by Professor Michael Artis.

2.11 One problem with the business cycle definitions based on growth rates considered so far is that they do not draw any distinction between movements in output caused by demand or supply shocks. So another measure of the business cycle is defined by the gap between actual output produced and long-run supply potential. This is known as the output gap.3 From a monetary policy perspective, this measure of the business cycle is more relevant because, as the gap between demand and supply, it provides valuable information about inflationary pressure in the economy. As such, this measure of the business cycle is the one to which more weight is given in evaluating convergence in the context of the EMU debate.

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1 This technique was first developed by Burns and Mitchell (1946) at the National Bureau for Economic Research (NBER) in the US. ‘Turning points’ in the US business cycle have been dated in this way ever since.

2 Somewhat misleadingly, this measure of the business cycle is sometimes known in the classical business cycle literature as a ‘growth cycle’. See for example Harding and Pagan (2002). It is misleading because it refers to a levels gap between demand and supply not a rate of growth.
This approach, where supply-side influences on growth are removed from the measure of the business cycle, is also important because it emphasises that differences in potential, whether in terms of levels or rates of growth, have no necessary implications for the degree of cyclical convergence between economies. Different countries, whether they are in a monetary union or not, are likely to have different structural characteristics. For example, productivity levels per head may differ (see O’Mahoney, 2002), or the natural rate of unemployment rate may vary across countries (see OECD, 2002). It is sometimes argued that these divergences provide evidence that the UK should not contemplate EMU entry until the differences have been eliminated. But this is too simplistic.

What matters is whether these structural differences imply differences in the ability of the UK economy to respond to shocks compared to the euro area. In general, this will not follow, but in some cases there may be institutional reasons that link the structural impediments in an economy to its ability to respond to shocks. So, for example, countries...
with high structural unemployment rates may tend to be associated with inflexible labour markets that are slow to respond to shocks. This issue will be examined further in later sections.

2.14 Different empirical measures of the output gap-based definition of the business cycle can be obtained depending on how potential output is estimated. Charts 2.2(a) and (b) show one such measure of the output gap, again comparing business cycles for the UK, the euro area and the US, first over the period since 1971, then over the last 18 years (covering roughly two cycles). As with the simple measures of the growth rate, there are strong similarities between these measures, though again significant business cycle divergences do emerge at times.

**Chart 2.2: The output gap (constructed using HP filter)**

(a) 1971 Q1 – 2002 Q3

(b) 1984 Q3 – 2002 Q3

Source: Output data as in Chart 2.1. Output gaps derived by means of a simple Hodrick-Prescott (HP) filter defined using a smoothing parameter of 1600 for quarterly data. See the EMU study Analysis of European and UK business cycles and shocks by Professor Michael Artis for an explanation.
Apart from a visual inspection, it is possible to measure the degree of similarity between business cycles in two countries by calculating simple correlation coefficients, either over the whole period or on a rolling basis, to show how the degree of correlation is changing. Chart 2.3 shows correlation coefficients of the UK with the euro area and the US both for the growth rate and the output gap, calculated over a rolling five-year interval. Interestingly, this shows that, for the output gap, the UK is on average more correlated with the US (0.56 versus 0.38). This has been confirmed in other work (for example in Artis, 2000), although a large part of the fall in the UK-euro area correlation in the early 1990s reflects the effects of German reunification which probably disrupted the usual correlation pattern.

One shortcoming of simple correlation measures is that they do not take account of differences in the amplitude of the business cycles being compared.
2.16 One obvious issue raised by this analysis is how well correlated business cycles need to be before EMU membership is deemed to be appropriate. The OCA criteria suggest that the incidence of asymmetric shocks should be low, but the question remains as to how low.

2.17 A useful benchmark is provided by the regional correlations within existing monetary unions. Wynne and Koo (2000) compared the relationship between US Federal Reserve Bank districts with the experience of prospective EMU members. In general, these studies tend to find that on average US regions are more correlated than the UK has been with the rest of the euro area, but there are nevertheless some regions within the US which are similarly or less correlated with the rest of the US than the UK has been with the euro area. So it is difficult to draw definitive conclusions from this type of approach.

**Why do business cycles differ between countries?**

2.18 Having derived a range of different measures of the business cycle and shown that they have not always coincided in the UK and the euro area, it is now necessary to understand why they are different and examine more deeply whether these differences would be likely to compromise UK membership of EMU.

2.19 As already discussed, OCA theory (and its later extensions) provides an organisational framework for this question. It suggests that differences in observed outcomes can be decomposed into two main parts, both reflecting different structures:

- business cycles will differ between countries if they are subjected to *asymmetric shocks*. These can take a number of forms. For example, an exceptional increase in household or government spending in the UK is unlikely to have any direct effects on the euro area. Or a supply shock, in the form of a natural resource discovery such as North Sea oil, will not necessarily be mirrored in other countries. Political changes will also manifest themselves as ‘asymmetric shocks’. German reunification is perhaps the best example of a shock which had pronounced effects in one country; and

- business cycles will differ between countries if countries have *asymmetric transmission mechanisms* (i.e. asymmetric structural characteristics) implying that their response to a common shock differs. Again, these can take a number of forms:
  - transmission mechanisms may differ because of different behavioural characteristics; for example, UK consumers may be more responsive to interest rates than consumers in the euro area;
  - or economies may differ in their ability to respond to shocks; for example, markets in the UK may be more flexible so that wages and prices may respond more quickly;
  - or transmission mechanisms may differ due to different trade patterns. So a large economy like the euro area will tend to be less open than a smaller economy such as the UK. And trade destinations will be influenced by history. For example, the UK trades extensively with English speaking countries such as the US and the Commonwealth countries; and
  - responses may differ because policymakers have different preferences and choose to respond differently to the same shock. So countries with a high aversion to inflation could experience different business cycles even if all other shocks and structures were the same.
2.20 In practice, the distinction between asymmetries in shocks and in the transmission
mechanism of shocks may be hard to define. For example, a ‘symmetric’ shock to the oil price
will have asymmetric effects on the UK and the euro area due to their different exposures to
oil. More important is how to interpret these structural differences in shocks and
transmission mechanisms in the context of the EMU decision.

2.21 Empirical methods have been developed which attempt to disentangle the different
influences on business cycles. One technique uses structural vector autoregressive models
(SVARs). The intuition behind this approach is simple. It begins by focusing on a small
number of macroeconomic variables (e.g. output, inflation and interest rates), modelling
each as a function of current and lagged values of the other variables. It then makes the
assumption that variations in these variables are driven by a small number of shocks (e.g.
demand shocks, supply shocks and policy shocks) where the number of shocks is equal to the
number of variables. In order to disentangle the influence of different shocks on different
variables, it is necessary to make ‘identifying’ assumptions that specify how particular shocks
affect particular variables; for example that demand shocks cannot affect output in the long
run, or that policy shocks cannot affect output in the first period. The results of this exercise
provide two types of information:

- estimates of the response of endogenous variables to each policy shock; and
- estimates of the policy shocks that impinged on the economy over the
  estimation period.

2.22 This allows the asymmetry of the shocks and structures to be examined directly.

2.23 One of the earliest and most influential examples of this approach in the EMU context
was that taken by Bayoumi and Eichengreen (1993). They estimated a bivariate VAR for output
and prices, identifying the system by restricting demand disturbances from having long-run
effects on output. This allowed estimates of demand and supply shocks to be derived for each
country, and their correlations across countries to be calculated.

2.24 Later applications developed this technique by recognising that two different types of
demand shock were potentially important:

- real demand shocks, resulting for example from increases in private sector
  spending or government expenditure; and
- nominal demand shocks, resulting from shocks to the stance of monetary
  policy or from shocks arising in foreign exchange markets.

2.25 These shocks can be disentangled by a variety of identification restrictions. Gerlach and
Smets (1995), for example, include interest rates as an additional variable in their analysis and
distinguish between the different demand shocks by assuming that nominal shocks only
influence output with a lag. The distinction between these different types of demand shock
will be found to be particularly important in the later discussion in Section 8.

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1 Mundell in his contribution to the EMU study Submissions on EMU from leading academics argues that “all shocks are
asymmetric in that they affect countries differently”.

2 Indeed, one can always re-define an asymmetric shock as being a symmetric shock with a non-zero impact in one
country and a zero impact in the other, i.e. a special case of the more general form of structural asymmetry where model
parameters differ.

3 See also Monticelli and Tristani (1999) for a study closely related to the analysis presented in this section.
The original context in which Bayoumi and Eichengreen and later authors developed the shock correlation methodology was to evaluate the compatibility of the EMU project with the OCA criteria. They, and most of the subsequent studies in their spirit, therefore evaluated the correlations of individual countries with respect to Germany, which was considered the anchor country of the Exchange Rate Mechanism (ERM). This provided an answer to the question of whether the EMU member countries fulfilled the OCA criteria relative to Germany. However, the question of interest in the context of the UK decision on EMU membership is the extent to which the UK fulfils the OCA criteria with respect to the euro area.

To help to answer this question, the charts below show the results from a recently estimated update of the Gerlach-Smets analysis which has applied their technique to a direct comparison of the UK and the euro area.

Charts 2.5(a)-(c) show the estimates of the supply, demand and nominal shocks respectively for both the UK and the euro area. The extent to which the UK and euro area shocks are correlated is plotted in Charts 2.5(d)-(f). In interpreting these, the rough intuition is that the higher is this correlation, the higher is the proportion of symmetric shocks relative to asymmetric shocks. They show that over much of the 1980s and in the second half of the 1990s, all three types of shock were positively correlated between the UK and the euro area, with a correlation coefficient of around half. But over the first half of the 1990s, the average correlation was close to zero, although this period is likely to have been significantly influenced by the episode of German reunification.

Overall, this evidence tends to be consistent with the simpler measures of the business cycle already examined which suggested that there are strong similarities between business cycle characteristics of the UK and the euro area, but potentially significant differences too.

Why might SVAR-based estimates of asymmetries be misleading?

These SVAR-based studies provide valuable insights into business cycle differences between the UK and the euro area. By attempting to separate out the contribution of asymmetries in shocks and structures on observed business cycle behaviour, these methods are potentially more informative than simple output gap measures that necessarily conflate

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8 This finding is reproduced in some other studies (for example Dornbusch et al., 1998, find smaller effects on output from interest rate changes). But other papers find similar or larger effects in the UK, as in the original Gerlach-Smets analysis, carried out over a different sample period.

9 As with the simple output gap correlations, these results are significantly influenced by the episode of German reunification.

10 This emphasises the point that, for a given shock, the observed estimated impulse response will be a weighted average of the impulse responses to a symmetric shock and an asymmetric shock.

11 This finding is also consistent with other SVAR-based studies which have examined the similarity of responses to shocks across EU countries (see for example, Kieler and Saarenheimo, 1998).
Empirical Evidence on Business Cycle Differences Between the UK and Euro Area

Those influences. Even so, it is important to recognise that these more sophisticated analytical tools share many of the shortcomings of simple output gap measures when it comes to evaluating the implications of EMU membership, both in terms of the estimates of responses to shocks and shocks in turn.

Chart 2.4(a)–(i): SVAR analysis of impulse responses to shocks in UK and euro area

(a) Supply shock on output
(b) Demand shock on output
(c) Nominal shock on output
(d) Supply shock on prices
(e) Demand shock on prices
(f) Nominal shock on prices
(g) Supply shock on interest rates
(h) Demand shock on interest rates
(i) Nominal shock on interest rates


The impulse responses show the percentage effect on each variable in response to a standard deviation shock.
There is one overwhelming issue that complicates the interpretation of outcome-based measures of the business cycle such as output gaps, and by extension that affects the interpretation of SVAR-based estimates of responses to shocks. These measures are constructed using historical data over a period when UK monetary policy was set autonomously paying attention to UK objectives. This has ambiguous effects on the observed data:

(i) Caveats to the interpretation of estimated impulse responses

There is one overwhelming issue that complicates the interpretation of outcome-based measures of the business cycle such as output gaps, and by extension that affects the interpretation of SVAR-based estimates of responses to shocks. These measures are constructed using historical data over a period when UK monetary policy was set autonomously paying attention to UK objectives. This has ambiguous effects on the observed data:

Source: Data from International Financial Statistics, shocks derived from SVAR analysis described for Chart 2.4.

The correlation between UK and euro area shocks is calculated using a 17-quarter rolling window beginning with the shocks computed for the period 1981 Q2 – 1985 Q2 and is computed for the actual shocks, and for a four-period moving average of the shocks.
• on the one hand, observed differences over past history between the UK and euro area business cycles may underestimate the extent to which the underlying economies differ. *Ex ante* differences in behaviour may, *ex post*, have been compensated for by efficient monetary policy action. But in EMU, these stabilising policy influences will be absent; and

• on the other hand, the historically observed business cycle correlations may exaggerate the scale of the likely differences in EMU. Policy action may instead have had a destabilising influence on policy outcomes causing greater cyclical divergence; Kontolemis and Samiei (2000) argue this case in the UK context.

2.33 Apart from changes in the way that the economy responds to shocks due to differences in policy responses, EMU membership might also cause private sector behaviour to alter. Indeed, the essence of the Lucas critique of econometrically estimated models (Lucas, 1976) is precisely that private sector responses will be conditioned by their expectation of the policy reactions. So again, care needs to be taken when interpreting differences in estimated policy responses between the UK and the euro area.

2.34 In fact, the situation may be even worse because the estimated policy responses may not even be a reliable estimate of behaviour in the immediate pre-EMU period. Typically, the estimation period is likely to span regimes where responses have been changing, for example as the UK economy moved from a high inflation economy to one in recent years where inflation has been low and stable. So, for example, it is often argued that UK consumers are more sensitive to interest rate changes (or in the VAR context, to interest rate shocks) due to their greater reliance on short-term floating-rate borrowing compared to more longer-term fixed-rate financing in the euro area (see MacLennan et al., 1998; Britton and Whitley, 1997). Simple VAR-based impulse response estimates support this finding. But this may give a misleading impression of how UK consumers have behaved more recently when inflation expectations have been lower, or indeed how they would behave once in EMU since it is possible that they would tend to behave in a similar way to their European counterparts.

2.35 Another channel through which estimated responses may exaggerate the degree of asymmetry between the UK and the euro area relates to the fact that estimated responses will be based on historical trade patterns. But Frankel and Rose (1998, 2002) have argued that business cycle convergence is likely to be endogenous to monetary union.\(^{12}\) Rose (2000) has carried out a large cross-country econometric study which suggests that bilateral trade between countries is up to three times greater for countries participating in a monetary union compared to trade between non-members. While the scale of this empirical estimate seems implausibly large,\(^{13}\) it seems likely that countries inside EMU will tend to trade more with other members to some extent as a consequence of lower bilateral exchange rate volatility. For a more detailed description of these issues, see the EMU study by HM Treasury *EMU and trade*.

2.36 Apart from changes to the responsiveness of the economy to shocks in EMU, it is also possible that the shocks themselves will change their nature inside EMU.

2.37 One influential line of argument has been developed by Krugman (1993) who has argued that the observed increase in trade in a monetary union may be the result of

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\(^{12}\) Ciccarelli and Rebucci (2002) examine the extent to which this type of convergence might have occurred since the start of EMU in 1999.

\(^{13}\) It is also worth noting that the effect of monetary union on trade intensity in the Rose work is over and above the benefits to be obtained from the effects of exchange rate volatility. For a survey and evaluation of this literature, see the EMU study by HM Treasury *EMU and trade*. A range of views is also expressed in the EMU study *Submissions on EMU from leading academics*. 
underlying structural changes in the sectoral composition of the economies. This will increase the possibility of idiosyncratic (asymmetric) shocks, if industry-specific shocks are important. For more elaboration of this argument and why it may be overstated in practice, see the EMU study by HM Treasury EMU and business sectors.

2.38 On the other hand, there are also two compelling reasons why the nature of the shocks may become more benign inside EMU:

- inside EMU, the sterling-euro bilateral exchange rate would no longer be subject to ‘risk-premium’ shocks, or to movements unrelated to the state of the economy. Of course, as will be discussed later, this comes at a cost because ‘warranted’ movements in the sterling-euro bilateral rate would also be prevented. But some commentators (see Buiter, 2000) have argued that exchange rate shocks have been a significant source of volatility to the UK outside EMU, so joining EMU will remove this source of volatility. The question of the importance of exchange rate shocks is central and is examined in more detail in the EMU study The exchange rate and macroeconomic adjustment. The present study will also return to this issue in Sections 7 and 8 where both the scale and nature of these exchange rate disturbances will be found to have a crucial bearing on the results of the stochastic simulation exercises; and

- similarly, as already noted in the discussion of interpreting output gap measures, much of the historical volatility in the UK economy may have been caused by inappropriate monetary policy (or in the current context by shocks to the interest rate). Again, if monetary policy were to be better conducted within EMU, this would be another reason why volatility might be expected to fall within EMU. Since the advent of the inflation targeting regime in the UK in 1992, this argument is almost certainly less relevant for the UK in the context of the EMU decision.14

How does the UK respond to shocks inside and outside EMU?

2.39 So far, this study has explained how it is possible to disentangle observed business cycle behaviour into the influence of shocks and structures respectively. But it has been argued above that the estimated responses obtained from SVAR studies may be misleading when it comes to evaluating likely performance inside EMU. To address this problem more directly, it is necessary to use a different tool: structural macroeconometric models.

2.40 Structural macroeconometric models have the advantage that, when being used to investigate how the economy might respond to shocks, the maintained monetary policy response can be controlled directly. So different assumptions can be made about the monetary regime being followed. This allows the implications of the UK being inside or outside EMU to be examined explicitly.

2.41 Importantly, well-designed structural models also capture how other agents in the economy respond to changes in the policy regime. In fact, macroeconometric models originally developed in the 1970s failed to capture these responses adequately since, like VARs already discussed, they tended to rely on ‘reduced form’ relationships where model parameters reflected a mixture of behavioural and policy influences. So they could not be relied upon to give plausible predictions when the policy assumptions were changed.

14 This issue is discussed further in the EMU study by HM Treasury The five tests framework.
2.42 But in response to the influential Lucas critique on the use of these models for policy evaluation (as discussed in paragraph 2.33 and see Lucas, 1976), macroeconometric models were increasingly designed to have more robust microeconomic properties: for example, the models incorporated responses that better reflected the likely private sector responses to changes in government policy. This modelling of anticipatory behaviour necessarily led to the incorporation of ‘forward-looking’ expectations into macroeconomic models.\textsuperscript{15}

2.43 This transformed the analysis of macroeconomic dynamics, especially in modelling the behaviour of financial markets, making explicit the idea that asset prices would ‘jump’ in the face of new information.\textsuperscript{16} And here, this more sophisticated understanding of exchange rate determination will be seen to be particularly important in clarifying the role of the nominal exchange rate in the adjustment mechanism of monetary policy.

2.44 This is not to say that all structural macroeconometric models are completely immune from the original Lucas critique. Typically model-builders face a trade-off between theoretical rigour and empirical goodness of fit.

2.45 At one end of the spectrum, many recent academic studies have adopted models with tightly defined theoretical underpinnings where all agents in the economy are assumed to behave optimally according to well-defined criteria. Examples of this type of dynamic stochastic general equilibrium (DSGE) approach are typical in the so-called ‘New Open Economy Macroeconomics’ (see Lane, 2001, for a useful survey, and Obstfeld and Rogoff, 1996, for the most influential exposition). But such models tend not to be able to reproduce many of the dynamic patterns of the real world, especially when it comes to explaining the influence of monetary policy in the presence of sticky wages and prices.

2.46 As a consequence, many macroeconomic models developed for practical policy analysis, as used for example by policymaking institutions such as Finance Ministries and Central Banks and policy think tanks, tend to take a hybrid approach. This usually involves:

- taking a fairly rigorous structural approach in some aspects of modelling, for example in defining policy reaction functions and in modelling the more significant forward-looking responses, for example in asset prices and wage and price-setting; and
- taking a more data-driven and hence more theoretically \textit{ad hoc} approach to dynamic behaviour in other aspects of the model, though usually ensuring that long-run behaviour is theoretically coherent.\textsuperscript{17}

2.47 In the context of analysing the implications of EMU, this approach has the advantage that the relevant questions can be addressed while using the same types of models that are used by policymakers in a forecasting and policy analysis context.

\textsuperscript{15} For a good account of these developments, see Begg (1982).

\textsuperscript{16} Dornbusch (1976), for example, provided the seminal analysis on why exchange rates have a tendency to overshoot.

\textsuperscript{17} For a more detailed articulation of this approach, see Bank of England (1999).
By way of illustrating how these types of models can be used to examine the likely response of the UK economy to shocks inside and outside EMU, this study reports simulations run on two different structural macroeconometric models. Both are multi-country models that articulate the relationship between the UK, the euro area and the rest of the world and how different shocks impinge on them. These are:

- The National Institute Global Econometric model (NiGEM).\(^{18}\)
- The International Monetary Fund (IMF) Multimod model.\(^{19}\)

Although both models make serious attempts to model the relationships between economies in a structural manner, NiGEM tends to place greater emphasis on econometric goodness of fit compared to Multimod which tends to rely on calibrated parameters, often in the context of more tightly specified theoretical models.\(^{20}\) Further details of the specification of these models are contained in NIESR (2003), Laxton \textit{et al.} (1998) and Hunt \textit{et al.} (2001).

The simulations examined here are chosen to illustrate how differences in the estimated structure of the UK and the euro area economies affect the macroeconomic response to a common (i.e. symmetric) shock. They are run first under the assumption that monetary policy in the UK is set independently, then under the assumption that the UK has joined EMU.

The illustrative shock chosen is a two-year 1 percentage point increase in nominal interest rates. This shock is typically used to examine the transmission mechanism of monetary policy (see for example, Bank of England, 1999).\(^{21}\) As such, it is examined in more detail in the EMU study by HM Treasury \textit{EMU and the monetary transmission mechanism}.

Here, the focus is on illustrating how macroeconometric models can cast light on how economies might adjust to shocks and also on how robust the insights might be when taken across two different models. Charts 2.6(a) and (b) show the responses of inflation and output for the case when the UK remains out of EMU and has an independent monetary policy. Charts 2.7(a) and (b) shows the simulation responses when the UK is assumed to be inside EMU.

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\(^{18}\) The simulations for this exercise are run on the January 2003 version (1.03 as described in NIESR (2003). The EMU study by Dr Peter Westaway \textit{Modelling the transition to EMU} also runs forecast scenarios based on this version of the model.

\(^{19}\) The simulations are run on Multimod Mark 3b, a modification of Mark 3 amended to include the euro area as a country block, as described in Hunt \textit{et al.} (2001). The version used here is programmed up in Winsolve (see Pierse, 2000).

\(^{20}\) For example, in modelling consumer spending, Multimod relies on a specific version of the life-cycle hypothesis and builds in the assumption that key structural parameters are equal across countries. Modelling of consumption in NiGEM is broadly consistent with life-cycle predictions but model parameters are estimated econometrically and consequently may differ across countries.

\(^{21}\) Strictly speaking, policy shocks are conceptually different to other shocks, say to demand and supply, since in principle they represent an intended deviation from the maintained policy rule by the relevant monetary authority.
Chart 2.6: UK out of EMU: Simulation of 1 percentage point 2-year shock to the short-term interest rate obtained with MULTIMOD and NiGEM

(a) Inflation

(b) Output
Chart 2.7: UK in EMU: Simulation of 1 percentage point 2-year shock to the short-term interest rate obtained with MULTIMOD and NiGEM

(a) Inflation

(b) Output
2.53 Two important insights emerge from these simulation results:

- for both models, the responses of inflation and output to the interest rate shock are fairly similar between the UK and the euro area when monetary policy is set independently. As a consequence, the macroeconomic responses of the UK economy inside EMU are hardly different. On this basis, EMU membership would not be costly for the UK in the face of this type of shock; and

- the difference between predicted responses across the two models are rather more striking, with the Multimod results implying quicker and stronger inflation and output responses than NiGEM. The total fall in inflation is estimated to be around three times larger in Multimod, occurring in the second year rather than in the fifth year as with NiGEM.

2.54 On the face of it, these results would seem to suggest that the responses of the UK and the euro area economies to interest rate shocks would be very similar. This may not necessarily imply, however, that the UK and the euro area will respond so symmetrically to all other shocks. And, on the basis of these rather different results in terms of the scale of the responses across models, it is difficult to draw definitive conclusions on how the UK might fare in the face of shocks inside EMU. The asymmetries in the revealed responses will stem from a range of sources:

- differences in estimated responses in different countries on the same model;
- differences in estimated responses for a given country on different models; and
- differences in theoretical specification across different models.

2.55 In principle, the differences in responses between countries and across models, and indeed between these and any of the many other possible models, can be reconciled by a careful decomposition of the relevant factors. But in practice, this still leaves some of the key questions unanswered when considering how EMU membership affects the response of the UK economy to shocks. The following questions seem particularly important:

- most fundamentally, how would the UK economy adjust to shocks in the absence of an independent monetary response and with a permanently fixed euro-sterling exchange rate?
- what are the key channels of adjustment?
- are policy options available which might enhance the ability of the economy to adjust inside EMU?
- which structural asymmetries are the most influential in affecting the degree of macroeconomic volatility inside EMU compared to outside?
- how should the differing influences on macroeconomic volatility inside EMU compared to outside be evaluated?

2.56 The rest of this study deals with these questions.

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22 Interestingly, the EMU study by HM Treasury EMU and the monetary transmission mechanism notes that, although the predicted GDP responses are similar on the NiGEM model, there are differences in the composition of demand between the UK and the euro area. Domestic demand tends to be more sensitive to the interest rate increase in the UK, but the UK’s greater degree of international openness implies that there is an offsetting effect on output from net trade.

23 Later on in this study, for example, analysis carried out on the Liverpool model of the UK economy is used to examine these same issues.
A STYLISED MODEL OF MACROECONOMIC ADJUSTMENT IN AND OUT OF EMU

Motivation

3.1 Section 2 highlighted some of the difficulties faced when attempting to interpret business cycle differences in the past and when attempting to understand how the UK might respond to shocks inside EMU compared to outside. The following key conclusions have been reached so far:

- typical business cycle measures are informative but should not be taken at face value. In particular they may not always provide a reliable guide to how the business cycle will evolve within EMU;
- various more sophisticated tools, such as SVARs, allow the different causes of historical macroeconomic divergences to be disentangled, providing useful but, again, not unambiguous indications of whether divergences would persist inside EMU; and
- macroeconomic models can be used to provide more direct estimates of how the adjustment mechanisms inside EMU would alter. But these models are often complicated, so it may not always be straightforward to focus on the key parameters driving policy conclusions.

3.2 The approach taken in this study to analyse macroeconomic adjustment mechanisms is to use a stylised model of the UK and the euro area economies, specifically designed with the question of UK entry into EMU in mind, and developed further to assist HM Treasury in its preliminary and technical work for the EMU assessment.

3.3 This focus on a simple, tractable model proves useful for a number of reasons:

- it can be used as a diagnostic tool to facilitate greater understanding of the key adjustment channels of monetary policy when interest rates are set independently, and to illustrate how those adjustment channels are eliminated or modified inside EMU;
- it enables an investigation of the importance of different asymmetries between the UK and the euro area in terms of their implications for macroeconomic volatility;
• it facilitates a sensitivity analysis of how the adjustment processes might differ when different assumptions are made about the workings of the UK and the euro area economies. This is informative, not only because of inherent uncertainty about the magnitude of the model’s parameters, but more particularly because some parameters might be expected to evolve or converge towards euro area levels, once EMU membership is established;

• it allows a stylised examination of the extent to which fiscal policy might be used more actively to compensate for the absence of an independent monetary policy; and

• with particular reference to the Government’s flexibility test for EMU entry, it allows an examination of the extent to which greater nominal price flexibility in the UK might change the nature of macroeconomic adjustment inside EMU.

3.4 The broad approach taken here is novel in terms of the model adopted and the scope of the questions being addressed. But it draws on a rich tradition of model-based analysis in two particular respects.

3.5 First, in the context of exploring the monetary policy design problem, especially when investigating inflation targeting regimes, it has recently become commonplace to use stylised macroeconomic models which combine the simple predictions of textbook theory with the more recent insights of modern macroeconomic theory. The development of this literature is well described in the influential paper by Clarida et al. (1999).

3.6 Second, in the context of examining the implications of EMU for macroeconomic adjustment, a number of studies have addressed this question to varying degrees. These include:

• the original ‘One Market, One Money’ study undertaken by the European Commission which examined the question in some detail, basing its analysis on simulations of the Quest model;¹

• other studies that have focused on different aspects of how economies adjust in a fixed exchange rate regime (see for example Driffill and Miller, 1993) or in a monetary union (see Dornbusch et al., 1998; Hughes Hallett and Vines, 1993; Driver and Wren-Lewis, 1999); and

• more recently, a number of papers that have drawn on the experience of EMU member countries since 1999, focusing on the extent to which macroeconomic outcomes are influenced by the needs of different countries to respond to asymmetric shocks (see for example European Commission, 2001a; Blanchard and Giavazzi, 2002).² Of particular relevance is the study by Blanchard (2001), who emphasises the role of inflation as an adjustment mechanism and warns against ‘demonising’ inflation differentials inside EMU. This issue will be seen to be especially important in the later analysis of this study.

¹ See Chapter 6 of European Commission (1990), Adjusting without the Nominal Exchange Rate.

² One important concern in the policy-related discussion of these papers is the practical problem of decomposing macroeconomic developments into cyclical and structural influences, for example relating to Balassa-Samuelson effects on inflation differentials inside EMU. By focusing on the response to shocks in a stylised model, this study abstracts from this problem.
The ‘Three Bears’ model

3.7 The stylised model analysed in this study is designed to capture the macroeconomic interaction between the UK, the euro area and the rest of the world. Since the three country blocks in the model can broadly be characterised as small, medium-sized and large, it is referred to as the ‘Three Bears’ model.3,4

3.8 In describing the workings of the model and the structures they represent, it is useful to begin by examining the assumed form of the individual models of each country or country block. Further detail is given in Annex A of this study.

Theoretical underpinnings

3.9 The behavioural core of each country block in the model is based on what has become known as the ‘workhorse’ model of monetary policy analysis. In its closed economy form, this would comprise:

- a fixed level of potential output;
- an IS curve where aggregate demand depends negatively on the real interest rate;
- a Phillips curve where changes in inflation are driven by the output gap (i.e. the gap between aggregate demand and supply); and
- a policy rule for nominal interest rates, usually specified in terms of a ‘Taylor rule’ specifying a positive response to deviations in inflation from target and to the output gap.5

3.10 Early examples of this type of model were specified in a simple backward-looking form (see for example Rudebusch and Svensson, 1999). But later versions have incorporated forward-looking behaviour consistent with optimising behaviour on the part of firms and consumers (see for example McCallum and Nelson, 1999 and Clarida et al., 1999).

Similarity with previous models...

3.11 The ‘Three Bears’ model shares all these basic characteristics of the conventional ‘workhorse model’ and similarly builds in the option of including forward-looking behaviour. In particular:

- inflation dynamics are based on the Fuhrer and Moore (1995) overlapping contracts model where inflation is determined as an equally weighted sum of lagged and future inflation.6 Following Blake and Westaway (1996), the implementation in this study is generalised to allow the weight on backward-looking inflation to be higher to capture additional nominal inertia; and

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3 The title also alludes to the practice during the 1990s of referring to the US economy as the ‘Goldilocks economy’, in the sense that it was ‘not too hot, not too cold’. See also Driver et al. (2003) for a similar fairy tale reference.

4 Because the focus of interest in this study is primarily on the interaction between the UK and the euro area, the rest of the world is assumed to be exogenous. This is a standard treatment usually implicit in single-country open-economy models, but made explicit here. Doing so avoids consideration of endogenous movements in world real interest rates.

5 The original research in Taylor (1993) found that nominal interest rates in the US had, historically, responded to inflation deviations and the output gap with coefficients of 1.5 and 0.5 respectively. See also the discussion in the EMU study The United States as a monetary union.

6 Unlike the earlier overlapping contracts model of Taylor (1980), this approach more realistically imparts inertia into inflation itself rather than into the price level only.
• output dynamics are also assumed to include backward and forward-looking elements consistent with optimising models of the IS curve augmented to include elements of inertia, caused for example by habit persistence (see for example Fuhrer, 2000).7,8

3.12 Given the multi-country nature of the ‘Three Bears’ model, the individual country models also need to incorporate open-economy characteristics. Again, this property has already been incorporated in a range of previous studies mostly applied to the analysis of policy rules (see for example Blake and Westaway, 1996; Batini and Haldane, 1999; Ball, 1999).

3.13 Open economy models have three additional important features, all included in the ‘Three Bears’ country models:

• an equation for the nominal exchange rate, typically in the form of an uncovered interest parity (UIP) condition;
• an effect on demand in the IS curve from the real exchange rate capturing the relative price of domestic and foreign goods; and
• an effect in the Phillips curve from the real exchange rate capturing the effects of imported price inflation on consumer prices9; to the extent that pass-through from exchange rates to domestic inflation is incomplete due to pricing to market effects, so this effect will be moderated.10

3.14 So far, the description of the ‘Three Bears’ model has deliberately emphasised its reliance on conventional modern models of macroeconomic behaviour widely used in other studies. This is important in placing the findings of this study in a familiar context.

3.15 But it is also important to emphasise where the ‘Three Bears’ model represents an innovation relative to other studies. This is in its modelling of the interaction between the UK, the euro area and the rest of the world. In previous ‘open-economy’ studies relying on small, stylised models, the second-round effects of one country on another have usually been ignored. Of course, in studies focusing on monetary policy rules in a given country, this simplification may have been justified. But in the context of understanding the implications of EMU membership for the adjustment mechanism in the UK, this simplification cannot be justified.

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7 Since the theory of the optimising IS curve is less well-founded in the open economy case, the constraint that the coefficients on the leads and lags of output should sum to unity is not imposed in the ‘Three Bears’ implementation of the model.
8 The ‘Three Bears’ model does not include any credit channel, although a means by which this can be straightforwardly incorporated is suggested in Bean et al. (2002).
9 The model of inflation dynamics based on Fuhrer and Moore (1995) used in the ‘Three Bears’ model implies that the real exchange rate term appears with a particular functional form, involving the current value, a lead and a lag, in the Phillips curve. Box A1 in Annex A explains the derivation in more detail.
10 Recent literature has examined the role of pass-through in the context of new open economy macroeconomic models (see for example Devereux and Engel, 2002). The extent of exchange rate pass-through and its implications for the role of the exchange rate in the adjustment mechanism is discussed in more detail in the EMU study by HM Treasury The exchange rate and macroeconomic adjustment.
3.16 The interactions between the three country blocks in the ‘Three Bears’ model are captured via the following three channels:

- the real exchange rate feeding into the IS curve and the Phillips curve is defined as a weighted average of competitors’ prices deflated by the relevant bilateral exchange rates. The weights are determined by the assumed pattern of trade between the countries;
- the demand for exports of one country by another is determined by the extent of aggregate demand in the importing country, where the size of the effect is scaled by the degree of bilateral trade between the two countries; and
- the bilateral exchange rate between two countries is driven by the relevant UIP condition which is itself driven by the interest rate differential between the two countries.

3.17 To help explain these mechanisms, Box 3.1 sets out a simple representation of the equations of the UK economy embodied in the ‘Three Bears’ model. Annex A contains a more comprehensive description of the whole model.

3.18 The key structural parameters in the ‘Three Bears’ model are as follows:

- the interest rate sensitivity of the the IS curves;
- the exchange rate sensitivity of the IS curves;
- the degree of inertia in the IS curves;
- the degree of forward-lookingness in the Phillips curves;
- the degree of output sensitivity of the Phillips curves;
- the weight on inflation and the output gap in the policy rules;
- the strength of the automatic stabilisers on fiscal policy;
- the degree of openness of each country bloc;
- the share of imported goods in each domestic consumer price index (CPI);
- the degree of pricing to market;
- the proportion of trade carried out by each country block with others; and
- the share of UK GDP in euro area GDP, post monetary union.

3.19 The model is designed so that these structural parameters can be explicitly identified and particular assumptions about their values can be investigated. As a consequence, the model is calibrated rather than econometrically estimated.

3.20 For some structural parameters, the choice of parameter is relatively straightforward, for example, with the degree of openness of the economy where there is broad consensus based on the simple measurement of trade data. For others however, for example the interest rate sensitivity of the IS curve, the choice is less obvious. In these cases, the parameters are chosen where possible to be consistent with the assumptions of previous work, or they are chosen to match as far as possible the response patterns found in other macroeconomic models.

11 The coefficients appearing in the equations, however, will often be complicated products of more than one of these structural parameters, as in Box 3.1 for example. This is an illustration of the problem discussed in Section 2 that estimated model coefficients are ‘reduced form’ parameters.

12 For further discussion, see the EMU study by HM Treasury EMU and trade.
Box 3.1: The UK economy as described in the ‘Three Bears’ model

Key:
Model variables: y (output), y_s (potential output), dp (inflation), er (real exchange rate), r (real interest rate), i (nominal interest rate), fisc (fiscal policy influence on demand).
Subscripts: t (time period), t+1,e (expectation for time period t+1), targ (target value)
Superscripts: UK, EA (euro area), ROW (rest of the world), UKv.EA (bilateral relationship between UK and euro area).

Output determination (IS curve):
• Hybrid forward-backward dynamics.
• Effect from real interest rate and exchange rate (vis-à-vis the euro area and the rest of the world).
• Effect from demand in the euro area and the rest of the world.
• Effect from fiscal policy (embodying automatic stabilisers plus potential for discretionary stabilisation policy).

\[ y_{t}^{UK} = a_{1}y_{t+1,e}^{UK} + a_{2}y_{t}^{UK} + (1 - a_{1} - a_{2}) \left[ a_{3}r_{t}^{UK} + a_{4}er_{t}^{UKv.EA} + a_{5}er_{t}^{UKv.ROW} + a_{6}y_{t}^{EA} + a_{7}y_{t}^{ROW} + fisc_{t}^{UK} \right] \]

Inflation determination (Phillips curves):
• Hybrid forward-backward dynamics with lag and lead adding to unity to ensure dynamic homogeneity.
• Effect from real exchange rate (vis-à-vis the euro area and the rest of the world) with dynamics determined by generalised Fuhrer-Moore contract dynamics.
• Effect from output gap (with moving average dynamics also determined by contract dynamics).

\[ d_{p_{t}}^{UK} = b_{1}d_{p_{t+1,e}}^{UK} + (1 - b_{1})d_{p_{t-1}}^{UK} + b_{2}(er_{t+1}^{UKv.EA} - er_{t}^{UKv.EA}) + b_{3}(er_{t+1}^{UKv.ROW} - er_{t}^{UKv.ROW}) + b_{4}(y_{t}^{UK} + y_{t-1}^{UK} - y_{st}^{UK} - y_{st-1}^{UK}) \]

Real exchange rate UIP equations:
UK outside EMU
\[ er_{t}^{UKv.EA} = er_{t+1,e}^{UKv.EA} + r_{t}^{UK} - r_{t}^{EA} \]
UK inside EMU
\[ er_{t}^{UKv.EA} = p_{t}^{UK} - p_{t}^{EA} \]

Real interest rate definitions:
\[ r_{t}^{UK} = d_{p_{t+1,e}}^{UK} + c_{1}(d_{p_{t}}^{UK} - d_{p_{t}^{arg,UK}}) + c_{2} (y_{t}^{UK} - y_{st}^{UK}) \]
\[ r_{t}^{EA} = d_{p_{t+1,e}}^{EA} + c_{1}(d_{p_{t}}^{EA} - d_{p_{t}^{arg,EA}}) + c_{2} (y_{t}^{EA} - y_{st}^{EA}) \]

Monetary policy rules:
UK outside EMU
\[ i_{t}^{UK} = d_{p_{t+1,e}}^{UK} + c_{1}(dp_{t}^{UK} - dp_{t}^{UK}) + c_{2}(y_{t}^{UK} - y_{st}^{UK}) \]
UK inside EMU
\[ i_{t}^{EA} = w dp_{t+1,e}^{EA} + (1 - w) dp_{t}^{EA} + w[c_{1}(dp_{t}^{UK} - dp_{t}^{UK}) + c_{2}(y_{t}^{UK} - y_{st}^{UK})] + (1 - w)[c_{1}(dp_{t}^{EA} - dp_{t}^{EA}) + c_{2}(y_{t}^{EA} - y_{st}^{EA})] \]

where w is the share of UK GDP in euro area GDP post UK-entry.

Fiscal policy rules:
\[ fisc_{t}^{UK} = f_{a} y_{t}^{UK} + f_{i}(dp_{t}^{UK} - dp_{t}^{UK}) + f_{l}(y_{t}^{UK} - y_{st}^{UK}) \]

All forward-looking variables are solved under the assumption of model-consistent expectations with conventional rate-of-growth terminal conditions.
3.21 In explaining how the model is to be used to investigate adjustment processes, and in particular where there is a focus on the implications of asymmetries between the UK and the euro area, it is useful to separate the model’s parameters into three categories: policy-related parameters, ‘long-run structural’ parameters and behavioural parameters.

### Policy-related parameters

3.22 The two sets of policy-related parameters relate to:

- the feedback response of monetary policy, which would change if the UK entered EMU since UK interest rates would be determined by the ECB’s reaction function (which, as Box 3.1 has shown, would respond to conditions in the extended euro area as a whole, including the UK). In this analysis, the conventional ‘Taylor’ coefficients of 0.5 are adopted throughout and no attempt is made to derive ‘optimal’ feedback parameters or more sophisticated rules which might deliver better outcomes; and

- the responsiveness of the fiscal automatic stabilisers to:
  1. output movements (here chosen to take the value 0.5 in line with conventional empirical estimates, see Van den Noord, 2000, and discussed further in the EMU study by HM Treasury *Fiscal stabilisation and EMU*); and
  2. other macroeconomic variables in the fiscal policy rule, for example inflation and output gap deviations, which may be activated inside EMU to compensate for the loss of independent monetary policy as an adjustment mechanism (this role is discussed in Section 5).

### ’Long-run structural’ parameters

3.23 ’Long-run structural’ parameters relate to features of the economy which are unlikely to be altered in the short to medium term by the monetary regime in place. These include:

- the degree of openness to trade (defined as the average import and export ratio relative to GDP, assumed to be 0.33 for the UK and 0.165 for the euro area); and

- the pattern of trade (where the euro area countries comprise 50 per cent of UK trade, while the UK comprises 18 per cent of euro area trade).

### Behavioural parameters

3.24 Behavioural parameters refer to features of the economy which are more likely to respond and alter following membership of the single currency. These include:

- the sensitivity of demand to interest rate changes (here assumed to have an elasticity of 0.2, broadly consistent with econometrically-estimated model-based estimates); and

- the flexibility of wage and price setting (here it is assumed that the weight on forward-looking expectations is 0.25, and the output elasticity of the Phillips curve is 0.25, again consistent with model-based estimates).

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13 It should also be emphasised that monetary policy in the UK and the euro area is characterised by a simple Taylor rule on the grounds of modelling simplicity. It is not intended to imply that the Monetary Policy Committee of the Bank of England or the ECB actually follow such a rule.

14 The EMU study by HM Treasury *EMU and trade* and Andrew Rose’s contribution to the EMU study *Submissions on EMU from leading academics* examine the extent to which recent evidence supports the view that trade intensity and trade patterns might change more rapidly once inside EMU.

15 This is based on expenditure shares of GDP in 2002.

16 This estimate is based on UK trade data for 2002.
3.25 The distinction between these three categories is slightly arbitrary. But for the purposes of this study, it is used to set up a benchmark calibration of the model where, for simplicity, all behavioural parameters between the UK and the euro area are assumed to be identical. This is done not because it is necessarily the most realistic assumption, but because it allows an initial focus on a case where the only differences between the model structures are in terms of policy setting and long-run structural differences reflecting country size and trade patterns. In fact, to anticipate the later discussion, even when the model structures are close to being symmetric across countries, there are highly interesting differences in the responses to shocks inside compared to outside EMU. Subsequent sections will investigate the implications of additional asymmetries by changing the behavioural parameters.

3.26 Having established the workings of the model of the UK and euro area economies, the final feature of the model to be described is the specification of the shock processes impinging on the model.

3.27 Four main types of disturbance are assumed to impinge on the ‘Three Bears’ economies: demand shocks, supply shocks, monetary policy shocks and exchange rate shocks. These can be applied to the model asymmetrically (i.e. to one country only) or symmetrically (i.e. to the UK and the euro area together).17 Of course, there are many different types of shocks in the real world. For example, the implication of a supply shock will differ depending on whether it is a shock to labour supply or to underlying productivity. But for the purposes of this study, where the analysis is intended to be informative but stylised, the categorisation of all shocks into one of these four categories seems justifiable.18

3.28 The main characteristics of these shocks are briefly explained in turn:

Demand shocks

- Demand shocks impinge on the IS curve (either directly, for example representing a shock to consumer preferences, or via a shock to fiscal policy). In the long run, permanent demand shocks will not change the level of output which is fixed by supply potential. For asymmetric shocks, demand and supply will be reconciled by a long-run movement in the real exchange rate. For example, a permanent ex ante demand expansion in the UK would lead to a permanent real exchange rate appreciation so causing net trade to deteriorate.19

Supply shocks

- Supply shocks impinge on the level of potential output which feeds into the output gap in the Phillips curve and the policy rule. Permanent asymmetric supply shocks are similarly reconciled with demand by a long-run change in the real exchange rate. A permanent supply-side improvement will be associated with a depreciation which brings demand into line with increased supply.20

Monetary policy shocks

- Monetary policy shocks represent the component of interest rate movements over and above the ‘systematic’ movement determined by the Taylor rule. This can represent the extent to which policy is, in practice, more sophisticated than a simple Taylor rule. Or, historically, such shocks might represent the extent to which monetary policy had been set ‘badly’ (see Kontolemis and Samiei, 2000). Due to the long-run neutrality of monetary policy, these shocks

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17 Note that because the rest of the world is held fixed for the exercises conducted in this study, ‘symmetric shocks’ will not be assumed to impinge additionally on the rest of the world.

18 Further discussion on the typology of shocks is contained in the EMU study by HM Treasury The five tests framework.

19 This mechanism is examined in more detail in the EMU study Modelling the transition to EMU.

20 This prediction is often found to be controversial but is entirely consistent with the predictions of standard macroeconomic theory. More complicated models where productivity shocks impinge on the tradeables sector only can generate an appreciation in the CPI-based real exchange rate via the Balassa-Samuelson effect (see for example, Bailey et al., 2001).
have no long-run effect on output or the real exchange rate, though under an inflation targeting regime, the price level may end up at a different point.

Exchange rate shocks represent the extent to which exchange rates move for reasons unassociated with interest rate differentials or movements in long-run fundamentals. These are sometimes designated by the catch-all term ‘shocks to the risk premium’. Like monetary policy shocks, temporary movements in risk premia have no long-run influence on real variables. Permanent changes, however, will change the long-run domestic real interest rate, which by changing demand will alter the long-run real exchange rate.

3.29 It is important to emphasise that the long-run responses of the ‘Three Bears’ model to these shocks are very conventional and are consistent with the analogous responses in many empirically estimated macroeconomic models (see for example the Bank of England medium-term macromodel, Bank of England, 1999), in other stylised models (see Batini and Haldane, 1999) and even in dynamic general equilibrium models (see for example Benigno and Thoenissen, 2002).

The dynamic response to shocks: UK in and out of EMU

3.30 Having described the ‘Three Bears’ model in some detail, questions of interest relate to how the UK economy might adjust to shocks inside EMU. The long-run effect of a given shock should be the same whether the UK is inside EMU or not. But how does the choice of policy regime affect the dynamic responses to shocks over the short to medium term?

3.31 This raises the question of how different dynamic macroeconomic outcomes should be compared across different policy regimes and under different assumptions about private sector behaviour. This is an important issue that the study addresses more formally in Section 7 where the choice of policymakers’ ‘objective function’ is discussed.

3.32 The rest of this section explains how, in the model, the adjustment mechanism works inside and outside EMU. To achieve this, much of the analysis that follows is presented in the form of charts that are designed to clarify the key channels of adjustment. Box 3.2 provides a brief guide to explain how these charts should be read and interpreted.

Box 3.2: A guide to interpreting the simulation results

Most of the results from the ‘Three Bears’ model are presented in graphical form.

- In most cases, the focus of attention is on the response of the UK economy, though where the focus of interest is on the contrast between the UK responses and those in the euro area, euro area outcomes are also shown.
- For a given shock, charts are displayed in a set of (usually four) panels displaying the relevant macroeconomic variables.
- In all cases, macroeconomic responses are plotted relative to ‘base values’ (i.e. the interest is in the effect of the shock in terms of the difference from the base). Variables are plotted in terms of percentage difference from base except for inflation and interest rates which are defined in terms of percentage points relative to base.
- The time scale of the model calibration, and hence of the charts, is quarterly.
- Where possible, the convention is adopted that the responses outside EMU are depicted by solid lines and inside EMU by dashed lines.
3.33 Before examining the first shock – on monetary policy – it should be noted that the monetary policy reaction function assumed to be followed by the UK outside EMU, and by the ECB inside EMU, is deliberately stylised. The intention of this study is primarily to examine how the adjustment mechanism compares inside and outside EMU under reasonable assumptions about the likely efficiency of monetary policy action.21

3.34 To begin analysing the model, the responses of the UK and the euro area to a two-year 1 percentage point shock to the nominal interest rate are examined. This is done first with an independent UK monetary policy, so the shock is applied to the UK and the euro area simultaneously; and then with the UK in EMU, so the shock applies to the interest rate set by the ECB. This symmetric shock is almost identical22 to the policy experiment examined in Section 2 as applied to the NiGEM and IMF Multimod models.

3.35 Chart 3.1 illustrates the results in the standard format explained in Box 3.2. Outside EMU, the assumed simultaneous interest rate increase in both countries causes very similar responses. Output falls initially by 0.4 per cent as the real interest rate increase of 0.8 percentage points (comprising the effect of the shock plus the endogenous response of the policy rule) depresses demand. The resulting effect on activity causes inflation to fall by over 1 percentage point by the end of the first year via the Phillips curve. This is reinforced by the direct effect of the real exchange rate that appreciates in effective terms (not shown) for both countries.23

3.36 The symmetry of the model structures, in particular with respect to direct interest rate sensitivity, explains the symmetry of the responses. Perhaps unsurprisingly, the responses inside EMU remain very similar both to each other and to the previous independent responses.

3.37 Since the shock is symmetric, the bilateral real exchange rate response between the UK and the euro area is relatively small, both countries experiencing a return to base levels over a period of four years. Even so, it is interesting to compare the nature of the responses (see Chart 3.1(c)). Outside EMU, equilibrium is restored by a long-run appreciation of the nominal exchange rate (between the UK and euro area) of around 0.25 per cent, offset by a long-run fall in the relative price level of the same magnitude (caused by the slightly greater inflation response in the UK). But inside EMU, when the nominal exchange rate is fixed, the real exchange rate response is entirely accounted for by relative price movements, so in the long run, the accumulated effect on the UK price level is required to be identical to that in the euro area. Or put differently, more of the adjustment is required to be carried out by prices in the absence of a flexible nominal exchange rate. The consequence of this is that the real exchange rate response is more oscillatory, a pattern which is explained in more detail in Section 4.

3.38 The results from the symmetric interest rate shock confirm the results from the larger structural macroeconomic models, namely that EMU membership would not pose problems for the UK in the face of symmetric policy shocks so long as the behavioural components of the economy that were affected were similar in structure to those in the euro area. Another type of ‘symmetric’ shock is now explained, where though the shock is symmetric, the effects of the shock are not because of differences between the UK and euro area in the way the shock is transmitted.

21 Later in this study, when more behavioural asymmetries are assumed, this assumption that the UK and the ECB would both follow the same rule may lead to slightly misleading inferences. This issue is examined more systematically in Aksoy and de Grauwe (2002). But the disadvantage of this is judged to be outweighed by the comparability across the results of the study that the simple ‘Taylor rule’ assumption brings.

22 The difference here is that the two-year 1 percentage point increase in interest rates is superimposed on the endogenous response of interest rates according to the Taylor rule. So over the first two years, interest rates will not move by exactly 1 percentage point. This is done to be consistent with the later stochastic analysis in Section 7 where interest rate shocks relate to the ‘unsystematic’ component of monetary policy.

23 The exchange rate measures shown in Chart 3.1(c) and elsewhere in the study are for the bilateral UK-euro area rate.
This is a sustained shock to output in the rest of the world economy where a 5 per cent increase is assumed, returning to zero in around two years. This implies an increase in the demand for both UK and euro area products by consumers and firms in the rest of the world. But this has different effects because the feed-through into the respective demand curves of the UK and the euro area will depend on the degree of exposure of each country to rest of the world demand.

\[^{24}\text{The initial 5 per cent shock is assumed to return to base levels at a speed determined by an autoregressive parameter of 0.5.}\]
Chart 3.2 illustrates the responses as modelled:

• as with the symmetric interest rate shock, the effects on output and inflation are similar across countries. Output is stimulated by slightly more in the UK, just over 0.25 per cent relative to base, compared to 0.2 per cent in the euro area. So inflation peaks just above 0.2 percentage points relative to base in the UK, very slightly more than the inflation response in the euro area. And again, the responses are similar for the UK inside EMU;

• one further point on the output and inflation responses is worthy of note. The inflation deviations over the first two to three years are slightly smaller inside EMU than outside, although output deviations are larger in EMU. For this simulation, this difference is rather insignificant, but it does illustrate the point that, for a given policy rule, inflation and output volatility will both not necessarily be worse inside EMU in the face of a given shock; and

• again, the oscillatory response of the bilateral UK-euro area real exchange rate is more marked inside EMU compared to outside, although for this shock the magnitude is again small, as might be expected in the face of a symmetric shock where behavioural responses are also fairly symmetric. The differences in the response patterns, though small, can be seen to be more significant when considering the response to asymmetric shocks. Outside EMU, the nominal exchange rate initially appreciates before depreciating below base levels. The price level in the UK accordingly ends up above that in euro area. Overall, the real exchange rate appreciates before depreciating smoothly back to base levels in less than two years. By contrast, once in EMU, relative prices are required to do all the adjustment and the adjustment path of relative prices causes the equivalent real exchange rate (which in EMU is of course exactly equal to relative prices) to appreciate by over twice as much as in the case outside EMU before oscillating back to base levels over four to five years.

To recapitulate, the stylised model predicts that inflation and output volatility would not be much greater inside EMU in the face of symmetric shocks. This is perhaps unsurprising because, up until now, it has been assumed that the structure of the economies in the UK and the euro area is rather similar. Even under these assumptions, however, this relatively small deterioration in inflation and output performance is achieved at the same time as greater UK-euro area real exchange rate volatility inside EMU compared to outside. Since EMU is more commonly associated with exchange rate stability, this merely serves to emphasise that it is important to distinguish between nominal and real exchange rate movements. And it emphasises that relative prices are required to bear all the burden of adjustment inside EMU in the absence of a country-specific interest rate and in the absence of a shock-absorbing role for the nominal exchange rate.

The next diagnostic considers a shock specific to the UK economy. Here a 1 per cent persistent shock to UK demand is assumed (again returning to zero with an autoregressive parameter of 0.5). It can be thought of as a shock to the preferences of UK consumers, for example reflecting developments in the housing market or a change in UK government spending. Its key characteristic is that it does not impinge directly on the demand curve of the euro area.

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\[3\] This can be explained by the balance of two effects. The UK is twice as open as the euro area but trade with the rest of the world is more important to the euro area than to the UK.
A Stylised Model of Macroeconomic Adjustment In and Out of EMU

Chart 3.2: Temporary ‘symmetric’ demand shock to the rest of the world: comparison of UK with independent monetary policy and UK inside EMU

(a) Inflation

(b) Output

(c) Real and nominal bilateral exchange rate

(d) Relative prices (UK versus euro area)
3.43 Chart 3.3 illustrates that with monetary policy operating independently, the effects of the shock are largely confined to the UK. Output increases in response to the shock and inflation rises as a consequence, peaking at 0.2 percentage points after one year. In response, nominal interest rates rise by 0.3 percentage points by the end of the first year. This results in an initial appreciation of the sterling-euro exchange rate by 0.6 per cent. Thereafter, the higher interest rate causes the nominal exchange rate to depreciate via the uncovered interest parity (UIP) condition, falling almost 1 per cent below base levels in the long run. Correspondingly, as the UK-euro area real exchange rate smoothly returns to base over four to five years, the UK price level rises by just over 1 per cent over the same horizon (euro area prices are only slightly higher by 0.1 per cent).

3.44 When the UK is assumed to be inside EMU facing the same shock, the initial effects of the demand shock are larger on inflation. In this case, the impact peaks at 0.25 percentage points after two quarters, due to the more muted interest rate response from the ECB, which is targeting inflation in the euro area as a whole. Accordingly, output rises by almost half as much again as with an independent monetary policy but subsequently undershoots base levels sharply after two years and thereafter gently cycles back to base levels after five years. The real exchange rate, i.e. the relative UK-euro area price level, also exhibits the same type of oscillatory response, showing a greater and later appreciation inside EMU before cycling back to base levels.

3.45 Having established the model’s responses to demand shocks, Chart 3.4 illustrates the responses to an asymmetric supply-side shock to the UK economy, assumed to take the form of a permanent increase in the level of total factor productivity, designed so that output increases by 1 per cent in the long run. This type of permanent shock is particularly informative for illustrating the difference between the UK transmission mechanism inside and outside EMU:

- in the long run, the bilateral UK-euro area real exchange rate would be required to depreciate by around 2 per cent. The intuition behind this result was discussed earlier. The key point to note here is that this long-run response would be the same whether the UK is inside or outside EMU. Outside EMU, the real exchange rate depreciation would occur via an immediate depreciation of the nominal exchange rate. But inside EMU, with an implicitly fixed nominal exchange rate, the required real exchange rate depreciation would happen more slowly via the effects on relative prices of a fall of UK inflation below target;

- in both cases, demand would initially fail to keep up with the sudden increase in supply potential. Outside EMU, the depressing effect of the negative output gap on inflation would be outweighed by the direct effect of higher import prices on the CPI, so inflation would actually rise. Inside EMU, however, the negative output gap would initially need to be twice as large, at almost 1 per cent, to bring about the required fall in inflation. Again, this emphasises the point that the greater burden placed on relative price adjustment inside EMU has a cost in terms of greater output fluctuations; so

- in the long run, despite the identical real equilibrium, the burden of real exchange rate adjustment would mainly have been taken by the nominal exchange rate outside EMU with a small increase in prices. While inside EMU, UK prices would have been required to fall by 2 per cent, the entire extent of the required real exchange rate fall.

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26 This study does not attempt to address formally the question of whether, from the perspective of the UK, the ‘optimal’ response to shocks outside EMU necessarily dominates the ECB’s optimal response (where the ECB pays attention to euro area objectives).

27 This shock is assumed to be unanticipated but immediately perceived.

28 To repeat, since the supply of goods in the UK has increased, it is necessary in imperfectly competitive markets for their relative price to fall, hence the depreciation of the real exchange rate.
So far, one feature of all the simulations presented is worthy of emphasis. This relates to the contrast between the relatively smooth responses when UK monetary policy is independent compared to the more cyclical outcomes inside EMU. This result would seem to be generic, so it is useful to examine this feature of the model in more detail. Section 4 does this.
Chart 3.4: Permanent asymmetric supply shock to UK only: comparison of UK with independent monetary policy and UK inside EMU

(a) Inflation

(b) Output

(c) Exchange rates and relative prices

(d) Nominal interest rates
There are three main elements to the adjustment mechanism of the economy in the face of asymmetric shocks: first, the role of real interest rates, second the role of the real exchange rate and third, the split between movements in the nominal exchange rate and relative prices.

Outside EMU, a well-designed independent monetary policy would deliver counter-cyclical real interest rate movements. But inside, where the weight on UK inflation is relatively small in the ECB’s reaction function, real interest rate movements in the UK might prove destabilising.

Outside EMU, required relative price movements between the UK and euro area would be brought about by a combination of price changes in the UK and the euro area and changes in the nominal euro-sterling exchange rate. Inside EMU, the nominal exchange rate movement would be absent.

Outside EMU, the effects of a UK-specific shock to UK inflation would be reversed by bringing inflation back to target. But usually, the price level itself would be allowed to ‘slip’ from its original path, where the long-run slippage would be accommodated by an offsetting change in the nominal exchange rate. Inside EMU, the burden of real relative price adjustment would be entirely borne by prices themselves. The euro area price level effectively would act as a nominal anchor for UK prices.

4.1 Is the more cyclical response inside EMU generic or is it a quirk of the ‘Three Bears’ model? This question is central to understanding how the UK might respond to asymmetric shocks inside EMU compared to its response outside EMU. As such, it bears closer analysis which is carried out in this section.

4.2 The stylised analysis has suggested that it is useful to focus on three key aspects of the adjustment process. These relate to the roles of:

- the real interest rate;
- the real exchange rate; and
- the nominal exchange rate.

**The role of the real interest rate**

4.3 It is a defining characteristic of EMU that individual member countries lose their ability to manipulate the domestic nominal interest rate to respond to asymmetric shocks. But this does not imply that the domestic real interest rate is no longer affecting the domestic economy. To elaborate, consider the case of an asymmetric demand shock.

4.4 With independent monetary policy, the domestic interest rate is manipulated according to a Taylor rule (see Section 3). Here, the conventional assumption is made that nominal interest rates would respond by 1.5 percentage point for every 1 per cent that UK inflation rises above target. So real interest rates would also rise by 0.5 per cent. This monetary tightening will help to suppress demand, directly via the real interest rate effect in the IS curve, and indirectly via its effect on the real exchange rate. Both these effects will curb the inflationary response.
4.5 This effect on interest rates will be supplemented by the response to the output gap, where the conventional Taylor rule assumption adopted in the ‘Three Bears’ model is that nominal interest rates are raised by 0.5 percentage points for every percentage point that output rises above potential.

4.6 Inside EMU, the nominal interest rate responds positively but only to the extent that UK inflation and output impinge on the overall euro area aggregate measures which the ECB is responding to. In the stylised model, it is assumed that the UK has a weight of one fifth in the extended euro area aggregates. So now, under a Taylor rule response by the ECB, every 1 percentage point increase in inflation in the UK will cause the ECB nominal interest rate (which now applies to both the euro area and the UK) to increase by a mere 0.3 percentage points (i.e. 1.5*0.2). So the direct effect of the 1 percentage point increase in UK inflation would be to cause UK real interest rates to fall by 0.7 percentage points, thus causing a monetary loosening from this channel. This loosening effect might be modified if there were a corresponding increase in the UK output gap. In this example, the output gap would have to rise by 7 percentage points before real interest rates were neutral.

4.7 Chart 4.1 shows precisely this response in the case of the asymmetric demand shock examined earlier. This perverse interest rate response should be familiar to students of economic history, since it is the destabilising real interest rate response first noted by Wicksell (see Wicksell, 1907). He examined this phenomenon in the context of the feasibility of a nominal interest rate peg where he noted the inherent instability in the face of inflationary shocks. With fixed nominal interest rates, an increase in inflation would cause real interest rates to fall, boosting demand, pushing up prices, and in turn causing real interest rates to fall further, and so on. But the case of monetary policy for a small economy in a monetary union is not very different. In the limit, an inflationary shock to a country with a small weight in the euro area will be exactly like the Wicksellian case.

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1 Using GDP at constant 1995 prices, converted at purchasing power parity exchange rates, UK GDP in 2002 comprised just under 20 per cent of the combined GDP of the UK and the current euro area.

2 The assumption that the ECB are using a Taylor rule implies that they would need to see the euro area output gap rise by 1.4 percentage points if they were to raise interest rates by 0.7 percentage points. Assuming that output in the rest of the euro area was unchanged, and given the assumed weight of 0.2 on the UK in the euro area including the UK, this implies that the UK output gap would need to increase by 7 percentage points.

3 It is also closely related to the destabilising influence which arises from deflationary shocks when economies are in a liquidity trap, that is when central banks are unable to cut nominal interest rates below zero.

4 This mechanism will also apply to economies facing deflationary shocks when they have zero nominal interest rates and are constrained from cutting interest rates by the liquidity trap.

5 More recently, Alan Walters (see Walters, 1998) for example, has drawn attention to a similar mechanism which occurs when nominal interest rates are forced to fall when a high inflation country enters into a fixed exchange rate regime. This argument, which is distinct but related, was made at the time that the UK entered the ERM in 1990.
4.8 The other main channel through which the economy adjusts to asymmetric shocks is through movements in the real exchange rate, which is a measure of competitiveness. In the short run, an inflationary shock to the UK economy alone will cause competitiveness to deteriorate relative to the euro area, thus curbing demand via the IS curve. And in the long run, the earlier discussion explained how the real exchange rate bears all the burden of adjustment in response to permanent asymmetric shocks. This remains the case whether the UK is in EMU or not.

4.9 The essential point to note is that not only is the real exchange rate channel still present within EMU, but it may be the dominant stabilising channel due to the destabilising feature of real interest movements in EMU. This is confirmed by Chart 4.2(a) comparing the path of the real exchange rate in the face of the asymmetric demand shock. Inside EMU, the temporary real exchange rate appreciation, while initially more sluggish, needs to be greater in order to stabilise the economy. Significantly, as noted earlier, the real exchange rate response inside EMU is more volatile. To understand why this should be, it is necessary to examine the role of the nominal exchange rate when monetary policy is set independently.
Chart 4.2: Temporary asymmetric demand shock to UK only: role of real and nominal exchange rate in adjustment mechanism in and out of EMU

(a) Real exchange rates

(b) Real and nominal exchange rates and relative prices
The role of the nominal exchange rate and relative prices

4.10 The crux of the explanation as to why the real exchange rate is more oscillatory inside EMU than outside lies in the role that the nominal exchange rate plays when monetary policy is set independently. Chart 4.2(b) shows the response of the real exchange rate, nominal exchange rate and relative price level (between the UK and the euro area) in the face of the asymmetric demand shock under independent monetary policy. As already discussed above, the smooth convergence of the real exchange rate back to base levels is reflected in a smooth increase in the relative price level, offset by a correspondingly smooth depreciation in the nominal exchange rate. The smooth increase in the price level is consistent with an initial increase in inflation that is gradually brought back to base levels. So with an independent monetary policy under inflation targeting, monetary policy allows the UK price level to ‘slip’ in the face of this type of asymmetric shock. To do otherwise by clawing back the price level slippage would be more costly in terms of output losses. And of course, the increase in the price level does not lead to any sustained loss of competitiveness due to the ‘shock absorbing’ role played by the nominal exchange rate.6

4.11 This all contrasts with the more oscillatory return to base of the real exchange rate required inside EMU where, in the absence of a bilateral nominal exchange rate between the UK and euro area, the UK price level is necessarily anchored by the price level in the rest of euro area.7 So the only price level slippage that occurs is due to the effect of the UK demand shock on inflation and output in the extended euro area (in this case, amounting to around 0.3 per cent). So this implies that, in response to the demand shock, UK inflation must be returned below base levels for a period in order to restore the relative price level between the UK and euro area. To achieve this with the accelerationist type of Phillips curve adopted here, output must fall below base levels so as to bring inflation down not only to base levels but also below base so as to claw back the price level slippage. Then inflation needs to rise back towards base levels (though the price level will continue to fall) thus requiring a period when output is above base again. This explains the inherently cyclical response to the asymmetric shock for the UK economy in EMU.

4.12 In fact, the necessary response inside EMU in the face of asymmetric shocks is rather similar to that required by a regime of price level targeting with autonomous monetary policy. And it is well known that price level targeting control tends to result in more volatile responses than inflation targeting rules.8 Chart 4.3 illustrates, comparing the inflation and output responses of an inflation targeting regime, a price-level targeting regime and a regime constrained by EMU. Interestingly, though the characteristics of the price-level targeting regime are similar to that under EMU in that inflation is required to undershoot, the degree of stability is otherwise rather good, more akin to the inflation targeting regime. This is because the response to the shock under EMU is necessarily less efficient than a true regime of price level targeting because of the destabilising influence of the real interest rate, as shown in Chart 4.3(d).

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6 Alternatively, this role for the nominal exchange rate is sometimes characterised as a ‘safety valve’ (see for example, Brittan, 2002).

7 The situation is more complicated in the case of permanent shocks, as shown for example in Section 3 for the asymmetric supply shock, because the relative price level is not constrained to return to the price level in the euro area. Instead, it must move to that level additionally adjusted for the required long-run movement in the real exchange rate. But the principle that the UK price level will ‘slip’ under inflation targeting but not under EMU remains valid.

8 Technically, this occurs because price-level targeting is an integral control mechanism while inflation targeting is a proportional control response. The unstable tendency of integral control rules was first noted by Phillips (1954).
Chart 4.3: Temporary asymmetric demand shock to UK only: comparison of UK with independent inflation targeting, independent price level targeting and UK inside EMU

(a) Inflation

(b) Output

(c) Real exchange rate

(d) Real interest rates

(e) Price level

- UK inflation targeting
- UK price-level targeting
- UK in EMU
Sensitivity analysis

4.13 The extent of the potentially perverse influence on real interest rate movements for a single country experiencing a country-specific inflationary shock within EMU will depend on the details of the model adopted and the assumed policy stance of the monetary authorities:

- it has already been noted that the destabilising effect would be mitigated or even reversed if the ECB were to respond sufficiently strongly to the output gap; and
- the severity of the instability would also depend on the degree to which private sector demand is influenced by short-term real interest rates or longer-term interest rates. The more forward-looking are private sector agents, the more likely it is that they would ‘see through’ the short-term perverse effect on real interest rates, since average real rates over a longer horizon would be more likely to move appropriately.¹

4.14 Chart 4.4 illustrates how the response to the temporary asymmetric demand shock might be modified inside EMU if different assumptions were to be made regarding the degree of inertia in the response of output. In the benchmark model, the IS curve is assumed to embody some backward-looking inertia in the form of a lagged response to past output changes (see Annex A for details). Here, two alternative assumptions are considered:

- first, the IS curve is assumed to be forward-looking rather than backward-looking;¹⁰ and
- second, real interest rates, real exchange rates and foreign demand are assumed to impinge on output with a one-quarter delay. This has the effect of making output slower to respond to shocks.

4.15 As might be predicted, the simulation responses under these alternative assumptions indeed show that when output is assumed to be more forward-looking the unstable tendency arising from the perverse real interest rate effect is lessened, though here not eliminated. But if a simple form of lag is built into the response of output, then the oscillatory tendency of the economy inside EMU is increased.

4.16 This type of sensitivity analysis, which will be repeated in later sections when examining the robustness of other assumptions, is carried out to emphasise that the stylised analysis of this paper can give broad indications of how the adjustment mechanism might change inside EMU compared to outside. But in the absence of precise empirical estimates, it may be misleading to take the model’s predictions too literally.

¹ The assumption that demand is affected by long-term rather than short-term interest rates is adopted in the small model of the euro area estimated in Coenen and Wieland (2000). Of course, this type of forward-looking behaviour by the private sector will also tend to lessen the effectiveness of short-term management of demand via monetary policy actions.

¹⁰ The forward-looking coefficient (C_{lead}) is assumed to be 0.5, while the coefficient on lagged output in the IS curve (C_{lag}), previously set at 0.5, is set to zero.
Chart 4.4: Temporary asymmetric demand shock to UK only: illustration of sensitivity of responses to different degrees of inertia in IS curve

(a) Inflation
(b) Output
(c) Real exchange rates
(d) Real interest rates

Benchmark model, UK in EMU
Lagged effects in IS curve, UK in EMU
Forward-looking IS curve, UK in EMU
5.1 So far the analysis has examined the adjustment processes inside EMU on the assumption that economic agents and governments do not attempt to adapt to the new monetary policy regime. This section examines how existing adjustment mechanisms, both policy-related and market-based, might be enhanced inside EMU to compensate for the loss of an independent monetary policy.

5.2 A full discussion of this issue would require an exhaustive treatment of the existing institutional arrangements in and out of EMU and consideration of the incentives facing consumers, firms and policymakers to bring this about. These aspects are only touched on briefly here but are dealt with more fully in other EMU studies by HM Treasury, notably Fiscal stabilisation and EMU, EMU and labour market flexibility, and Prices and EMU.

5.3 Here the focus is on using the stylised model to examine how the key adjustment processes in EMU might be modified or enhanced to compensate for the loss of an independent monetary policy.

5.4 To address this issue, it is first useful to revisit the broad principles of OCA theory to clarify the different mechanisms through which an economy might adjust to shocks.

5.5 Consider the possible responses to an increase in the demand for goods produced in the UK relative to those produced in the euro area. This would cause an ex ante gap between demand and supply; a positive output gap. Three broad channels would be available to close the output gap:

- **relative price adjustment**: movements in real wages or price mark-ups relative to overseas competitors can bring about an equilibrating appreciation in the UK-euro area real exchange rate;
- **supply or quantity adjustment**: factors of production can respond. So workers in the euro area might move to the UK to find work and higher wages; previously non-employed workers may choose to re-enter the labour force; or firms may choose to locate additional production facilities in the UK; and
• demand adjustment: consumers and firms may adjust their spending response to a shock. In particular, policymakers may suppress demand via the instruments of monetary or fiscal policy.

5.6 The analysis in Sections 3 and 4 has explained how an independent monetary policy response in the UK outside of EMU only relies on two of these channels to facilitate adjustment:

• by affecting demand via movements in UK nominal, and hence real, interest rates; and

• by affecting relative prices in the short run via the influence of the bilateral euro-sterling nominal exchange rate.

5.7 This suggests that any additional adjustment mechanism inside EMU would be best placed to compensate for the role of an independent monetary policy if it were able to mimic these two characteristics of an independent monetary policy. These types of policy option are considered below.

5.8 But this is not to say that other adjustment channels are not valuable in enabling the economy to respond to shocks. Consider the role of labour mobility. In the original discussions of optimal currency area theory, high labour mobility was deemed to be an important necessary condition of a well functioning monetary union. And the low degree of labour mobility in the UK compared to the US has since been used to suggest that UK membership of EMU might be costly in terms of its ability to adjust to shocks.1 But more recently, some (e.g. Bean, 1992, and Buiter, 2000) have argued that labour mobility cannot be a substitute for an independent monetary policy since it does not operate at the ‘cyclical frequency’. In other words, to the extent that the international supply of labour is responsive to international wage differentials, this is likely to apply to medium-term differences rather than short-term differences over the business cycle.2 So in comparing the US to the EU, it means that, while the US is likely to be a more efficient economy in terms of eliminating long-term unemployment differentials between regions, it does not necessarily mean that the US is more effective as a monetary union because of this.

5.9 This point is particularly important in evaluating empirical evidence on whether the UK economy is sufficiently flexible to join EMU (i.e. relating to the evaluation of the Government’s second economic test for EMU membership relating to flexibility). In particular it highlights the distinction between those characteristics of an economy that might make it perform well in a monetary union, and those characteristics which more generally allow it to deal effectively with shocks.

5.10 Having looked at labour mobility, this section now examines the implications of augmenting different adjustment mechanisms inside EMU. Two main types of adjustment are examined:

• regarding policy adjustment, the role of discretionary fiscal policy; and

• regarding market-based adjustment, the role of price flexibility.

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1 The EMU studies by HM Treasury EMU and labour market flexibility, The five tests framework and The United States as a monetary union discuss this issue in more detail.

2 The presence of considerable costs of relocation would justify this medium-term focus.
The role of fiscal policy

5.11 The stylised simulations so far have embodied the assumption that national finance ministries of EU countries allow the automatic stabilisers to work over the cycle. This involves, for example, counter-cyclical increases in tax receipts as economic activity increases or increases in payments of unemployment benefits during slowdowns. Such an assumption is consistent with the agreed approach to fiscal policy within the EU as described in the Stability and Growth Pact, so long as the resulting fluctuations in the budget balance do not exceed 3 per cent of GDP.

5.12 To understand what role the automatic stabilisers are playing, it is first informative to examine the dynamic response of the model in the absence of this stabilising influence. In the simple stylised model used here, this analysis is straightforward since the strength of the automatic stabilisers is summarised in a single responsiveness coefficient and there are no distinctions in the model between differential effects from taxes and spending. Of course, this is somewhat artificial since tax receipts and unemployment benefits undoubtedly will vary with activity and unemployment. Charts 5.1(a)-(d) illustrate the effects of the same asymmetric demand shock as discussed in Sections 3 and 4 when UK monetary policy is independent. The inflation and output responses are around 25 per cent more volatile, in the absence of the automatic stabilisers.

5.13 This stabilising feature applies for a wide range of policy shocks to the ‘Three Bears’ model although automatic stabilisers may be destabilising in the face of supply-side shocks (see European Commission, 2001b).

5.14 Within EMU, in the absence of a country-specific response from domestic interest rates or in any corrective influence from the bilateral exchange rate, fiscal policy is the only explicit policy instrument available to respond to country-specific shocks. Accordingly, fiscal policy responds more actively. Charts 5.2(a)-(d) illustrate this for the same demand shock. The last section has already illustrated how the macroeconomic responses are more cyclical inside EMU compared to outside. Here, nevertheless, it is seen that the automatic components of fiscal policy tend to play a stabilising role. Indeed, the results are consistent with the theoretical prediction that fiscal policy’s stabilising contribution is enhanced within EMU because there is less of a crowding out effect from UK monetary policy which will tighten by less in EMU.

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1 For an extended discussion of the role of the automatic stabilisers, see European Commission (2002), and for a summary of various empirical estimates of the strength of this influence, see European Commission (2001b) and Dury and Pina (2003). These issues are discussed in greater detail in the EMU study Fiscal stabilisation and EMU.

4 The problem is more complicated in empirical studies using full-scale macroeconomic models where it is necessary to offset the effects of the discretionary items in order to keep some definition of the structural fiscal balance at neutral levels. For slightly different approaches, see Barrell and Pina (2003), European Commission (2002), Cohen and Follette (2000).

3 This occurs because the automatic fiscal response causes tax receipts to rise and unemployment benefits to fall whether the source of the output increase is demand or supply-induced. With demand-induced increases in output, the output gap increases so the associated fiscal tightening is counter-cyclical. But for supply shocks, the output gap falls and the fiscal tightening reinforces this effect. These empirical studies which have included consideration of a wider range of shocks have tended to find a smaller degree of stabilisation from automatic stabilisers compared to those which only consider demand shocks (see Barrell and Pina, 2003).

6 This is predicted by the standard Mundell-Fleming model.
Chart 5.1: Temporary asymmetric demand shocks to UK only: UK outside EMU, different fiscal regimes

(a): Inflation
(b): Output
(c): Real UK-euro area exchange rate
(d): Fiscal policy

- Automatic stabilisers only
- Automatic stabilisers off
- Automatic stabilisers plus feedback on inflation
- Automatic stabilisers plus feedback on inflation and output gap
Chart 5.2: Temporary asymmetric demand shock to UK only: UK in EMU, different fiscal regimes

(a): Inflation

(b): Output

(c): Real UK-euro area exchange rate

(d): Fiscal policy

- Automatic stabilisers only
- Automatic stabilisers off
- Automatic stabilisers plus feedback on inflation
- Automatic stabilisers plus feedback on inflation and output gap
5.15 Since the automatic stabilisers generally play a stabilising role in the face of shocks, the question naturally arises inside EMU as to whether national fiscal authorities might be able to augment the stabilising role of the automatic stabilisers to compensate partially for the loss of the independent monetary policy.

5.16 This possibility raises three questions:

- First, how effective might fiscal policy be in this stabilising role? Since fiscal policy impinges directly on demand, is it feasible that, at least in principle, a suitably designed discretionary counter-cyclical rule might be able to compensate for, or even replicate, the similar counter-cyclical role that a well-designed interest rate rule was able to perform?\(^7\),\(^8\)

- Second, even if fiscal policy could be effective in principle, is it realistic to assume that fiscal policy could be manipulated in this manner?\(^9\)

- Finally, even if it were feasible and effective to implement a discretionary fiscal policy in this way, would the resulting fluctuations in fiscal policy be prevented under the rules of the Stability and Growth Pact?

5.17 Only the first of these issues is considered here. The ‘Three Bears’ model is again used to cast light on how, in principle, a suitably designed discretionary fiscal rule might operate and which assumptions about the workings of the economy are critical in arriving at any conclusions.

5.18 Consider how a stylised discretionary fiscal policy might be designed. Theoretically, since the discretionary element of fiscal policy can be designed to respond to the output gap rather than the output level, and to inflation deviations from target, it seems plausible that fiscal policy might be able to play a more effective stabilising role than the automatic stabilisers above would allow. Box 5.1 explains how this can be modelled.

**Box 5.1: Fiscal stabilisation in the ‘Three Bears’ model**

The default version of the ‘Three Bears’ model specifies that fiscal policy (\(f_t\)) only responds via the automatic stabilisers, as in:

(a) \(f_t = -0.5y_t\),

where the coefficient of 0.5 is chosen to be consistent with the estimates in Van den Noord (2000).

A discretionary rule can also include an explicit counter-cyclical element which might respond to inflation deviations from target (\(dp_t - dp_t^{\text{targ}}\)) and the output gap (\(y_t - y_s\)) as in:

(b) \(f_t = -0.5y_t + af_1(dp_t - dp_t^{\text{targ}}) + af_2(y_t - y_s)\)

where the feedback coefficients \(af_1\) and \(af_2\) would be negative.

To the extent that government spending plans are announced and implemented in nominal terms, subsequent unplanned developments in inflation could have the effect of augmenting the automatic stabilisers via induced changes in real government spending. This effect is not examined here, though the EMU transition scenarios examined in the EMU study *Modelling the transition to EMU* are assumed to be influenced by this effect to a small extent.

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\(^7\) Note that ‘discretionary’ is used here to signify fiscal adjustments over and above the automatic stabilisers rather than in the pejorative sense of ‘discretionary’ policy in the rules-versus-discretion debate. Indeed, discretionary fiscal policy is rule-based in this context.

\(^8\) While fiscal policy might be able to mimic the effect of real interest rates on demand, it is not clear how it can additionally compensate for the absence of the exchange rate shock absorber role.

\(^9\) A particularly important related issue in this context is whether some form of fiscal transfer system within EMU (usually known as ‘fiscal federalism’) might be feasible or effective.
5.19 Charts 5.1 and 5.2 also include the simulated responses when two different versions of these discretionary fiscal policy rules are implemented, first where an additional stabilising response to inflation deviations (with a coefficient of 0.5) has been included, second when a further stabilising response to the output gap is included (again with a coefficient of 0.5).

5.20 Inside EMU, Charts 5.2(a)-(c) show how the mildly oscillatory response of inflation and output in response to the asymmetric demand shock is ameliorated by the rule which actively responds to the cyclical deviations. Indeed, inflation and output deviations under this regime are broadly comparable to those achieved when monetary policy was independent and the automatic stabilisers alone were operating.

5.21 It is open for the fiscal authorities to implement a discretionary fiscal policy outside EMU too. As Chart 5.1 shows, with independent monetary policy and the same activist fiscal rule, inflation and output deviations are now even smaller. So volatility remains higher inside EMU once the same fiscal rule is assumed. Nevertheless, these illustrative simulations are interesting for two reasons:

- they show how judicious use of fiscal policy can go a long way in this model to offset the loss of the independent monetary policy instrument in EMU; and
- they also show that there is potentially scope to adopt this type of approach outside EMU.

5.22 One question begged by this stylised analysis is whether the particular assumptions adopted in the ‘Three Bears’ model are exaggerating the likely effectiveness of fiscal policy as a stabilisation mechanism. There are usually two related strands to this argument:

- first, it is claimed that the uncertainties surrounding the use of fiscal policy as a fine-tuning policy instrument are too great. This relates not only to the imprecision regarding the necessary calculation of the relevant cyclical component of activity but also to the assessment of the time lags and magnitudes involved in the transmission mechanism of fiscal policy. These criticisms certainly have some validity, though it is unclear that these arguments apply any more strongly to the use of fiscal policy than to monetary policy which has been increasingly used as a fine-tuning instrument in inflation targeting regimes; and

- second, modern macroeconomic theory would predict that in a world of rational optimising agents, consumers will be forward-looking and anticipate that any cyclical movement in fiscal instruments will subsequently need to be financed, so offsetting the original effect. This will tend to dampen the Keynesian effects of these measures. Nevertheless, it is important not to exaggerate the importance of this so-called ‘Ricardian’ view in undermining the relevance of the possibility of counter-cyclical stabilisation in EMU:

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10 This relates not only to the appropriate measurement of the output gap but also to an accurate assessment of the national target inflation rate which may differ from the implicit euro area target due to structural reasons, e.g. Balassa-Samuelson effects (see ECB, 1999).

11 The ‘Three Bears’ model is too simple to illustrate this point, but there is an extended discussion of the effectiveness of different fiscal instruments using the European Commission’s Quest model in European Commission (2002). This is a particularly informative vehicle for analysing these effects because of the rigorous approach taken to modelling the behaviour of consumers. For more detail of that model, see Roeger and in’t Veld (1997).
first, there is considerable empirical evidence that consumers are not fully Ricardian, due to the presence of credit constraints, for example; and

second, to the extent that the theory is valid, then the more forward-looking are consumers, the more inherently stable the economy will be. So by smoothing their expenditure responses to shocks, the private sector in effect takes on some of the burden of adjustment to shocks.

The role of market flexibility

5.23 The issue of the possible role for fiscal policy in enhancing the ability of the UK economy to adjust to shocks will be returned to in Section 8. There it will be relevant in evaluating the overall costs associated with adjustment to the full range of possible shocks inside EMU compared to outside.

5.24 The stylised modelling approach has thrown light on how policy action might be used to enhance the responsiveness of the economy to shocks. This raises the question of how private sector behaviour might influence the adjustment mechanism of the economy in the face of shocks.

5.25 Of course, the role of market-based adjustment is a familiar issue originally raised in the literature on optimal currency area criteria. There it was well understood that countries with more flexible markets would be better placed to join a monetary union. Here, it is not implied that UK markets would suddenly change their nature if the UK was inside EMU, rather the question of interest is how the adjustment mechanisms inside EMU would differ if prices responded more flexibly.

5.26 It is difficult to exaggerate the importance of the degree of price flexibility in assessing the costs of EMU compared to an independent monetary policy regime. Monetary policy is generally believed to have short-run real effects precisely because of the presence of wage and price stickiness, i.e. nominal inertia.

5.27 Conventionally, two distinct types of nominal inertia have been postulated:

- structural inertia, caused for example by the overlapping nature of wage contracts (see Taylor, 1980), or by the presence of menu costs in price-setting which make it sub-optimal for firms to adjust their prices continuously (see for example Carlton, 1986); and

- expectational inertia arising from ‘rule-of-thumb’ behaviour by economic agents which implies that private sector agents’ expectations may respond slowly to new information (i.e. more slowly than if they were able to calculate the fully rational model-consistent expectation).

5.28 In terms of the stylised ‘Three Bears’ model of the economy, it is this inertia which motivates the pattern of leads and lags in adjustment of inflation to changes in activity in the simple Phillips curve specification. And it is due to this sticky adjustment of prices that shocks to the model cause temporary activity effects (i.e. a non-zero output gap as demand temporarily differs from supply potential) and temporary deviations of inflation from its target level.

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12 The question of whether firms and workers would have a changed incentive inside EMU to undertake structural reform to make themselves more flexible is discussed in Hughes Hallett and Hougaard Jensen (2001).
To illustrate the central role that price stickiness is playing here, it is informative to focus on the responses to the same simple asymmetric demand shocks as examined earlier (as illustrated in Charts 3.3 and 4.2). But now, the original responses are compared with the analogous responses of an otherwise similar economy but one where prices are perfectly flexible in both the UK and the euro area; the implications of prices in the UK being more flexible than in the euro area will be examined in the next section.

Charts 5.3(a)-(f) illustrate the responses, contrasting the flexible price outcome with the familiar one with sticky prices both for the case when the UK is outside EMU, and for when the UK is assumed to have joined.

Outside EMU, the flexible price responses have a number of important characteristics:

- inflation stays exactly at target and output remains unchanged at potential. This contrasts with the sticky price case where inflation and output rise in response to the demand shock;

- real (and hence nominal) interest rates rise in the UK in response to the original demand shock as in the sticky price case. But the magnitude of this increase is much larger in the flexible price case, threefold for the nominal response;

- the real exchange rate in the UK appreciates relative to the euro area, again by twice as much as in the sticky price case; and

- most importantly, because monetary policy actions are able to keep inflation at target, the real exchange rate appreciation and subsequent depreciation back to base levels is entirely achieved by means of movements in the nominal exchange rate. So intriguingly, as Chart 5.3(a) shows, when prices are more flexible, nominal prices actually move by less than in the sticky price case and all of the burden of adjustment is taken by the nominal exchange rate, as in Chart 5.3(d).
Chart 5.3: Flexible versus sticky prices with asymmetric demand shock: UK outside and inside EMU

(a): Inflation
(b): Output
(c): Real bilateral exchange rates
(d): Nominal bilateral exchange rates
(e): Real interest rates
(f): Nominal interest rates

-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
191715131197531
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
191715131197531
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
191715131197531
-1.0
-0.5
0.0
0.5
1.0
1.5
191715131197531
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
191715131197531

Flexible prices, UK out of EMU
Flexible prices, UK in EMU
Benchmark, UK out of EMU
Benchmark, UK in EMU

Flexible prices, UK out of EMU or in EMU
Now compare those responses with the outcome when the UK is assumed to be inside EMU and prices are flexible. Three key points stand out:

• first, the outcomes for all real variables (output, real interest rates and real exchange rates) will be unaffected by whether the UK is in EMU or not. This simply emphasises the point that all the real costs of EMU (in terms of output volatility, for example) are entirely driven by the degree of nominal inertia in price setting;

• second, since the bilateral UK-euro area real exchange rate equilibrium is identical whether the UK is in or out of EMU, the required real exchange rate adjustment inside EMU must necessarily take place by means of relative price adjustment. The ‘shock-absorbing’ role previously played by the nominal exchange rate is absent. Now, all of the required appreciation of the real exchange rate between the UK and euro area is required to take place in terms of relative price movements. So UK inflation responses in EMU are more volatile in the flexible price case; and

• third, since monetary policy in the enlarged euro area (i.e. euro area plus UK) is set to achieve the inflation target, this will be achieved exactly in the flexible price case. So the required real exchange rate movement implies that inflation in the UK will be temporarily above target while euro area inflation will be below target (though not by as much because of their larger weight in the monetary union).

These predictions arising from the stylised flexible price model have one particularly important implication. For an economy with highly flexible price-setting institutions, EMU membership may lead to more inflation volatility. This raises the question of whether policymakers should be worried about inflation volatility in an environment where the inflation movements may well simply be a manifestation of an efficient adjustment mechanism. This issue will be examined more explicitly in Sections 7 and 8 in the context of empirical attempts to evaluate the costs of EMU.

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13 This relates back to the reference in Section 3 to Blanchard (2001) warning against “demonising inflation”.
6.1 The analysis of Sections 3-5 has deliberately adopted a benchmark version of the ‘Three Bears’ model where all possible behavioural asymmetries in the structure of the model were assumed to be absent. This approach was motivated by three main considerations, all of which are analysed in more detail in the EMU study *EMU and the monetary transmission mechanism*:

- first, there is a good deal of empirical evidence to suggest that the transmission of monetary policy is actually rather similar across EU countries (see for example Ehrmann, 2000 and Ramaswamy and Sloek, 1998);
- second, to the extent that empirically estimated macromodels do show evidence of variations in behaviour, these differences are often found to result from arbitrary differences in equation specification across countries, or from variations in theoretical specification across models (see BIS, 1995, for a comprehensive comparative study of this issue); and
- third, it has been argued that even if there are differences in the behavioural characteristics of EMU, then the very process of EMU may quickly bring about ‘endogenous convergence’ of these structural characteristics (see Frankel and Rose, 1998).¹ Perhaps the best example relates to the behaviour of UK consumers who have been found empirically to be more sensitive to variations in short-term interest rates compared to average behaviour in the euro area. This can be attributed to the history of relatively high inflation in the UK that has led to a greater reliance on floating rate mortgage finance.²

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¹ This is a particular manifestation of the Lucas critique (see Lucas, 1976) that any model estimated under one policy regime, in this case an independent monetary policy, is likely to break down when confronted with an alternative regime, in this case EMU.

² For an extended discussion, see the EMU study by HM Treasury *Housing, consumption and EMU*. 
But to the extent that this characterisation is true, it can be argued that any differences in the preferred means of housing finance, and hence in the sensitivity of consumers to short-term interest rates, would be less, and in the limit would disappear once UK consumers were subject to the same monetary regime as the rest of the euro area.

6.2 Nevertheless, one of the striking conclusions that has emerged from the analysis so far is that even when behavioural asymmetries are assumed to be absent, interesting and important differences are apparent in the adjustment mechanisms of the economy inside EMU compared to outside.

6.3 But what if there are current and prospective behavioural differences in the structure of the UK economy compared to the euro area? This question has been examined more comprehensively elsewhere (see, for example, BIS, 1995). Here it is useful to focus on some of the more plausible asymmetries to see how understanding of the adjustment processes inside EMU might be extended. Two particularly important potential asymmetries are examined; first relating to the sensitivity of demand to interest rates, and second, to the degree of flexibility of prices.

**What if UK demand is more sensitive to interest rates?**

6.4 While it has been argued above that there may be reasons why the sensitivity of UK consumers to short-term interest rates might eventually converge inside EMU, there is nevertheless a range of arguments as to why UK consumers may be more sensitive to interest rates. The EMU study by HM Treasury *Housing, consumption and EMU* examines the important role played by the UK housing market in the transmission mechanism of monetary policy, noting in particular the high relative degree of owner occupation. More recently, UK consumers have increasingly been able to take advantage of their housing equity as a means of consumer credit via mortgage equity withdrawal (for a theoretical justification of this transmission channel, see Aoki *et al.*, 2002). The case for a higher elasticity of UK consumption with respect to short-term interest rates is borne out by empirical estimates of this elasticity (see NIESR, 2003; OEF, 2002; and the contribution by Geoffrey Meen to the EMU study *Submissions on EMU from leading academics*).

6.5 Charts 6.1(a)-(e) and 6.2(a)-(e) below illustrate the simulation responses when:

- the interest rate elasticity in the IS curve is equal to its benchmark value of 0.2 in both the UK and the euro area; and these are compared to
- an alternative where the UK elasticity is assumed for illustrative purposes to be five times higher (i.e. equal to unity).

6.6 Charts 6.1(a)-(e) compare the sets of responses to the asymmetric demand shock to the UK considered in earlier sections.
Chart 6.1: Temporary asymmetric demand shock to UK: illustration of effect of changing interest-rate elasticity in UK's IS curve

(a): Inflation

(b): Output

(c): Real exchange rate

(d): UK real interest rates

(e): UK nominal interest rates

- Interest elasticity of demand = –0.2, UK out of EMU
- Interest elasticity of demand = –0.2, UK in EMU
- Interest elasticity of demand = –1, UK out of EMU
- Interest elasticity of demand = –1, UK in EMU
More cyclical response to asymmetric shock when elasticity is higher

6.7 With independent monetary policy, macroeconomic responses are very similar for both versions of the IS curve. This can be explained by the fact that, outside EMU, the increase in real interest rates in response to the shock is rather moderate, only 0.1 percentage points by the end of the first year. More of the burden of adjustment is taken by the nominal exchange rate.

6.8 Inside EMU, the effect of the stronger interest elasticity is more marked. It was noted in Sections 3 and 4 that the real interest rate channel could become potentially destabilising under EMU in the face of asymmetric shocks (due to the Wicksellian effect on real interest rates); Chart 6.1(a) shows how real interest rates fall by 0.2 percentage points. So the effects of this potential instability become more severe the higher is the degree of interest rate sensitivity. Inflation, output, the real exchange rate and real interest rates all display increased cyclical in their responses in the high-elasticity case. The implications of this in the face of a random sequence of demand shocks (rather than in the face of a single demand shock) are examined empirically in Section 7.

6.9 Charts 6.2(a)-(e) compare the sets of responses to a symmetric positive demand shock, that is a shock not only assumed to hit the UK but also, simultaneously, the euro area.

6.10 As with the responses to the symmetric demand shock described in Section 3, the differences between the results when the UK is assumed to be inside or outside EMU are rather small. But comparing the overall UK responses between the two cases with the different interest rate elasticities, some interesting insights emerge:

- the initial movement in interest rates is largely driven by the effect of the demand shock on output and so is similar across regimes and for different versions of the model. Outside EMU, interest rates are brought back towards base values more quickly in the high-elasticity case since interest rates are more effective in curbing demand. But inside EMU, interest rates are held higher for longer since policy is tailored to the lower responsiveness of the euro area as a whole (see Chart 6.2(e)). So inside EMU, UK output returns to base more quickly – Chart 6.2(b). This in turn impedes the process of bringing inflation back to target levels – Chart 6.2(a);

- the depreciation of the real UK-euro area real exchange rate needs to be larger in the high elasticity case to boost demand by enough to offset the effect of the stronger interest rate response on demand; and

- as with the asymmetric case, the responsiveness of the economy inside EMU is more cyclical in the high elasticity case.

6.11 Consideration of these different types of demand shock under different behavioural assumptions has reinforced arguments developed in Sections 3 and 4:

- the response of output and inflation in the face of a particular shock would not necessarily get more volatile inside EMU compared to outside. Here, in the case of the symmetric shock, interest rates would be moved too strongly for the UK inside EMU when the UK is more interest-sensitive, so the output correction would be more vigorous than would have occurred outside EMU; and

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3 The only difference between that shock and the symmetric demand shock considered here is that the symmetric demand shock is assumed to feed identically into the respective UK and euro area IS curves. The effect of the rest-of-the-world shock depends on the degree of openness and the degree of trade exposure to the rest-of-the-world in the UK and euro area respectively.

4 This effect would be even greater if the assumed policy rule for the UK outside EMU was tailored to the higher interest rate sensitivity of UK output. This would occur because the UK’s independent monetary policy response to the output gap would be smaller than the ECB’s response to the euro area output gap because of the greater effect on output of interest rate charges in the UK.
Chart 6.2: Temporary symmetric demand shock to UK and euro area illustration of effect of changing interest-rate elasticity in UK’s IS curve

(a): Inflation

(b): Output

(c): Real exchange rate

(d): UK real interest rates

(e): UK nominal interest rates

Interest elasticity of demand
-0.2, UK in EMU
-1, UK out of EMU
-1, UK in EMU
-0.2, UK out of EMU
the earlier finding that monetary policy in the UK would tend to ‘under-react’ to UK-specific shocks inside EMU, tending to destabilise the response of real interest rates, would be made worse when the UK interest rate elasticity is assumed to be higher.

What if UK prices are more flexible than in euro area?

6.12 There is considerable anecdotal and empirical evidence that UK product and labour markets are more flexible than those in the euro area (see, for example, Barrell and Dury, 2003). The EMU study EMU and labour market flexibility provides corroborative quantitative and qualitative evidence to the argument that UK labour markets are more flexible. But as already noted, it is important to distinguish clearly between those types of flexibility which improve the level of potential (e.g. by causing the NAIRU to fall) and those which make the economy more flexible in response to shocks around that level of potential.

6.13 Here, as in the previous section, the implications of greater price flexibility will be examined in a simple way. This is done by analysing the response of the economy if prices were to be perfectly flexible. Two variants are examined. First, the UK alone is assumed to have more flexible prices while prices in the euro area are assumed to remain sticky. This allows an examination of the limiting case where the UK is more flexible than the euro area. Second, euro area prices are also assumed to be perfectly flexible (as was previously assumed for the responses shown in Section 5, Charts 5.3(a)-(d)). This is interesting because, by comparing this outcome with the first variant where euro area prices are sticky, it casts light on whether it is better to be more flexible or more symmetric.

6.14 Charts 6.3(a)-(d) illustrate the first variant, again for a temporary UK-specific shock to demand, where UK prices alone are assumed to be fully flexible. The results echo the conclusions arrived at in the previous section where the same shock was examined but the euro area as well as the UK was assumed to be perfectly flexible. Outside EMU, perfectly flexible prices allow the UK to achieve its inflation target perfectly with no variability in the output gap. Any required equilibrating movements in the exchange rate are taken up by shifts in the nominal exchange rate. But once EMU is entered, the situation changes. Output gap variability can still be eliminated, but now relative inflation movements are required to take the burden of greater adjustment. So as Chart 6.3(a) shows, in the face of asymmetric shocks, inflation volatility is actually higher, not only than in the non-EMU case, but also higher than in the sticky price EMU situation.

5 Higher flexibility of ‘out’ countries raises questions of the incentives for those countries to join a less flexible monetary union, and for the member countries to accept new members (see Hughes Hallett and Hougaard Jensen, 2002, for example). These political economy issues are not addressed here.

6 Nevertheless, in practice the contribution of ‘real inertia’ which causes the NAIRU to increase may interact with the dynamics caused by price stickiness (nominal inertia) to make the adjustment to shocks more protracted (see Layard et al., 1991).

7 This approach is also adopted in the EMU study Modelling the transition to EMU in the context of explaining movements in the short-term equilibrium exchange rate.

8 Note also that Chart 6.3(d) shows that the perverse Wicksellian effect on real interest rates disappears inside EMU when prices are sufficiently flexible because UK inflation does not increase.
Comparing the responses in Chart 6.3(a) with those shown in the previous section in Charts 5.3(a), it can be seen that the required inflation adjustment is slightly larger in the case when euro area prices are sticky (i.e. in chart 6.3(a)). This would seem to suggest that the relative degree of price flexibility between the UK and the euro area is relatively unimportant.

But this would be a misleading conclusion because a large relative price adjustment is needed in this case whether euro area prices are sticky or flexible. A more important influence of euro area flexibility on UK responses can be seen, however, when considering the response to a symmetric shock. When the degree of price flexibility is the same in the UK and the euro area, the required relative price adjustment is small because the shock is symmetric. But if price flexibility is high in the UK while prices are sticky in the euro area, the response is more complicated.
Chart 6.4: Temporary symmetric demand shock to UK and euro area: illustration of effect of changing price flexibility in UK and euro area

(a): Inflation

(b): Output

(c): Real bilateral exchange rate

(d): UK real interest rates

(e): Nominal bilateral exchange rate

(f): Nominal interest rates

- UK out of EMU, UK and euro area prices sticky
- UK in EMU, UK and euro area prices sticky
- UK out of EMU, UK prices flexible, euro area prices sticky
- UK in EMU, UK prices flexible, euro area prices sticky
- UK in or out EMU, UK prices flexible, euro area prices sticky
- UK in EMU, UK and euro area prices flexible
6.17 Charts 6.4 (a)-(d) illustrate the responses for the same temporary demand shock as before but now assumed to impinge simultaneously on the UK and the euro area.

6.18 Outcomes are presented for the cases when inside and outside EMU the UK and the euro area are assumed to have sticky prices, when the UK is assumed to have flexible prices but the euro area prices remain sticky, and when both the UK and euro area have flexible prices. The following features of the comparison are noteworthy:

- when both the UK and euro area are assumed to have sticky prices, the inflation and output responses are very similar whether the UK is inside or outside EMU, as would be expected given the symmetric ‘behavioural’ structures of the ‘Three Bears’ model;

- if the UK is assumed to have fully flexible prices, then outside EMU, despite the asymmetry in price setting behaviour, inflation can be controlled perfectly at target with no output costs. With euro area prices still assumed to be sticky, the asymmetry gives rise to a required appreciation in the real exchange rate relative to the euro area (see grey solid line in Chart 6.4(c)). But this is brought about via the nominal exchange rate (with a contribution from changes in euro area prices);

- but inside EMU, fully flexible prices imply that the burden of the same required real exchange rate adjustment must fall on relative prices. And since UK prices respond more readily, UK inflation rises by almost one percentage point in the first year; and

- if euro area prices are assumed to be flexible too, the required movement in the real exchange rate is again small since the shock and the structures of the UK and euro area economies are broadly symmetric. As a consequence, the effect of the shock on UK inflation is minimal.9

**General lessons from study of asymmetric structures**

6.19 There is a tendency in the optimal currency area literature, and indeed in discussion about EMU, to discuss asymmetries in ‘symmetric’ terms. In other words, it is implied that an asymmetry in one direction is just as bad for the appropriateness of EMU membership as an asymmetry in another. But the two examples given in this section show that this is not necessarily the case and suggest that the nature of the asymmetry is relevant to assessing its implication.

6.20 With interest rate sensitivity, it was shown that higher elasticities for the UK could have important implications for macroeconomic prospects inside EMU:

- either because the ECB might react too vigorously to symmetric shocks if the UK were inside EMU; or

- because of the potentially destabilising role that real interest rates can play inside a monetary union in the face of asymmetric shocks. So the lower the interest rate sensitivity of the economy is, or the more forward-looking private sector agents might be, the less harmful this effect might be inside EMU.

9 It is not zero because a small fall in UK inflation offsets a slightly larger increase in euro area inflation to leave the ECB’s inflation rate exactly at target.
6.21 The price flexibility example brought to light a more nuanced message. Again, in considering entry to EMU, it illustrated that policymakers would not be indifferent between situations where prices were more flexible than euro area averages, and one where they were less flexible. If UK prices were more flexible than in the euro area, EMU membership would be likely to imply that the effects of symmetric and asymmetric shocks would show up in inflation volatility. But if prices were less flexible, greater output volatility would be expected because markets are less able to cope with the implications of an inappropriate interest rate. But of the various outcomes, the preferred situation is likely to be one in which both the UK and the euro area are highly flexible. In that case, the UK economy would suffer less output volatility in the face of all shocks, and little inflation volatility in the face of symmetric shocks; but for asymmetric shocks, inflation differentials would still need to bear the burden of adjustment inside EMU, even in the flexible case.

6.22 Having touched on this issue already, this brings to prominence the importance of the relationship between policymakers’ output-inflation preferences and the likely degree of convergence of the economy entering monetary union. The next section tackles this issue directly.
7.1 This study has examined a number of empirical measures designed to shed light on differences in the business cycle behaviour of the UK and euro area economies. And the previous sections have analysed a stylised model of the interaction between the UK and euro area economies in an attempt to disentangle the different influences that may be relevant in evaluating the net costs of EMU membership for the UK. But no attempt has yet been made to evaluate whether, on the basis of the modelling exercise, there would be net macroeconomic costs arising from the single monetary policy if the UK were to join EMU.

7.2 It is worth re-emphasising that these monetary policy consequences are not the only ones to be considered in modelling an overall cost-benefit analysis of the UK’s decision to join EMU. This study has deliberately not considered, for example, the possible welfare gains to be had from a reduction in transaction costs and possible increases in market integration occurring as a consequence. Nor has it considered possible supply-side improvements that may result from EMU. But in economic terms, the ramifications of the single monetary policy for the costs of adjustment to shocks are likely to constitute the most significant potential ongoing costs. So if, for example, these ongoing costs were estimated to be small, this would represent an important argument in favour of EMU membership for the UK. Or if they were large, it would be necessary to consider even more carefully the possible benefits from EMU arising from other channels.

7.3 This section deals with two hitherto unanswered questions:

- How should the expected degree of macroeconomic volatility in the face of a range of plausible shocks under the two different regimes be estimated?
- For a given set of predictions regarding the degree of UK macroeconomic volatility inside EMU compared to outside, how should these adjustment costs be compared?
How should the costs of adjustment to shocks be compared?

7.4 So far in this study, the question of how to evaluate and compare the amount of macroeconomic volatility under different policy regimes has been treated in a rather ad hoc manner. In describing the simulation responses of the stylised model in earlier sections, for example, the results were largely described in qualitative terms. This was appropriate and informative when attempting to gain insight into the key adjustment mechanisms of the economy for particular shocks. But in evaluating the macroeconomic implications of a whole range of possible shocks, a more systematic quantitative approach needs to be adopted. Obviously, if all macroeconomic series became more volatile in moving between policy regimes, then it would be straightforward to conclude that the initial regime was more stable. But in practice, as will be seen, there may be more complicated trade-offs to consider with some variables becoming more volatile and others less volatile.

7.5 Conventionally, macroeconomic performance is often evaluated in terms of a simple quadratic cost function of the form

$$C_T = \sum_{t=0}^{T} \partial \{a(d_{pt_i} - d_{ptarg}^{t+1})^2 + b(y_{t+i} - y_{s\, t+i})^2\}$$

[1]

i.e. a time-discounted, weighted combination of the squared deviations of inflation (dp) from target (dp\textsuperscript{agg}) and output (y) from potential (ys) are summed over some finite time horizon T.\(^1\) This approach is widely adopted and is consistent with the argument, discussed earlier, that macroeconomic volatility has costs that may have implications for the level of real activity.\(^2\) In this study too, the focus of attention will primarily be on inflation and output variability. And in the results that are reported in this and the following section, the implications of EMU membership for the UK will be drawn out in terms of the effects on both inflation and output variability. But no attempt is made here to specify a preferred relative weighting between inflation and output volatility. This is beyond the scope of this study.

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\(^1\) In empirical evaluations, a finite time horizon, T, is necessarily adopted though theoretically, the appropriate time horizon would usually be infinite with a suitable discount factor. In practice, T is typically chosen to be large enough such that the expected volatility in macroeconomic variables has reached its long-run or asymptotic variance. Alternatively, the asymptotic variance itself can be used as the objective function; this measure will be close in value to the original objective function if T is large and the discount function is not too different from unity.

\(^2\) No attempt is made to model the effects of volatility on productive potential in this study.
7.6 But before describing this, it is important to emphasise some of the key features of this specification and to point out some alternative approaches:

- the conventional specification embodies the assumption that the aim of policymakers, in the context of responding to shocks, is to stabilise output around its natural rate rather than attempt to achieve a higher level. If instead, policymakers are assumed to try to achieve an infeasibly high level of output, or to drive unemployment below its natural rate, then an ‘inflationary bias’ will result. Here, the analysis follows Blinder (1998) in assuming that policymakers do not adopt this strategy;

- it is possible to add in to the cost function other macroeconomic variables which may affect economic welfare, for example deviations in unemployment from its natural rate, exchange rate volatility, or interest rate volatility, either in nominal or real terms (see for example Minford, 2001) and sectoral or distributional considerations. The simple two-variable objective function is usually justified on the grounds that the main costs associated with volatility in these additional macroeconomic variables will be reflected in output and inflation volatility; and

- problems arise when examining the costs associated with moving between regimes with different explicit or implicit inflation targets (as may happen in moving from the UK’s inflation targeting regime to EMU, for example). For the purposes of simplicity, this complication is ignored here.

7.7 In fact, most of these complications can be avoided if a more explicit welfare-maximising approach to the policy optimisation problem is taken. This is done in the recently developed dynamic stochastic general equilibrium (DSGE) modelling approach as introduced briefly in Section 2. These models are designed to have rigorous microfoundations in the sense that all behaviour is derived from utility maximising behaviour subject to budget constraints and technological constraints. Accordingly, the objective function for policymakers is naturally defined in terms of the welfare of the representative consumer who maximises utility defined in terms of consumption but where labour effort has disutility.6

7.8 Some authors have attempted to show that the ‘first generation’ ad hoc objective functions described above provide a good approximation to the more rigorous definition of utility. The intuition here is that a policy that minimises inflation and output uncertainty will look very similar (see Woodford, 1999, for the closed economy case and Clarida et al., 2001, for the open economy extension).

7.9 These arguments are relied on here to underpin the focus on inflation and output variability in this study rather than one based on a more rigorous utility-based approach.
7.10 As an aside, it is worth noting that there is one important set of circumstances where the more ad hoc approach may yield misleading conclusions. This occurs when considering the implications of asymmetric (i.e. country-specific) shocks in a world where consumers are able to diversify their wealth holdings, thus lowering their exposure to shocks occurring in their own countries. In the extreme case where consumers are able to take advantage of fully integrated financial markets and where consumers express no bias towards domestically produced goods, consumers will hold claims (in the form of shares) on the output of all countries. Thus consumers in different countries are able to ‘share the risks’ associated with country-specific shocks and so maintain smooth consumption paths in the face of these shocks. This has important implications in the context of the OCA criteria since it implies that asymmetric shocks should not be seen as an obstacle to EMU. In practice, the real world economy is some distance away from this picture of ‘complete markets’ described in theory. This is confirmed by empirical work carried out in a growing risk-sharing literature; see for example Sørensen and Yosha (1998). For this reason, the analysis here does not consider this issue further.\footnote{The EMU study The United States as a monetary union reviews this literature for the US. Other implications of risk-sharing are considered in the EMU studies by HM Treasury EMU and business sectors and EMU and the cost of capital.}

The role of stochastic simulations in evaluating volatility

7.11 Some of the empirical tools described in this study have given a broad indication of what the expected net macroeconomic costs associated with the adjustment to shocks inside EMU compared to outside might be. For example, measures of \textit{ex ante} business cycle convergence give some indication of how well aligned the UK and euro area economies might be in the future. And macroeconomic models, both econometric and calibrated, have illustrated how the UK economy might respond to particular shocks either in or out of EMU. Such exercises are sometimes known as ‘deterministic simulations’ since they involve the simulated response to a shock that is assumed to be known.

7.12 But none of these exercises reveal how the UK might perform in the face of the full range of possible shocks that might hit it. This involves consideration of the stochastic environment; that is where the probability distribution of the possible shocks might be known, but the precise shocks likely to occur at any particular time are not. Fortunately, using the modelling tools that have been described in this study, an attempt can be made to answer this question. Inevitably, these estimates are only as precise as the models and assumptions used to generate them. Nevertheless, by making these assumptions explicit, it provides a powerful tool for exploring the likely scale of these net costs and the possible sensitivities according to different assumptions.

7.13 This technique, whereby macroeconometric models can be used to explore the likely outcomes arising from different policy scenarios, is known as stochastic simulation analysis. The approach is intuitively straightforward and involves two key ingredients:

- first, a model of the behaviour of the economies in question needs to be adopted (eg NiGEM, IMF Multimod, etc.); and
second, a statistical distribution of all relevant shocks expected to hit those economies needs to be postulated. For empirically estimated macroeconometric models, these shocks can be obtained from the residuals of the estimated equations. Ideally, if the estimated equations are well-specified, the residuals will be white noise (i.e. mean zero with no serial correlation).

Obviously, it is important to evaluate the macroeconomic implications of a particular policy regime associated with the full range of possible shocks. For example, simulation response analysis may have revealed that the UK economy can cope relatively easily inside EMU in response to symmetric shocks (vis-à-vis the euro area) but may fare less well in the face of asymmetric shocks. So to understand the full picture, it is necessary to calculate how these different types of shocks interact and how prevalent each type of shock is.

Stochastic simulations are able to do this, as follows:

1. by choosing a random combination of shocks from the estimated or assumed distribution;
2. by subjecting the model to these shocks, one period at a time over the period of interest. This will give one possible outcome (or one ‘realisation’ as it is technically known);
3. by taking repeated drawings from the shock distribution so as to simulate alternative ‘realisations’; and
4. by generating a large number of drawings, so allowing the calculation of the average or expected amount of volatility in any macroeconomic variable such as inflation or output.

Previous empirically – based stochastic simulation exercises

Considering the importance of the question and the relevance of the technique, there have been relatively few attempts to conduct stochastic simulation exercises quantifying the net costs of joining EMU, either in the specific UK case or for European countries more generally. Those studies that examined the problem before EMU was set up tended to predict that there would be an increase in macroeconomic volatility. Examples include the work on the Liverpool models (both the UK and multi-country versions) described in Minford et al. (1993) and an application to the IMF’s Multimod model (another multicountry model) by Masson and Symansky (1993). But an influential study by the European Commission (1990) arrived at the opposite conclusion, suggesting that EMU would lead to more stability.

In practice, unless the whole model has been estimated as a simultaneous system, these shocks do not have a ready economic interpretation as demand or supply shocks. As such, they may have a tendency to be correlated with each other. In practice, too, adjustments often need to be made to estimated residuals to adjust the mean to zero and to remove the autocorrelation.

Cross equation correlations are often captured by the use of ‘bootstrapping’ techniques where, period-by-period, randomly chosen time-slices of residuals are applied to the model. The motivation for this approach is that the set of residuals which actually occurred should accurately reflect the appropriate degree of cross-correlation.

In models where agents are assumed to be forward-looking, it is necessary to shock the model one-period-at-a-time so as to build in the assumption that the shocks in each period are unanticipated. For more details of the need for this stacked-solution technique, see Ireland and Westaway (1990).

The ‘deterministic’ simulations described earlier in the study e.g. the response to an asymmetric demand shock, can be thought of as particular realisations of the shock process.

Note that the expected level of any macroeconomic variable will be the same as that on the forecast base since the shocks are assumed to be normally distributed with mean zero.
More recent studies have been carried out specifically to evaluate the macroeconomic costs or benefits of UK membership. Table 7.1 summarises the main results from these studies.13

**Table 7.1: Recent stochastic simulation results addressing the UK decision to join the EMU**

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<thead>
<tr>
<th></th>
<th>Output Variability</th>
<th>Inflation Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Barrell and Dury (2000)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK inflation targeting out, ECB combined rule (shocks drawn from 1991-97)</td>
<td>1.23</td>
<td>0.75</td>
</tr>
<tr>
<td>UK inflation targeting out, ECB combined rule (shocks drawn from 1993-97)</td>
<td>1.61</td>
<td>0.78</td>
</tr>
<tr>
<td>UK combined rule out, ECB combined rule (shocks drawn from 1993-97)</td>
<td>1.73</td>
<td>0.78</td>
</tr>
<tr>
<td><strong>Minford (2001)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK out: interest rates respond to inflation, output and M0, (shocks drawn from 1986-2000)</td>
<td>1.12</td>
<td>3.12</td>
</tr>
<tr>
<td>More exchange rate instability out</td>
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<td>2.92</td>
</tr>
<tr>
<td>Enhanced fiscal stabilisers</td>
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<td>3.12</td>
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</tbody>
</table>

1 Note, estimated volatility in macroeconomic variables can be reported in different ways. In this section, volatility will usually be defined in terms of standard deviations and all ratios analysing the costs of EMU membership compared with staying out are presented on that basis. In fact, the NIESR results here are defined in terms of root mean squared deviations. Some studies, as in Minford (2001) for example, present volatility in terms of expected variance.

These findings have turned out to be just as ambiguous as the earlier results:

- Barrell and Dury (2000), apply the technique to NiGEM, the global multi-country macroeconometric model utilised in Section 2. They adopt a range of assumptions on UK monetary policy outside EMU14 and on the period from which the stochastic shocks are estimated. They find that inflation variability is predicted to be lower by some 22-25 per cent inside EMU15 while output variability is estimated to be between 23 and 73 per cent higher;16 and

- by contrast, the most recent application of this technique by Minford on the Liverpool model (see Minford, 2001) predicts that both inflation variability and output volatility will increase inside EMU under a range of modelling assumptions. In the main case, inflation is expected to be as much as three times more volatile in EMU while output volatility also rises by around 10 per cent.

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13 This is not intended to be exhaustive. Other studies have also examined this issue. For example, using the National Institute’s model of the UK economy (NiDEM), Blake and Young (1998) predict that EMU membership would imply, with an unchanged fiscal policy regime, a doubling of inflation volatility and a ten per cent increase in the volatility of output growth.

14 In all variants, the ECB are assumed to adopt a ‘combined rule’ whereby nominal interest rates respond to a weighted average of inflation and money GDP relative to some target levels. Outside EMU, the UK are assumed to adopt either ‘inflation targeting’ (i.e. a feedback rule which responds to inflation only) or a ‘combined rule’.

15 The authors also report falls in price-level volatility within EMU which they argue have important beneficial implications for the supply-side of the UK economy.

16 This study has recently been updated in Barrell et al. (2003). These preliminary results suggest that, while the predicted changes in volatility caused by EMU entry are more moderate, the conclusions are broadly similar.
7.19 More detailed descriptions are contained in the original studies and are drawn on in the contributions by Barrell and Minford to the EMU study *Submissions on EMU from leading academics*.

7.20 Although there are many differences between these studies, two particularly striking results seem apparent:

- first, under all assumptions adopted, Barrell and Dury (2000) predict lower inflation volatility in EMU, with higher output variability; and
- second, for all assumptions adopted, Minford finds higher inflation and output variability inside EMU, considerably more in the case of inflation.

7.21 To try to understand the differences between these empirically-based results, it is helpful to return to the simple set of inferences described in the introduction of this study. This explained how, without getting into the specific details of any particular model-related exercise, the following simple principles should guide thinking about the macroeconomic costs of entering EMU:

i for any country entering a monetary union, the loss of the domestic interest rate as an instrument of monetary policy and the loss of the nominal exchange rate as a ‘shock absorber’ would compromise the ability of the economy to respond to shocks;

ii but other adjustment mechanisms may compensate for the absence of an independent monetary policy;

iii and the nature of the transmission mechanism for the country entering monetary union might alter so as to lessen this problem; or

iv some of the shocks impinging on the economy might change their nature, offering a further potential mechanism acting to lessen or even outweigh the costs of inefficient adjustment to other shocks.

7.22 A focus on these simple principles allows some insights to be gained into the model-based results. Three differences between the studies seem most significant:

- the treatment of monetary policy regimes in and out (relating to (ii) above);
- the properties of the macroeconometric models on which the stochastic simulation are run (relating to (i) above); and
- the techniques used to calculate the shocks, in particular regarding the exchange rate shocks (this relates to (iv) above).

Characterisation of monetary policy regimes in versus out 7.23 In evaluating the effects of EMU membership, the comparison is more straightforward if the policy reaction of the UK outside EMU, and of the ECB in EMU is assumed to take the same form (e.g. a Taylor rule).

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17 Minford (2001) and Blake and Young (1998) also conduct sensitivity analysis on the implications of assuming a more activist fiscal policy regime in EMU. This does not alter the main thrust of Minford’s conclusions. Blake and Young, however, predict that output growth volatility would be lower than in the ex ante case outside EMU (without an active fiscal policy regime).

18 Note that because neither set of studies assume that there are any ‘endogenous convergence’ effects upon entering EMU, at least in the main results presented here, (iii) is not considered in attempting to understand the results.
7.24 In fact, for both studies considered here, the evaluation of the effects of EMU membership is complicated by the assumptions adopted.

- In Minford (2001), no explicit policy rule is assumed for the ECB because the exercise is conducted on a single country model of the UK, with ECB policy responses proxied by shocks to the otherwise exogenous ECB interest rate. This may therefore underestimate the extent to which the ECB’s monetary policy response might be able to respond to shocks inside EMU. So the increase in inflation and output volatility predicted in EMU by Minford (2001) may be overestimated.19

- Barrell and Dury (2000), on the other hand, do assume an explicit policy rule for the ECB, but this takes the form of a monetary policy rule which includes some element of price-level targeting20 whereas the UK outside EMU is assumed to target inflation. One consequence is that, for this reason alone, price-level stability may be predicted to be more stable inside EMU21 compared to a regime where the ECB also targets inflation.22 In fact, row 3 of Table 7.1 suggests that this is unlikely to explain much of the fall in inflation variability inside EMU because there is a similarly large fall when the UK is assumed to adopt the same ‘quasi-price-level targeting’ rule outside EMU.23

7.25 Another difference between the NIESR and Liverpool studies is the macroeconomic model on which the stochastic simulations were conducted:

- the NiGEM model adopted in Barrell and Dury (2000) is a large multi-country model where the linkages between countries are contained within the model, and the effect of shocks to different countries can be treated explicitly (for more details, see NIESR, 2003). In terms of theoretical structure, the individual countries are not vastly different from that of the UK in the Liverpool model, each country being based on New Keynesian principles, with nominal inertia in wage and price setting causing slow adjustment back to a well-defined neoclassical long run; and

- the Liverpool model used in Minford (2001) is a single country model of the UK economy where the rest of the world (including the euro area) is treated exogenously, though subject to stochastic shocks. The model has strong neoclassical underpinnings.24 As such, while the model embodies nominal inertia as in NiGEM, it tends to have quicker inflation dynamics than competing empirical models of the UK economy (see Wallis et al., 1987).

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19 This potential shortcoming is shared by Blake and Young (1998) which similarly uses a single country model of the UK economy to evaluate the costs of EMU membership.
20 The ECB is assumed to adopt a ‘combined rule’ which responds to a mixed target of inflation targeting and money GDP targeting. It is the latter element that embodies an element of price-level targeting. Barrell and Dury justify this approach by arguing that the remit of ECB monetary policy is better characterised by a rule with an element of price-level targeting. Accordingly, they do not examine the policy scenario with the ECB adopting an inflation-targeting rule, which would allow the contribution of this assumption on the results to be disentangled.
21 Price level targeting is also likely to imply higher output volatility than under inflation targeting, as in the NiGEM case, though in theory, Svensson (1999) has shown that output volatility can be lower if price flexibility is sufficiently high.
22 Whether this will necessarily imply that inflation is more stable too will depend on the degree of forward-looking pricing behaviour in the model (see Svensson, 1999).
23 The preliminary results reported in Barrell et al. (2003), however, find a larger influence on the results from the specification of the UK’s policy rule outside EMU.
24 The Liverpool model was the first empirical UK model to incorporate forward-looking rational expectations in response to the influential Lucas critique.
It is possible that the greater degree of price flexibility in the Liverpool model may be accounting for the greater degree of inflation volatility inside EMU in that study. The discussion in Sections 5 and 6 has already noted how, in the face of asymmetric shocks in an economy with full price flexibility, the mechanism by which the real exchange rate necessarily adjusts is transferred from the nominal exchange rate outside EMU to the relative inflation rate inside EMU. So since prices are more flexible in the Liverpool model, it seems possible that there will be increase in price and inflation volatility in moving to monetary union (see also the discussion in Minford and Peel, 2002).

But even if this explains why inflation volatility in EMU may be greater according to the Liverpool model, this does not explain why the overall level of inflation volatility actually falls inside EMU in many of the scenarios examined in the NIESR studies.

One alternative explanation is suggested by the conclusions of the earlier deterministic simulation results on the stylised model. There it was shown how, for some shocks, usually those with symmetric or near-symmetric effects on the UK and euro area economies, it was possible that either inflation volatility or output volatility could on average be lower in EMU compared to outside. In fact, experimentation with a range of deterministic shocks on NiGEM itself suggests that this outcome is relatively uncommon, the more typical outcome being that both inflation and output responses would tend to be larger. So this explanation is unlikely to be the whole story.

To get a handle on this key difference, it is necessary to consider additionally the characterisation of the shocks hitting the UK economy in and out of EMU and how they might alter in moving between the two regimes.

In fact, the answer is quite straightforward and intuitively obvious. If it is assumed that the transmission mechanism of the UK economy does not alter upon entering EMU, then the only way that the environment can become less volatile is if the shocks hitting the UK economy become more benign. This may not necessarily be sufficient to overcome the less efficient outcome implied by the single monetary policy in response to those shocks that remain the same, but it should certainly make the EMU outcome less volatile than it otherwise would be.

There are two broad reasons why the shocks hitting the economy are likely to differ inside EMU compared to out:

- first, shocks to UK interest rates will no longer be present. In this specific context, shocks should be interpreted as meaning unexpected deviations of interest rates from their policy rule. Or, to use the terminology of structural VARs described in Section 2, shocks refer to the 'unsystematic' component of policy. As such, they may impart unnecessary volatility to the economy. Of course, once inside EMU, the UK economy will instead be directly influenced by 'shocks' to the ECB interest rate that may be more or less detrimental to

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25 This result may be partly dependent on the maintained assumption that a simple Taylor rule is specified for UK monetary policy outside EMU, and for the ECB inside EMU. The results of the volatility comparison may be different if monetary policy were to be set ‘optimally’ in some sense.

26 To resolve this question systematically, it would be necessary to subject NiGEM successively to different subsets of the stochastic shocks to determine whether particular shocks were causing inflation volatility to fall inside EMU. This would be a resource-intensive exercise.

27 See Artis (2000) and Kontolemis and Samiei (2000) who argue that ‘bad’ monetary policy was partly responsible for macroeconomic volatility in the UK over the 1970s and 1980s.

28 In practice, empirically estimated measures of this unsystematic component may additionally capture more beneficial aspects of interest rate movements that are not adequately captured by simply specified policy rules.
stability. So it is not possible to draw any a priori conclusions about the implications of EMU entry; and

- second, inside EMU, shocks to the bilateral sterling-euro rate will be absent, by definition. So this source of macroeconomic volatility will be removed. But the volatility of the shocks to the UK’s bilateral nominal exchange rate with all other currencies (e.g. sterling-US dollar) will in EMU take on the volatility characteristics of the shocks to the euro’s bilateral exchange rate with that currency (i.e. euro-US dollar). This may be either greater or smaller within EMU. So the overall effect on the volatility of shocks to the exchange rate in effective terms could be positive or negative. And the key point remains that the question of whether EMU can result in higher macroeconomic volatility will hinge importantly on the magnitude and influence of exchange rate shocks. This issue is examined in more detail in the EMU study by HM Treasury *The exchange rate and macroeconomic adjustment*.

7.32 Does consideration of these two classes of shock help to interpret the differing results of the various empirical studies?

- As far as interest rate shocks are concerned, neither set of authors place any emphasis on this feature, so this will not be considered further here.

- Importantly, however, the authors of both sets of studies acknowledge that there is an important role for exchange rate shocks in influencing their respective results.

### The role of exchange rate shocks

7.33 To understand how different assumptions regarding exchange rate shocks may be important, it is necessary to examine how empirical measures of exchange rate shocks might be derived. Box 7.1 considers this technical issue in more detail.

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29 Or, as will be assumed later in this section, it may take on an appropriately weighted average of sterling’s previous bilateral volatility with these currencies and that of the euro, where obviously the weight of sterling is now smaller, here assumed to be 0.2. This is discussed in more detail in Taylor (2002) and in the EMU study *The exchange rate and macroeconomic adjustment*.

30 Of course, any such calculations also require an assumption to be made on whether EMU will additionally change the nature of these underlying shocks if the UK were to join.

31 The stochastic simulation exercise carried out by the European Commission in the One Market, One Money study (see European Commission, 1990) also includes an extensive discussion of alternative treatments of exchange rate shocks.
The key point from Box 7.1 is that observed volatility in the exchange rate can be attributed to two sources. Conceptually, these are clearly distinct, but empirically, the two are very difficult to disentangle, comprising:

- ‘fundamental’ volatility caused by the endogenous response of the exchange rate to real shocks (such as demand and supply); and
- ‘financial market’ volatility that can not be justified by observed economic fundamentals.

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**Box 7.1: Estimating shocks to the exchange rate**

Consider the models of the exchange rate adopted in both the Liverpool and NIESR models. These are based on the UIP (uncovered interest parity) condition, as used in the ‘Three Bears’ model already studied:

\[ e_t^e = e_{t+1}^e + rdif_t - sig_t + u_t^e \]

where \( e_t \) is the exchange rate for some bilateral pair of currencies at time \( t \), \( e_{t+1}^e \) the one-period ahead expectation of the exchange rate at time \( t+1 \), \( rdif_t \) the differential between interest rates in the pair of countries and \( sig_t \) the risk premium which captures constant or slow moving elements of the bilateral risk between two countries (so when country-specific risk is high, interest rates in that country need to be higher). \( u_t^e \) represents the ‘shock’ to the exchange rate, which can be thought of as a time-varying element of the risk premium that captures ‘fad’-based movements in the exchange rate, or changing perceptions about the risk characteristics of different currencies.

To complete the model of the exchange rate, it is necessary to specify how exchange rate expectations are formed. In the stochastic simulation exercises, it is assumed that economic agents are able, at the beginning of period \( t \), to predict correctly the value of the exchange rate next period on the basis of information available to them at that time. So if there were no shocks to any part of the economy during period \( t \), then they would predict the next period’s exchange rate perfectly. But in fact, period by period, they will make errors due to unexpected shocks which cause the exchange rate to move:

\[ e_{t+1}^e = e_{t+1} + u_t \]

\[ = e_{t+1} + u_t^e + u_t^y \]

where \( u_t \) represents a combination of forecast errors due to the presence of the exchange rate noise, \( u_t^e \), as well as forecast errors due to unexpected shocks to any other part of the economy, \( u_t^y \), which will have caused an endogenous response from the exchange rate.

When conducting stochastic simulations on a macroeconometric model, this distinction between the two types of shocks impinging on exchange rate movements becomes crucial:

- the response of the exchange rate to ‘fundamental shocks’, \( u_t^y \), will be predicted by the model itself. So no explicit assumption needs to be made by the modeller; but
- the time series properties of the exchange rate shocks, \( u_t^e \), need to be assumed explicitly, ideally on the basis of their historical behaviour. This is a tricky task empirically. Not only is it necessary to measure \textit{ex ante} exchange rate expectations but also to estimate how much the \textit{ex post} forecast error is caused by the exchange rate shock itself (which is the object of interest) and how much is caused by other shocks.

\[^*\] Different approaches to this problem were discussed in Annex E of the European Commission study (European Commission, 1990).
In the context of model-based stochastic simulations, the distinction is crucial. An explicit assumption about the stochastic properties of the ‘financial market’ shocks needs to be made by the modeller. But the endogenous response of the exchange rate to ‘fundamental’ shocks should be automatically generated by the model.32

The NIESR and Liverpool studies approach the estimation of these exchange rate shocks in different ways:

- the NIESR study circumvents this problem by effectively assuming that all the ex post failure of the UIP condition is caused by exchange rate noise (i.e. by $u_t$ as defined in Box 7.1);
- Minford (2001), on the other hand, assumes that the distribution of exchange rate shocks is based on the stochastic distribution of the exchange rate itself.33

Perhaps as important as the method used to estimate the shocks is the historical time period from which the shocks are estimated:

- Minford argues that on average, over the last 20 years, sterling-US dollar shocks have been negatively correlated with sterling-euro shocks, so tending to offset each other in their effect on the sterling effective exchange rate. At the same time, Minford estimates that euro-dollar shocks have been more volatile still. So once in EMU, when sterling would take on the historical volatility of the euro vis à vis the dollar, this would imply an overall increase in the volatility of shocks to sterling in effective terms;
- the NIESR study estimates the shocks over a more recent time period, the early to late 1990s only,34 when shocks to sterling in general may have tended to be more volatile than those affecting other bilaterals such as euro-dollar. If these assumptions are assumed to condition the behaviour of future exchange rate shocks if the UK were to join EMU, then the UK effective exchange rate would benefit from much more benign shocks than when it had been outside.

Both these sets of judgements on estimation method and sample period are likely to be important in affecting the conclusions:

- if the estimated exchange rate residuals have not satisfactorily disentangled the noise component (which is required) from the fundamentals component (which is not) then the resulting stochastic simulation results will wrongly impart volatility directly to the exchange rate, when in fact, the relevant fundamental shocks are already being taken into account in the exercise. So the effects will be double-counted; and
- even if it is possible to estimate the shocks appropriately over the past, heroic assumptions are required on the likely stochastic behaviour of these risk premium effects if the UK were to join EMU.

32 In general, too, the definition of what constitutes a ‘fundamental’ shock will likely differ across models.
33 As European Commission (1990) discuss, the change in the exchange rate will only approximate the shocks when expectations are based on a random walk model.
34 Using a sample period based on the 1990s, Table 7.1 shows that the NIESR results are affected by starting the sample in 1991 or 1993, presumably reflecting the importance of including or excluding the episode of sterling’s exit from the ERM in 1992.
Other approaches are available to distinguish between the different influences on exchange rate movements. One potentially powerful approach is provided by structural VAR techniques (already described briefly in Section 2). Inevitably, these methods too rely on a host of underlying assumptions but they at least attempt to account systematically for the different types of shocks to which exchange rates might respond. This approach is discussed briefly in Box 7.2 but is examined more thoroughly in the EMU study The exchange rate and macroeconomic adjustment. There it is suggested that, although the empirical evidence is not overwhelming, the balance of evidence tends to suggest that a non-negligible proportion (and in some studies, the majority) of exchange rate volatility has been caused by ‘fundamental’ shocks rather than by ‘extraneous’ noise.

Box 7.2: The role of SVARs in identifying the shocks which cause exchange rate movements

In an influential study, Clarida and Gali (1994) used an SVAR-based approach to suggest that movements in the dollar were largely driven by shocks to real demand (e.g. to fiscal policy, foreign trade or consumer preferences). Astley and Garrett (1998) subsequently replicated these findings in the case of sterling. The implicit conclusion was that exchange rates tended to be moving in response to shocks rather than as an exogenous source of noise.

Confusingly, however, an alternative strand of research findings using very similar techniques has tended to arrive at the opposite conclusion. Research by Artis and Ehrmann (2000) takes the contrary view (see also Canzoneri et al., 1996, Funke, 2000, and Thomas, 1997 for similar approaches). They argue that most exchange rate fluctuations can be explained by nominal shocks associated with exchange rate risk premia that ought to disappear inside EMU strengthening the case, other things equal, for EMU.

In an attempt to resolve this puzzle, Labhard and Westaway (2002) apply the techniques of Clarida-Gali and Artis-Ehrmann to a common dataset and over a common sample period. Importantly, they find that the conflicting message remains, implying that the different conclusions obtained depend on the technique adopted, not on differences in the dataset adopted.

To investigate which technique is more reliable, Labhard and Westaway (2002) adopt a stylised model similar to that adopted in this paper. For a given calibration of the model, and for given assumptions about the properties of the shocks, a stochastic simulation is performed in order to generate a quasi-history of data. The advantage of these data series compared to the real data is that the true contribution of exchange rate shocks to the movements in macroeconomic variables is exactly known. They then apply the techniques of Clarida-Gali and Artis-Ehrmann to uncover which approach most accurately reproduces the true model. Interestingly, they find that Artis-Ehrmann has a tendency to overexaggerate the contribution of exchange rate shocks, while Clarida-Gali has a tendency to be inaccurate when the countries under consideration are highly asymmetric.

On balance, the SVAR-based evidence tends to support that there is a significant shock-absorbing role for the exchange rate. So any empirical approach which implicitly assumes that exchange rate volatility is largely caused by ‘extraneous shocks’ may over-exaggerate the degree of volatility arising directly from speculation in financial markets.

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*Primarily to real demand shocks.

*In practice, ‘nominal shocks’ comprise a mixture of exchange rate risk-premium shocks and unsystematic interest rate shocks. Artis and Ehrmann (2000) use a technique devised by Smets (1997) to disentangle the two based on an assumed contemporaneous response of the monetary authorities to exchange rate changes.

*The EMU study The exchange rate and macroeconomic adjustment replicates this result.
8.1 The analysis of the previous section goes some way to reconciling the apparently conflicting conclusions to be drawn from stochastic simulations carried out on empirically estimated macroeconometric models.

8.2 But as an additional aid to understanding the problem, it is also useful to examine the predictions of stochastic simulation exercises carried out on the stylised ‘Three Bears’ model developed and analysed in Sections 3-6. There, the stylised responses to particular shocks gave some generic insights into the adjustment mechanisms inside and outside EMU. Here too, this approach can be used to disentangle the effects of different modelling assumptions on the overall conclusions of the stochastic simulations.

8.3 There are a number of advantages to using the stylised model:

- the shocks to the stylised model have well-defined economic interpretations in terms of demand shocks, supply shocks, monetary policy shocks and exchange rate shocks; and
- it is straightforward to implement the assumption that particular shocks are symmetric or asymmetric. By contrast, estimated equation residuals in empirical macroeconometric models may be difficult to interpret.

8.4 Of course, the major disadvantage with using a calibrated stylised model is that the stochastic properties of the different shocks are not readily available. In the illustrations that follow, this problem is confronted in two stages:

- first, the contribution of each type of shock to inflation and output volatility is presented for a unit variance shock. Even without empirical estimates of their relative size and frequency, this can provide relevant information on the potential impact of different types of symmetric and asymmetric shocks and on how their relative contribution varies according to the calibration of the model; and
- second, the building blocks developed in the first stage will be weighted together according to a range of empirical estimates of the actual shocks estimated according to structural VAR analysis. With this additional information, broad conclusions will be drawn on the likely net macroeconomic costs of entering EMU not only for our benchmark calibration but also for plausible alternative scenarios.
8.5 It should be emphasised that the objective of this approach is not to derive a superior set of stochastic simulations to those from the studies discussed in Section 7. Rather it is intended as an aid to the interpretation of the results from this type of exercise. Nevertheless, this approach does allow tentative conclusions to be drawn from the ‘Three Bears’ model as to how macroeconomic volatility is likely to be affected if the UK were to enter EMU. But these conclusions will be conditional on particular assumptions about the properties of the stylised model and conditional on the particular pattern of shocks assumed to be impinging on the model. Since the underlying model and shock processes are only relatively crudely calibrated, it is therefore important to examine the effects of varying key assumptions, either about the model or the shocks. This will help to illustrate the robustness of the conclusions to different features of the exercise.

Results for the benchmark calibration on a shock-by-shock basis

8.6 Table 8.1 below provides estimates of the predicted degree of volatility in inflation and output first outside EMU, then inside, in the face of unit variance shocks to each of the four different kinds of disturbance allowed for in the ‘Three Bears’ model:1

- demand shocks (comprising shocks specific to the UK, the euro area and the rest of the world, as well as a shock symmetric to the UK and the euro area);
- supply shocks (comprising shocks which are UK-specific, euro area-specific and symmetric to both);
- exchange rate shocks (outside EMU comprising shocks to the risk-premium associated with sterling, the euro and the rest-of-the-world (ROW) currency respectively, the latter being symmetric shocks to sterling and the euro); and inside EMU comprising shocks to the euro-ROW bilateral exchange rate, where the euro-specific shocks are a weighted average of the previous sterling and euro area shocks); and
- monetary policy shocks (comprising shocks specific to the UK policy rule, shocks specific to the ECB policy rule and shocks symmetric to both when the UK is outside EMU, and shocks to the ECB rule only when inside EMU).

8.7 At this stage, these results are derived using the benchmark version of the model where the only asymmetries in the structure between the UK and euro area arise because of differences in trade patterns and the degree of openness.

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1 The results are generated for each shock by calculating the estimated long-run, or asymptotic, standard deviations derived from running 100 antithetic simulations, i.e. 200 in total, where for each stochastic simulation, the opposite (i.e. negative) shocks are applied in a second run. The shocks are assumed to be unexpected each quarter, so the stochastic simulation must be solved using a stacked solution technique (see for example, Ireland and Westaway, 1990). Each simulation was run for 80 quarters, with the shocks applied for the first 60. The long-run standard deviation was calculated by averaging the estimated standard deviation at all time periods to which shocks were applied, excluding the first 20 periods when the model responses had not reached their steady state. Larger numbers of replications were found to give minimal improvements in the estimates of the asymptotic standard deviation.
**Table 8.1: Long-run volatility comparison of EMU versus non-EMU regimes for UK: ‘Three Bears’ model**

- all identified shocks
- symmetric version of ‘Three Bears’ model

<table>
<thead>
<tr>
<th></th>
<th>UK outside EMU</th>
<th>UK in EMU</th>
<th>Ratio in/out</th>
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<tbody>
<tr>
<td></td>
<td>Inflation</td>
<td>Output gap</td>
<td>Inflation</td>
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<tr>
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<td>0.38</td>
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<td>0.06</td>
<td>0.05</td>
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<td><strong>Supply shocks</strong></td>
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<td>$</td>
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<tr>
<td>Symmetric</td>
<td>0.22</td>
<td>0.16</td>
<td>0.22</td>
</tr>
</tbody>
</table>

8.8 How should these results be interpreted? Of course, without having information on the relative frequency of different types of shocks, it is not possible with this information to come up with a firm model-based estimate of the overall costs associated with shocks inside and outside EMU with this structure of the model. Even so, the results are very informative, building on the insights already gained from the deterministic simulations.

8.9 The following points seem particularly important:

- for all asymmetric shocks, with the obvious exception of those which will actually disappear inside EMU, the long-run level of output and inflation variability always increases inside EMU. This is particularly marked in the case of shocks specific to the euro area which, outside EMU, would be predicted to have rather small effects on the UK, but inside EMU would induce interest rate charges unnecessary from the UK perspective. These results are entirely consistent with the results of the deterministic simulations which similarly showed a deterioration in performance in the face of asymmetric shocks;

- in particular, it was noted with the deterministic simulations of UK-specific shocks that price level stability and potentially inflation stability could be enhanced for UK-specific shocks inside EMU. This result emerged because of the quasi-price-level targeting properties under EMU; that is, for shocks where the long-run real exchange rate is unchanged, the UK price level needs to be brought back to euro area levels, whereas with independent monetary policy, the price level could ‘slip’ due to the nominal exchange rate shock absorber role. But in the stochastic simulations, the potentially beneficial impact on inflation is overwhelmed by the deterioration in the ability of ECB interest rates to control UK inflation;

- in the case of symmetric shocks, the results are somewhat more nuanced, usually implying a small change in the trade-off between output and inflation variability, rather than an outright deterioration, in EMU. Again, these results are consistent with those shown in the earlier deterministic simulations (see for example Charts 3.2(a)-(d)); and
as expected, shocks to the sterling-euro risk premium and to the UK interest rate policy rule both incur costs for the UK economy in the regime where interest rates are set autonomously, but are much smaller in EMU (disappearing completely in the case of policy shocks and having a much smaller contribution to exchange rate volatility in the case of the sterling shocks).2

Sensitivity analysis of the stylised stochastic simulation results

8.10 To stress test these results, it is useful to compare them with a number of alternative calibrations of the model, along the lines of the earlier robustness checks in Sections 5 and 6, to highlight the potentially important role of different structural assumptions and different asymmetries which may be more relevant for the UK-euro area comparison than has been assumed so far. Here the sensitivity analysis will be carried out on the following aspects:

- the role of trade-related asymmetries (Table 8.2);
- the role of the interest-sensitivity of demand (Table 8.3);
- the role of price flexibility (Table 8.4);
- the possibility of an enhanced role for fiscal policy as an additional adjustment mechanism inside EMU (Table 8.5); and
- the sensitivity of results to different assumptions about exchange rate shocks (Table 8.6).

8.11 First consider the role of those structural asymmetries that remain in the benchmark version of the ‘Three Bears’ model used so far. These are related to differences in the degree of openness between the UK and the euro area, and to differences in their respective trade patterns with each other and the rest of the world. As the results in Table 8.1 have already shown, the influence of these asymmetries is rather minor since the inflation and output consequences of symmetric shocks are rather similar whether the UK is assumed to be in or out of EMU. This is confirmed by Table 8.2 below which shows the consequences of removing the trade-related asymmetries altogether:3

- as expected, the predicted macroeconomic costs would be identical in and out of EMU in the face of symmetric demand shocks; and
- for asymmetric demand shocks, the relative increase in inflation volatility improves slightly in EMU (the ratio is 0.97). The increase in output volatility is now less severe inside EMU but still increases by 28 per cent in EMU despite the symmetry of the structures of the model.

---

2 The effects of the sterling risk premium do not disappear altogether in EMU because of the maintained assumption that once the UK joins EMU, shocks to the euro are a weighted average of those to the old euro currency and the previously improving on sterling where sterling has a weight of 20 per cent.

3 This is done by making the degree of UK and euro area openness equal at 0.25 (the average of their respective values in the benchmark), the relative trade intensities equal at 0.5, and the share of import prices in the domestic consumer price equation to be equal at 0.85. So the comparison with the asymmetric case is affected both by the removal of the asymmetries and the change in the degree of openness in the UK.
Table 8.2: Long-run volatility comparison of EMU versus non-EMU for UK: ‘Three Bears’ model

- Demand shocks
- Symmetric versus benchmark version of ‘Three Bears’ model

<table>
<thead>
<tr>
<th>Model version</th>
<th>Shock type</th>
<th>UK outside EMU</th>
<th>UK in EMU</th>
<th>Ratio in/out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inflation</td>
<td>Output gap</td>
<td>Inflation</td>
</tr>
<tr>
<td>Symmetric</td>
<td>Symmetric</td>
<td>0.42</td>
<td>0.38</td>
<td>0.42</td>
</tr>
<tr>
<td>Benchmark</td>
<td>Symmetric</td>
<td>0.38</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>Symmetric</td>
<td>UK shock</td>
<td>0.30</td>
<td>0.33</td>
<td>0.29</td>
</tr>
<tr>
<td>Benchmark</td>
<td>UK shock</td>
<td>0.23</td>
<td>0.32</td>
<td>0.30</td>
</tr>
</tbody>
</table>

8.12 In fact, the benchmark calibration of the stylised model was partly chosen to highlight the richness of the contrast in dynamic responses inside EMU compared to out, even without large behavioural asymmetries. But, as in Section 6, it is interesting to examine how additional asymmetries, possibly reflecting more plausible assumptions than embodied in the benchmark case, might affect the stylised results. Table 8.3, for example, illustrates the implications of modifying the benchmark calibration by assuming that the interest-rate elasticity of demand in the UK is twice as high as in the euro area.

Table 8.3: Long-run volatility comparison of EMU versus non-EMU for UK: ‘Three Bears’ model

- Demand shocks
- Variations in degree of interest-rate sensitivity of IS curve

<table>
<thead>
<tr>
<th>Model version</th>
<th>Shock type</th>
<th>UK outside EMU</th>
<th>UK in EMU</th>
<th>Ratio in/out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inflation</td>
<td>Output gap</td>
<td>Inflation</td>
</tr>
<tr>
<td>Interest elasticity doubled in UK IS curve</td>
<td>Symmetric</td>
<td>0.35</td>
<td>0.36</td>
<td>0.35</td>
</tr>
<tr>
<td>Benchmark</td>
<td>Symmetric</td>
<td>0.38</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>Interest elasticity doubled in UK IS curve</td>
<td>UK shock</td>
<td>0.23</td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td>Benchmark</td>
<td>UK shock</td>
<td>0.23</td>
<td>0.32</td>
<td>0.30</td>
</tr>
</tbody>
</table>

8.13 The stochastic results are consistent with the simulation responses in the face of symmetric and UK-specific demand shocks described in Section 6:

- for symmetric shocks, the implication of a higher interest-rate elasticity in the UK is that, if the UK were in EMU, the ECB would over-compensate for symmetric shocks from the UK’s perspective. So inflation and output volatility would improve slightly inside EMU; but

- for UK-specific asymmetric shocks, the UK’s higher interest rate sensitivity worsens the ‘Wicksellian’ instability described in Section 4, so inflation and output volatility deteriorate inside EMU.

8.14 Earlier sections have already highlighted the crucial role that price flexibility plays in determining the potential costs of EMU. Broadly, it has been shown that the more flexible are prices, then the less volatile will output become relative to potential. Outside EMU, increased price flexibility allows the monetary authorities to target inflation more accurately, but inside EMU, inflation deviations will tend to increase as relative prices are forced to take the short-term burden of relative price adjustments.
8.15 Table 8.4 below compares the predictions for inflation and output variance results on the benchmark model with results for two alternative versions of the model, first when the UK is assumed to be more flexible than the euro area by having a greater degree of forward-lookingness in price-setting, then in a more extreme case where UK prices are assumed to be fully flexible.

<table>
<thead>
<tr>
<th>Table 8.4: Long-run volatility comparison of EMU versus non-EMU for UK: ‘Three Bears’ model</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Demand shocks</td>
</tr>
<tr>
<td>• Variations in degree of price flexibility</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model version</th>
<th>Shock type</th>
<th>UK outside EMU</th>
<th>UK in EMU</th>
<th>Ratio in/out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inflation</td>
<td>Output gap</td>
<td>Inflation</td>
<td>Output gap</td>
</tr>
<tr>
<td>UK fully flexible</td>
<td>Symmetric</td>
<td>0.00</td>
<td>0.00</td>
<td>1.17</td>
</tr>
<tr>
<td>UK and euro area fully flexible</td>
<td>Symmetric</td>
<td>0.00</td>
<td>0.00</td>
<td>0.15</td>
</tr>
<tr>
<td>UK Phillips curve more forward-looking Benchmark</td>
<td>Symmetric</td>
<td>0.26</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>Symmetric</td>
<td>0.38</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>UK fully flexible</td>
<td>UK shock</td>
<td>0.00</td>
<td>0.00</td>
<td>1.29</td>
</tr>
<tr>
<td>UK and euro area fully flexible</td>
<td>UK shock</td>
<td>0.00</td>
<td>0.00</td>
<td>1.09</td>
</tr>
<tr>
<td>UK Phillips curve more forward-looking Benchmark</td>
<td>UK shock</td>
<td>0.19</td>
<td>0.28</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>UK shock</td>
<td>0.23</td>
<td>0.32</td>
<td>0.30</td>
</tr>
</tbody>
</table>

8.16 In both cases, the results are consistent with the principles described in earlier sections:

- if price-setting in the UK is more flexible (here captured by a greater weight on forward-looking expectations in the Phillips curve, i.e. 0.75 compared to 0.25 in the benchmark case and in the euro area), then the less volatile is inflation and output, in or out of EMU. This is an important result in the context of the flexibility test, the second of the Government’s five economic tests, because it implies that more flexibility may be preferred even if it implies greater structural asymmetry with the euro area; but

- the greater degree of price flexibility does imply that inflation volatility in the face of symmetric shocks would increase by more upon UK entry to EMU compared to the benchmark case (though the increase in inflation volatility would be smaller for asymmetric shocks);

- in the limiting case where price flexibility in the UK is complete, EMU membership would imply a huge increase in inflation volatility since inflation differentials would take on all of the burden of relative price adjustment; but

- this increase would be greatly reduced if it were additionally assumed that prices in the euro area were also fully flexible. Under that assumption, the increase in inflation variability is much less than when the UK alone was flexible.

The benefits of discretionary fiscal policy inside EMU 8.17 One important issue discussed in Section 5 is the extent to which UK fiscal policy action might be enhanced inside EMU to compensate for the loss of an independent monetary policy. Table 8.5 compares the benchmark results with a case where a stylised discretionary fiscal policy is adopted, i.e. where the automatic stabilisers are augmented by a response to inflation and output deviations. Three clear messages emerge, again consistent with the conclusions drawn from the deterministic simulations in Section 5:
inflation and output volatility could be lowered, inside or outside EMU, by the more active use of discretionary fiscal policy action 4 (where, as in the earlier section, it is important to emphasise the caveat that the discretionary fiscal rule and its effectiveness is characterised in a stylised way 5);

on assuming that fiscal policy would be available inside EMU as well as out, inflation and output volatility would increase upon EMU entry (by 5 and 18 per cent respectively) but this would be less than the predicted deterioration (of 30 and 38 per cent respectively) when no compensating fiscal policy action was assumed; and

since fiscal policy in the UK’s is not currently characterised by an active role for discretionary fiscal policy, it may be more relevant to compare the results outside EMU without fiscal policy with the performance inside EMU with discretionary fiscal policy. On this basis, inflation and output volatility would be very similar inside and outside EMU. So, under these stylised assumptions at least, fiscal policy inside EMU can effectively mimic the effects of monetary policy outside EMU.

### Table 8.5: Long-run volatility comparison of EMU versus non-EMU for UK: ‘Three Bears’ model

<table>
<thead>
<tr>
<th>Model version</th>
<th>Shock type</th>
<th>UK outside EMU</th>
<th>UK in EMU</th>
<th>Ratio in/out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inflation</td>
<td>Output gap</td>
<td>Inflation</td>
</tr>
<tr>
<td>Augmented fiscal</td>
<td>UK shock</td>
<td>0.19</td>
<td>0.28</td>
<td>0.20</td>
</tr>
<tr>
<td>policy for UK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benchmark</td>
<td>UK shock</td>
<td>0.23</td>
<td>0.32</td>
<td>0.30</td>
</tr>
</tbody>
</table>

8.18 Given the importance attributed to the role of exchange rate shocks in the discussion of the previous stochastic simulation studies discussed in Section 7, it important to examine the implications of making different assumptions regarding exchange rate shocks when running stochastic simulations in the ‘Three Bears’ model.

8.19 The results for exchange rate shocks shown in Table 8.1 were conditioned by the simplifying assumption that three independent shocks could impinge directly on exchange rates when the UK was assumed to be outside EMU. These shocks were assumed to be associated with UK-specific risk, euro area-specific risk and rest-of-the-world-specific risk respectively. 6 And once the UK was assumed to be inside EMU, shocks to the augmented euro area (i.e. the previous euro area plus the UK) were assumed to comprise a weighted average of the previous UK and euro area shocks (where the UK was assumed to have a weight of 0.2).

8.20 But even given the constraints imposed by the ‘Three Bears’ model of a world of three country blocks, this may be a serious over-simplification. One possibility, already discussed in the context of describing the results of Minford (2001), is that exchange rate shocks rather than being independent may be positively or negatively correlated. For example, it has been
observed that over certain periods, movements in the sterling-euro and the sterling-dollar exchange rate have tended to be negatively correlated, so offsetting each other in their effect on sterling’s effective exchange rate. Table 8.6 compares the implications for inflation and output volatility of making this alternative set of assumptions. Since these results are closely related to the discussion on exchange rate volatility in the EMU study *The exchange rate and macroeconomic adjustment*, supplementary information on the variation in the real sterling-euro and sterling effective exchange rate is included in columns of Table 8.6.

8.21 The contrast with the previous results in the benchmark case is striking:

- with the previous results where shocks to sterling were assumed to be UK-specific, outside EMU these caused volatility in UK inflation and output. But these were predicted to be greatly reduced inside EMU, by over 80 per cent.\(^7\) And their contribution to real exchange movements was also predicted to be largely eliminated (with movements in the nominal sterling-euro exchange rate, of course, completely eliminated); and

- but when sterling-euro and sterling-US dollar shocks are assumed to be negatively correlated, the picture is reversed. Outside EMU, the shocks to sterling would tend to offset each other in their effects on the sterling effective exchange rate, so inflation and output volatility would be more than halved compared to the benchmark case. But once the UK enters EMU, sterling would ‘inherit’ the previous greater euro-US dollar volatility.\(^10\) The result is that inflation and output volatility would now double inside EMU and the real effective exchange rate would increase in volatility despite the elimination of nominal sterling-euro fluctuations.

### Table 8.6: Long-run volatility comparison of EMU versus non-EMU for UK: ‘Three Bears’ model

<table>
<thead>
<tr>
<th>Model version</th>
<th>Shock type</th>
<th>UK outside EMU</th>
<th>UK in EMU</th>
<th>Ratio in/out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Output gap</td>
<td>Real (£-€)</td>
<td>Real (£) eff.</td>
</tr>
<tr>
<td>Benchmark</td>
<td>(£-€) and (£-)</td>
<td>0.10</td>
<td>0.04</td>
<td>0.59</td>
</tr>
<tr>
<td>Benchmark</td>
<td>(£) shocks independent</td>
<td>0.26</td>
<td>0.13</td>
<td>0.51</td>
</tr>
</tbody>
</table>

---

\(^7\) It is worth repeating the point from the earlier discussion that the observed stochastic behaviour of a particular exchange rate will be generated by both fundamental shocks and by direct shocks to the exchange rate (See Box 7.1). It is only the effect of the latter that is captured by the ‘exchange rate shocks’ row in Table 8.1 and Table 8.6.

\(^8\) These two sets of assumptions are also intended to characterise, albeit rather crudely, the respective assumptions regarding exchange rate shocks made in the two empirically-based stochastic simulation exercises examined in Section 7.

\(^9\) It is not eliminated completely because the original sterling shocks are still assumed to impinge on the euro, but with a lower weight of 20 per cent.

\(^10\) If the variance of shocks to \(£-€\) and \(£-\) are both unity, and if they have a covariance of -1, then in a three-country world, the variance of \(€-\) will be double that of either of the sterling bilaterals.
An attempted calibration for all shocks

8.22 The preceding discussion of the stylised stochastic simulation results has so far deliberately stopped short of attempting to ‘add together’ the results for the effects of different shocks.\(^\text{11}\) Ultimately, however, policy conclusions can only be drawn on the basis of considering the likely response of the UK economy in the face of all the shocks that are likely to hit, in or out of EMU. So in the final part of this section, an attempt is made to estimate how important different types of shocks might be, in aggregate, for the UK economy, as depicted in the stylised ‘Three Bears’ model.

8.23 This calibration of the shocks is based on an empirical calibration of the shocks derived from the SVAR analysis already described in Section 2. Box 8.1 describes in detail how this is done. The two key stages to the calibration are:

- estimation of the respective contributions of demand, supply and nominal (policy and exchange rate) shocks to the average of output and inflation volatility in the UK. The analysis suggests that the average split is roughly 50 per cent from demand shocks, 40 per cent from supply shocks and 10 per cent from nominal shocks; and

**Box 8.1: Empirical calibration of shocks in the ‘Three Bears’ model**

Since the ‘Three Bears’ model adopted in this study is calibrated rather than empirically estimated, estimation residuals are not available as they would be with the econometrically estimated models employed in the empirical stochastic simulation exercises described in Section 7.

Instead, an SVAR model of the UK economy based on Gerlach and Smets (1995), as described in Section 2, is estimated. This is used to calculate the relative contribution that different structural shocks have made over the past to UK inflation and output volatility. Two stages are required:

(i) Compute the historical variance decomposition (see Enders, 1995) to derive the relative contribution of real demand shocks, supply shocks and nominal shocks. The results suggest that the split is roughly 50-40-10 for average inflation and output volatility.

The SVAR analysis considered here does not allow an explicit decomposition of the shocks into symmetric and asymmetric components, or for any shocks implying more complicated covariance with the euro area shocks. Indeed, one shortcoming of the SVAR analysis is that it is designed to reveal the ‘average’ response to a generic-demand or supply shock and does not usually allow the different types of symmetric and asymmetric shocks to be distinguished. Nevertheless:

(ii) The problem is addressed in the second stage of the calibration by assuming that the average correlation coefficient of the estimated UK and euro area shocks (as shown earlier in Chart 2.5) gives a rough proxy for the degree of symmetry of the shocks. This is estimated to be roughly a half.

It should be emphasised that this is a highly crude measure, since the revealed correlation coefficient for all types of shocks has varied greatly over the most recent 20 years, having had periods when the correlation was higher, but a period during the 1990s (arguably in the wake of German reunification) when the correlation was negative.

For this reason, an alternative assumption where the proportion of symmetric shocks is much higher, at 0.8, is also assumed in the stochastic simulation exercise.

\(^{11}\) Since the model is linear and since the shocks have been assumed to be independent so far, then it is possible to infer the total variance in macroeconomic outcomes by adding the variances associated with individual shocks, weighted by their relative size and frequency.
estimation of the contribution to average output and inflation volatility in the UK from symmetric and asymmetric shocks respectively. The analysis suggests that roughly 50 per cent of average output and inflation volatility can be attributed to symmetric shocks, and 50 per cent to asymmetric shocks, though this estimate is especially uncertain, so alternative assumptions are analysed too.

8.24 Table 8.7 gives estimates of total predicted inflation and output volatility comparing outcomes under the assumptions that the UK either stays outside or joins EMU. The following cases are presented:

<table>
<thead>
<tr>
<th>Case</th>
<th>Model version adopted</th>
<th>Shock distribution assumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Benchmark assumptions</td>
<td>Benchmark assumptions</td>
</tr>
<tr>
<td>2</td>
<td>Benchmark assumptions</td>
<td>Benchmark + symmetric shocks contribute 80 per cent</td>
</tr>
<tr>
<td>3</td>
<td>Benchmark assumptions</td>
<td>Benchmark + nominal shocks contribute 75 per cent (of which exchange rate shocks comprise 90 per cent).</td>
</tr>
<tr>
<td>4</td>
<td>Benchmark assumptions</td>
<td>Benchmark + negatively correlated shocks to £-€ and £-$</td>
</tr>
<tr>
<td>5</td>
<td>Benchmark assumptions</td>
<td>Benchmark assumptions + UK IS curve twice as interest-sensitive + UK Phillips curve twice as forward-looking</td>
</tr>
<tr>
<td>6</td>
<td>Benchmark assumptions</td>
<td>Benchmark assumptions + active fiscal policy inside EMU</td>
</tr>
</tbody>
</table>

Table 8.7: Long-run volatility comparison of EMU versus non-EMU for UK: ‘Three Bears’ model

- Calibrated distribution of all shocks
- Variations around benchmark model

<table>
<thead>
<tr>
<th>Model version:</th>
<th>Shocks assumed:</th>
<th>UK outside EMU</th>
<th>UK in EMU</th>
<th>Ratio in/out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inflation gap</td>
<td>Output gap</td>
<td>Inflation gap</td>
</tr>
<tr>
<td>Case 1</td>
<td>Benchmark</td>
<td>0.64</td>
<td>0.76</td>
<td>0.87</td>
</tr>
<tr>
<td>Case 2</td>
<td>Benchmark + shocks 80 per cent symmetric</td>
<td>0.66</td>
<td>0.74</td>
<td>0.70</td>
</tr>
<tr>
<td>Case 3</td>
<td>Benchmark + shocks 75 per cent nominal (of which 90 per cent exchange rate)</td>
<td>0.83</td>
<td>0.57</td>
<td>0.70</td>
</tr>
<tr>
<td>Case 4</td>
<td>Benchmark + £-€ and £-$ negatively correlated</td>
<td>0.64</td>
<td>1.01</td>
<td>0.76</td>
</tr>
<tr>
<td>Case 5</td>
<td>Benchmark + modified UK IS curve and Phillips curve</td>
<td>Benchmark</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 6</td>
<td>Benchmark + augmented fiscal policy for UK (in EMU only)</td>
<td>Benchmark</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.64</td>
<td>0.76</td>
<td>0.71</td>
</tr>
</tbody>
</table>
The conclusions to be derived from these results when the model is subjected to the full range of shocks follow naturally from the earlier analysis and from the assumptions made regarding the relative importance of particular types of shocks. Again, it needs to be emphasised that this exercise is based on the predicted response of a stylised model of the UK economy to an assumed set of shocks which are intended to be comparable to those shocks which have hit the economic environment in the past. But these calibrated shocks are necessarily stylised too. Nevertheless, the main points to emerge from this exercise are as follows:

- in the benchmark case, Case 1, both inflation and output volatility are predicted to rise inside EMU, by 36 and 20 per cent respectively;

- but the scale of this increase in volatility could be modified or even reversed under alternative assumptions. In Case 2, when asymmetric shocks are assumed to be much less important in generating macroeconomic volatility, the implications of EMU entry for UK and output inflation volatility are more balanced, showing only a small deterioration in macroeconomic volatility inside EMU;

- alternatively, if nominal shocks are assumed to make a much greater contribution to macroeconomic volatility, and within that, if exchange rate shocks are assumed to be the predominant influence12 (here 90 per cent) then Case 3 shows it is possible for both output and inflation volatility to fall once the UK enters EMU (by 16 and 1 per cent respectively). These results are consistent with a scenario where outside EMU, the exchange rate has been acting more as a source of shocks than a shock absorber;

- but as discussed earlier, a different assumption regarding exchange rate shocks can worsen the predicted effects for the UK inside EMU. Case 4 shows the effects of assuming instead that sterling-euro and sterling-US dollar shocks are negatively correlated outside EMU, so joining EMU would impart more not less stability from exchange rate shocks, with inflation and output volatility rising by 59 and 27 per cent respectively more than in the benchmark case;

- Case 5 examines the case, previously analysed in Section 6 and earlier in this section, where the UK is assumed to have more behavioural asymmetries than assumed in the benchmark case, first through having a more interest-sensitive demand, and second through having more flexibility in price-setting. If both these asymmetries are assumed to hold together (where here the relevant parameters are both assumed to be doubled), EMU membership still implies a deterioration in output and inflation volatility, though by slightly less than in the benchmark case. This finding is consistent with the earlier deterministic simulations where increased price flexibility was found to improve macroeconomic outcomes;

12 These assumptions are more in line with the SVAR results of Artis and Ehrmann (2000), rather than the approach to SVAR analysis used in this study which is based on the approach of Gerlach and Smets (1995).
finally, Case 6 examines the performance under the benchmark assumptions of Case 1, but where, upon entering EMU, UK fiscal policy is assumed to be used more actively as a discretionary instrument of demand management. As would be expected, this has a beneficial stabilising influence compared to Case 1. Now inside EMU, inflation variability is only 11 per cent higher rather than 36 per cent higher when only the automatic stabilisers were operating. And output variability now falls by 8 per cent inside EMU rather than increasing by 20 per cent. This suggests that if fiscal policy were used inside EMU in a discretionary manner, and if it were assumed to operate as effectively as is assumed here, it may be possible for the UK to join EMU without suffering too great an increase in inflation volatility, at the same time achieving slightly more stable output.
9 Conclusions

Key points

9.1 The convergence and flexibility tests are ultimately concerned with a comparison of how well the UK economy would be able to adjust to shocks inside EMU compared to a regime where UK interest rates are set independently and the sterling-euro exchange rate is free to move.

9.2 Many of the standard tools devised to judge the fitness of the UK economy to join EMU (e.g. historical correlations and VAR-based estimates of comparative responses) are highly informative but ultimately, can only be indicative.

9.3 Structural macroeconomic models, though inevitably an approximation and subject to their own flaws, represent a potentially more powerful tool for analysing how the economy might respond to different shocks under the two alternative regimes.

9.4 But most macroeconometric models are difficult to understand. Instead, there is a case for adopting simpler, stylised models that capture the essential features of the transmission mechanism of monetary policy. Such a model is employed in this study to unravel and provide a diagnostic analysis of the key characteristics of the adjustment mechanisms inside EMU. This analysis is new both in terms of the model adopted and in the scope of the questions addressed. But it is conducted in the spirit of earlier work by, for example, the European Commission (1990) in their original ‘One Market, One Money’ study and is related to more recent work that examine the workings of the adjustment mechanisms inside EMU since 1999 (see for example Blanchard, 2001).

9.5 Outside EMU, under inflation targeting, an independent monetary policy works through two main channels:

- by affecting demand via counter-cyclical movements in real interest rates, where real interest rates impinge directly on domestic demand and indirectly on net trade via the effect on the real exchange rate; and
- by facilitating required relative price changes via movements in the nominal exchange rate which plays a ‘shock absorbing’ role. In the face of inflationary shocks specific to the UK economy, for example, the UK price level is allowed to ‘slip’, and the nominal exchange rate will eventually move to accommodate this slippage and help to facilitate re-adjustment of the real exchange rate.

9.6 Inside EMU, the adjustment mechanism would work in much the same way if a symmetric shock prompted a response from the ECB similar to that which would have occurred to the UK outside EMU. But for an asymmetric shock which is specific to the UK, the adjustment mechanism would work rather differently:

- the primary burden would be placed on the bilateral real exchange rate between the UK and the euro area and this would necessarily take place via relative price adjustment;
- for asymmetric shocks, the euro area price level effectively acts as a nominal anchor for the UK price level; and
- real interest rates no longer play the primary adjustment role. Indeed, since the ECB would respond weakly to inflationary shocks that were specific to the UK, real interest rates might actually fall, tending to destabilise the adjustment mechanism.

Key features of adjustment

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- for asymmetric shocks, the euro area price level effectively acts as a nominal anchor for the UK price level; and
- real interest rates no longer play the primary adjustment role. Indeed, since the ECB would respond weakly to inflationary shocks that were specific to the UK, real interest rates might actually fall, tending to destabilise the adjustment mechanism.
9.7 Other mechanisms are available inside EMU to facilitate adjustment. Fiscal policy mechanisms can be augmented, but there may be practical problems in doing so. Ultimately wage-price flexibility offers the most effective means of avoiding output costs inside EMU. Greater flexibility among all euro area members would be the first best outcome in terms of minimising UK volatility in EMU. If the UK is relatively more flexible than the euro area, then UK inflation variability may be higher as a result.

9.8 The ease with which the UK economy might be able to respond to different shocks inside EMU is importantly affected by the degree of behavioural asymmetry between the UK and the euro area, for example in the degree of price flexibility and in the degree of sensitivity to interest rates. The conventional view arising from optimal currency area (OCA) theory is that the more diverse are the values of these parameters between the UK and euro area, the more costly EMU becomes in macroeconomic terms. But the analysis here has shown that the implication will differ according to both the source and direction of the asymmetry. So, for example, higher price flexibility in the UK would show up in higher inflation volatility, while lower price flexibility would result in greater output volatility.

9.9 Stochastic simulation methods have been used by empirical modellers in an attempt to measure the net macroeconomic costs of EMU. Overall, the conclusions to be drawn from these studies vary. While a range of technical aspects underlying these conclusions are important, the treatment of shocks to the exchange rate (and the associated question of whether the exchange rate is deemed to be a source of noise or a shock absorber) turns out to be critical. An extensive investigation of the stochastic properties of the ‘Three Bears’ model, culminating in a series of simulation exercises, tends to predict that EMU is likely to lead to more macroeconomic volatility. But it is shown how reasonable assumptions regarding the assumed specification of the model, or the shocks assumed to impinge, can either magnify or shrink this predicted increase. And under particular assumptions about the nature of the exchange rate shocks assumed outside EMU, it is possible that macroeconomic volatility could fall inside EMU.

9.10 Overall the analysis confirms the prediction that, on a priori grounds, it is not possible to say whether macroeconomic volatility in the UK will increase or decrease inside EMU compared to outside. But the analysis has provided a conceptual framework which helps to explain how different assumptions about the workings of the macroeconomic environment can lead to different conclusions regarding the degree of macroeconomic volatility inside EMU compared to outside.

9.11 In concluding, it is important to emphasise that, in making the assessment of the economic case for UK entry to EMU, these costs need to be compared against the potential benefits which EMU entry offers.

9.12 This study informs the assessment of the convergence test, the first of the Government’s five economic tests for EMU entry; the flexibility test, the second test; and the growth, stability and jobs test, the fifth test.
REFERENCES


REFERENCES


Annex A: A Detailed Description of the ‘Three Bears’ Model

Relationship of ‘Three Bears’ model to previous work

A1 This annex describes in more detail the ‘Three Bears’ model. The model adopted has very conventional properties in the spirit of recent simple models adopted for use in the analysis of the design of monetary policy in a single-country context (see Clarida et al., 1999, for a survey of this approach). But it is specifically tailored to reveal the key aspects of the interaction between the UK and euro area economies.

A2 There are three country blocks in the model representing the UK, the euro area and the rest of the world (and since these three country blocks in the model can broadly be characterised as small, medium-sized and large, this gives the model its name). In its full form, the model can be run with all three countries endogenous, but here, since the focus of interest is on the interaction between the UK and euro area, the rest of the world is held constant for simplicity.

A3 The behavioural core of each country block in the model is based on what has become known as the ‘workhorse’ model of monetary policy analysis. Early examples of this type of model were specified in a simple backward-looking form (see for example Rudebusch and Svensson, 1999). But in later versions, as here, forward-looking behaviour has been incorporated consistent with optimising behaviour on the part of firms and consumers (see for example McCallum and Nelson, 1999; and Clarida et al. 1999). And open-economy considerations have been taken into account (see for example Blake and Westaway, 1996; Batini and Haldane, 1999; and Ball, 1999).

A4 The ‘Three Bears’ model represents an innovation relative to most other studies of this type in its explicit modelling of the interaction between the UK, the euro area and the rest of the world. In previous open-economy studies, the second-round effects of one country on another have usually been ignored, but in the context of understanding the implications of EMU membership for the adjustment mechanism in the UK, this additional degree of complexity is vital.

Model overview

A5 The key equations for each country block in the model are as follows:

- a fixed level of potential output;
- an IS curve where aggregate demand depends negatively on the real interest rate; negatively on the respective bilateral real exchange rates and positively with respect to foreign demand pressures;
- a Phillips curve where changes in inflation are driven by the output gap (i.e. the gap between aggregate demand and supply) with important additional dynamics from the real exchange rate;
- bilateral exchange rates between pairs of countries driven by the relevant UIP condition, itself driven by the relevant interest rate differential; and
- a policy rule for nominal interest rates of the ‘Taylor’ form, specifying a positive response to deviations in inflation from target and to the output gap.

Equation listing

A6 A detailed listing of the model equations for the UK and the euro area now follows:

- equations are numbered where version (a) refers to the UK version and (b) to that for the euro area.
in most cases, except where specified, the accompanying description of the model equations will refer to those for the UK but the description will in all cases apply to the euro area too (with a suitable change of subscripts and superscripts in the model description);

all model variables are defined in natural logarithms, except for the real and nominal interest rate variables which are linear; and

the description will explain how the ‘reduced form’ coefficients in the equations of the model can be broken down into influences from structural and behavioural parameters.

Output potential (supply):

\[ y_{st}^{UK} = y_{sshock_{st}}^{UK} + y_{sshock_{st}}^{SYMM} \]  
\[ y_{st}^{EA} = y_{sshock_{st}}^{EA} + y_{sshock_{st}}^{SYMM} \]

Output potential in the UK (\( y_{st}^{UK} \)):

- is assumed to be exogenous to the model; and
- is affected by two types of shock, those specific to the UK (\( y_{sshock_{st}}^{UK} \)) and shocks which symmetrically hit the euro area too (\( y_{sshock_{st}}^{SYMM} \)).

Output determination (IS curve):

\[ y_{t}^{UK} = C_{lead}^{uk} \cdot y_{t+1,e}^{UK} + C_{lag}^{uk} \cdot y_{t-1}^{UK} + (1 - C_{lead}^{uk} - C_{lag}^{uk}) \cdot (\{C_{1}^{uk} \cdot r_{t}^{uk} + C_{2}^{uk} \cdot r_{t}^{UK}\cdot EA + C_{3}^{uk} \cdot r_{t}^{UK\cdot ROW} + C_{4}^{uk} \cdot y_{t}^{EA} + C_{5}^{uk} \cdot y_{t}^{ROW} + f_{is}^{UK} + y_{dshock_{t}}^{UK} + y_{dshock_{t}}^{SYMM}) \]

\[ y_{t}^{EA} = C_{lead}^{ea} \cdot y_{t+1,e}^{EA} + C_{lag}^{ea} \cdot y_{t-1}^{EA} + (1 - C_{lead}^{ea} - C_{lag}^{ea}) \cdot (\{C_{1}^{ea} \cdot r_{t}^{ea} + C_{2}^{ea} \cdot r_{t}^{EA\cdot UK} + C_{3}^{ea} \cdot r_{t}^{EA\cdot ROW} + C_{4}^{ea} \cdot y_{t}^{EA} + C_{5}^{ea} \cdot y_{t}^{ROW} + f_{is}^{EA} + y_{dshock_{t}}^{EA} + y_{dshock_{t}}^{SYMM}) \]

UK output (\( y_{t}^{UK} \)) is determined by an IS curve with the following properties:

- in its general form, it is assumed to include backward and forward-looking elements (with a lag and lead of \( C_{lag}^{uk} \) and \( C_{lead}^{uk} \) respectively) where \( y_{t+1,e}^{UK} \) refers to the expectation of UK output in period \( t+1 \) formed at period \( t \). This is consistent with optimising models augmented to include elements of inertia, caused for example by habit persistence (see for example McCallum and Nelson, 1999, and Fuhrer, 2000). Since the theory of the optimising IS curve is less well-founded in the open economy case, the constraint that the ‘structural’ coefficients on the leads and lags of output should add to unity is not imposed in the ‘Three Bears’ implementation of the model;
- real interest rates impinge negatively on demand with a coefficient \( C_{1}^{uk} \), which is a behavioural parameter;
- each bilateral real exchange rate (i.e. between the UK and the euro area and rest of the world, respectively) impinges negatively on UK demand, where the reduced form coefficients (\( C_{2}^{uk} \) and \( C_{3}^{uk} \)) appropriately reflect the openness of the UK economy (\( open^{UK} \)), the share of euro area and rest-of-the-world trade in total UK trade (\( r^{uk\cdot EA} \) and \( r^{uk\cdot ROW} = 1 - r^{uk\cdot EA} \)), the sensitivity of UK trade to real
exchange rate movements ($\gamma^{uk}$) and the degree of pricing-to-market in UK trade prices ($ptm^{uk}$),

\[ cy_{2}^{uk} = open^{uk} opn^{ae} \cdot ptm^{uk} \quad \text{and} \quad cy_{3}^{uk} = open^{uk} opn^{row} \cdot ptm^{uk} \]

- openness and trade shares can be viewed as ‘structural’ parameters in the sense that they can be easily measured and are unlikely to evolve rapidly, while exchange rate sensitivity and the degree of pricing to market are considered ‘behavioural’, since they must be estimated;
- foreign demand impinges positively on demand implicitly via the demand for exports, where the reduced form coefficients on euro area and rest-of-the-world demand (i.e. $c_{4}^{uk}$ and $c_{5}^{uk}$) are scaled by openness and trade shares,

\[ cy_{4}^{uk} = opn^{uk} opn^{ae} \quad \text{and} \quad cy_{5}^{uk} = opn^{uk} opn^{row} ; \]
- demand in the UK is assumed to be directly affected by two types of shock, those specific to the UK ($ydshock^{UK}$) and shocks that symmetrically hit the euro area too ($ydshock^{EU}$).

**Fiscal policy:**

\[ fisct^{UK} = cf_{AS}^{uk} yt^{UK} + cf_{1}^{uk} dpt^{UK} = cf_{2}^{uk} (yt^{UK} - yst^{UK}) \quad [3a] \]

\[ fisct^{EA} = cf_{AS}^{ea} yt^{EA} + cf_{1}^{ea} dpt^{EA} = cf_{2}^{ea} (yt^{EA} - yst^{EA}) \quad [3b] \]

**A9** Fiscal policy ($fisc^{uk}$) is assumed to impinge directly on demand:

- in the benchmark case, fiscal policy is assumed to respond only to the automatic stabilisers (with a sensitivity to output fluctuations of $cf_{AS}^{uk}$); but
- inside EMU, additional discretionary fiscal stabilisation is assumed to operate (as described in Section 5), responding to inflation deviations from target and the output gap (with coefficients $cf_{1}^{uk}$ and $cf_{2}^{uk}$ respectively).

**Inflation determination (Phillips curve):**

\[ dp_{t}^{UK} = cp_{t}^{uk} dp_{t-1,1}^{uk} + (1 - cp_{t}^{uk}) . dp_{t-1}^{uk} \]

\[ + cp_{1}^{uk} (er_{t+1,1}^{UK} - er_{t}^{UK}) + cp_{2}^{uk} (er_{t+1,1}^{UK} - er_{t}^{UK}) + cp_{3}^{uk} (er_{t+1,1}^{UK} - er_{t}^{UK}) + cp_{4}^{uk} (er_{t+1,1}^{UK} - er_{t}^{UK}) \]

\[ + cp_{5}^{uk} (er_{t+1,1}^{UK} - er_{t}^{UK}) - cp_{6}^{uk} (er_{t+1,1}^{UK} - er_{t}^{UK}) \]

\[ dp_{t}^{EA} = cp_{t}^{ea} dp_{t-1,1}^{ea} + (1 - cp_{t}^{ea}) . dp_{t-1}^{ea} \]

\[ + cp_{1}^{ea} (er_{t+1,1}^{EA} - er_{t}^{EA}) + cp_{2}^{ea} (er_{t+1,1}^{EA} - er_{t}^{EA}) + cp_{3}^{ea} (er_{t+1,1}^{EA} - er_{t}^{EA}) + cp_{4}^{ea} (er_{t+1,1}^{EA} - er_{t}^{EA}) \]

\[ + cp_{5}^{ea} (er_{t+1,1}^{EA} - er_{t}^{EA}) - cp_{6}^{ea} (er_{t+1,1}^{EA} - er_{t}^{EA}) \]

**A10** Inflation in the UK ($dp_{t}^{uk}$) is determined by a dynamic open-economy Phillips curve. Box A1 provides a more detailed justification of the specification:

- inflation dynamics are based on the Fuhrer and Moore (1995) overlapping contracts model where inflation is determined as an equally weighted sum of lagged and future inflation (where $dp_{t+1,1}^{uk}$ is the expectation of UK inflation in period $t+1$ formed at period $t$) This imparts inertia into the inflation process. Following Blake and Westaway (1996), the implementation of this approach here is generalised to allow the weight on backward-looking inflation to be higher to capture additional nominal inertia though the weights are constrained to add to unity to ensure dynamic homogeneity;
ANNEX A: A DETAILED DESCRIPTION OF THE ‘THREE BEARS’ MODEL

• the output gap appears in the Phillips curve via a two-period moving average effect, consistent with the dynamic contracting model;

• the price level \( p_t \) is defined as the cumulated inflation rate;

• the price modelled is a consumer price index defined as an appropriately weighted sum of domestic prices and import prices (where \( \mu_{\text{UK}} \) is the weight of UK-produced goods in the domestic CPI) captured by a weighted average of competitors’ prices deflated by the relevant bilateral exchange rates. Pricing to market effects modify the pass-through of exchange rates into import prices;

• the dynamics of the real exchange rate terms are also determined by the dynamic contract model, involving a change term in each of the expected and current bilateral real exchange rates, with respective coefficients of \( \phi_{2,\text{UK}} \) and \( \phi_{3,\text{UK}} \) for the UK-euro area real exchange rate, and \( \phi_{4,\text{UK}} \) and \( \phi_{5,\text{UK}} \) for the UK-rest-of-the-world real exchange rate. The related coefficients depend on the degree of inflation inertia \( (\phi_{1,\text{UK}}) \), the share of domestic goods in the consumer price basket \( (\mu_{\text{UK}}) \) and the degree of pricing to market \( (\text{ptm}_{\text{UK}}) \), i.e. \( \phi_{2,\text{UK}} = \phi_{1,\text{UK}} \) and where \( \phi_{4,\text{UK}} = 2(1 - \mu_{\text{ptm}_{\text{UK}}})/\mu_{\text{ptm}_{\text{UK}}} \)

and

\( \phi_{3,\text{UK}} = -(1 - \phi_{1,\text{UK}}) \phi_{4,\text{UK}} \)

and \( \phi_{5,\text{UK}} = -(1 - \phi_{1,\text{UK}}) \phi_{4,\text{UK}} \)

where \( \phi_{4,\text{UK}} = 2(1 - \mu_{\text{ptm}_{\text{UK}}})/\mu_{\text{ptm}_{\text{UK}}} \)

and where \( \mu_{\text{ptm}_{\text{UK}}} = \mu_{\text{UK}}/(1 - (1 - \mu_{\text{UK}}) \mu_{\text{ptm}_{\text{UK}}}) \); and

• supply shocks to the UK (\( \text{ysshock}_{\text{UK}}^{s,t} \) and \( \text{ysshock}_{\text{UK}}^{s,t} \)) impinge on the model via their effect on supply potential \( (\text{yst}_{\text{UK}}^{s,t}) \) which enters via the output gap terms in the Phillips curve.

Real exchange rate determination:

When the UK sets monetary policy independently:

\[
\text{ert}_{t}^{\text{UK},\text{EA}} = e_{t+1}^{\text{UK},\text{EA}} + \text{rt}_{t}^{\text{UK}} - \text{rt}_{t}^{\text{EA}} - \text{sig}_{t}^{\text{UK},\text{EA}}
\]  \[5a\]

When UK in EMU:

\[
\text{ert}_{t}^{\text{UK},\text{EA}} = p_{t}^{\text{UK}} - p_{t}^{\text{EA}}
\]  \[5a'\]

When the UK is outside or inside EMU:

\[
\text{ert}_{t}^{\text{UK},\text{ROW}} = e_{t+1}^{\text{UK},\text{ROW}} + \text{rt}_{t}^{\text{UK}} - \text{rt}_{t}^{\text{ROW}} - \text{sig}_{t}^{\text{UK},\text{ROW}}
\]  \[5b\]

All The equations for the bilateral real exchange rate will depend on the UK’s monetary regime:

• outside EMU, real bilateral exchange rates of the UK against the euro area \( (\text{ert}_{t}^{\text{UK},\text{EA}}) \) and the rest-of-the-world \( (\text{ert}_{t}^{\text{UK},\text{ROW}}) \) are determined by the uncovered interest parity condition containing the relevant expected exchange rate terms \( (e_{t+1}^{\text{UK},\text{EA}}) \) and \( (e_{t+1}^{\text{UK},\text{ROW}}) \), where for example \( e_{t+1}^{\text{UK},\text{EA}} \) is the expected bilateral UK v euro area real exchange rate in period \( t+1 \) formed in period \( t \) and the relevant real interest rate differentials (i.e. \( r_{t}^{\text{UK}} \) relative to \( r_{t}^{\text{EA}} \) and \( r_{t}^{\text{ROW}} \) respectively) plus a risk premium \( (\text{sig}_{t}^{\text{UK},\text{EA}} \) and \( \text{sig}_{t}^{\text{UK},\text{ROW}}) \);

1 To simplify the model, the real exchange rate is defined using consumer prices rather than trade prices which a richer model would additionally incorporate.

1 In principle, an alternative type of supply shock which does not directly impinge on productive potential could additionally impinge on inflation, for example due to an effect from unwarranted wage pressures. For simplicity, this type of effect is not separately modelled here.
Box A1: Derivation of the augmented Fuhrer-Moore model of inflation dynamics

The characterisation of inflation dynamics employed in the ‘Three Bears’ model is based on the model of inflation inertia originally developed in Fuhrer and Moore (1995). Its key characteristic is a model of overlapping wage contracts \( (w_t) \) specified in terms of real relativities. This assumes that real wages contracts negotiated in the current period are a weighted average of real wages struck in the previous and following contract period (with weights of \( \alpha \) and \( 1-\alpha \) respectively, summing to unity to ensure dynamic homogeneity). The original specification of Fuhrer and Moore assumed that the backward and forward-looking weights should be equal with a value of a half, but Blake and Westaway (1996) generalised this scheme to encompass differing degrees of backward-looking behaviour. The value of the wage contract is modified by an effect from the output gap, wage contracts being higher when the economy is operating above potential, i.e.

\[
w_t - p_t = \alpha(w_{t-1} - p_{t-1}) + (1-\alpha)(w_{t+1}^e - p_{t+1}^e) + \nu y_t \tag{A1}
\]

where \( w_{t+1}^e \) and \( p_{t+1}^e \) represent the expected value of wages and consumer prices at the time the contract is struck at time \( t \).

In the simplest form of the model where wage contracts last for two periods, with half of all wages being struck each period, then the domestic price is simply a weighted average of domestic costs, i.e.

\[
p_d t = 0.5(w_t + w_{t-1}) \tag{A2}
\]

The consumer price is then defined as a weighted average of domestically produced and imported goods, where domestic goods have a weight of \( \beta \) in the consumer price index, i.e.

\[
p_t = \beta 0.5(w_t + w_{t-1}) + (1-\beta) p_{m t} \tag{A3}
\]

Importing firms are assumed to price to market such that the consumer price of goods in the domestic market have a weight of \( \lambda \) in import prices \( (p_{m t}) \), but no lags are assumed in the adjustment of import prices to changes in prices in domestic markets, or in overseas prices \( (p^* t) \) or to the nominal exchange rate \( (e_t) \), i.e.

\[
p_{m t} = \lambda p_t + (1-\lambda)(p^*_t - e_t) \tag{A4}
\]

The real exchange rate is defined as

\[
e_{rt} = e_t + p_t - p^*_t \tag{A5}
\]

By manipulation of these equations\(^b\), it is possible to derive a Phillips curve relationship for the determination of inflation \( (\pi_t = p_t - p_{t-1}) \) given by

\[
\pi_t = (1-\alpha)\pi_{t+1}^e + \alpha\pi_{t-1} + 2\left(\frac{1-\beta}{\beta}\right)((1-\alpha)\Delta e_{rt+1}^e - \alpha\Delta e_{rt}) + \nu (y_t + y_{t-1}) \tag{A6}
\]

where \( \beta' = \beta/(1-(1-\beta)\lambda) \).

Unlike the earlier model of Taylor (1980) specified in terms of nominal wage relativities, equation (A6) for inflation dynamics contains inflation inertia (i.e. inflation depends on its own lagged values). This is an important property which, compared to a model where inflation is purely forward-looking, is more consistent with the empirical evidence for the dynamic behaviour of inflation in developed economies.

\(^a\) An earlier version of a similar wage-contracting model was also derived in Buiter and Jewitt (1981).

\(^b\) Specifically, it is necessary to add equation (A1) to a lagged version of (A1), then to take a first difference of equation (A3) and a lag of that, then to combine these expressions to eliminate the terms in wages. Then the import price terms should be substituted out using equations (A4) and (A5) to leave only terms in dynamics of inflation, the real exchange rate and output. Equation (A6) follows. This derivation abstracts from the effect of expectational errors in the face of shocks by assuming that \( \pi_{t+1}^e = \pi_t \) and \( e_{rt+1}^e = e_{r t} \) for all periods including the first.
• inside EMU, when the nominal exchange rate between the UK and the euro area is irrevocable fixed (here at unity for presentational simplicity), the real exchange rate becomes equivalent to the relative price between the UK \((p_t^{UK})\) and euro area \((p_t^{EA})\); and

• shocks to the real exchange rate occur via the risk premium terms (see below).

**Exchange rate risk premium:**

\[
s_{t}^{UKvEA} = risk_t^{UE} - risk_t^{EA} \tag{6a}
\]

When UK is outside EMU:

\[
s_{t}^{UKvROW} = risk_t^{UK} - risk_t^{ROW} \tag{6b}
\]

When UK in EMU:

\[
s_{t}^{UKvROW} = w.risk_t^{UK} + (1-w)risk_t^{EA} - risk_t^{ROW} \tag{6b'}
\]

where \(w\) is the share of UK GDP in euro area GDP post UK-entry.

**A12** Exchange rate risk premia can be defined in a variety of ways:

• in the simplest case where independent risks can be associated with particular countries, the risk premium on a particular bilateral is defined as the difference between the risks associated with the respective countries. Inside EMU, it is assumed that the risk associated with an extended euro area including the UK is a weighted sum of the previous risks in the UK and euro area; and

• in more complicated cases, as considered for example in the stochastic simulations in Section 8, risk premia may be cross correlated and the simple expression above is implicitly augmented by more terms.

**Nominal exchange rate:**

\[
et_{t}^{UKvEA} = ert_{t}^{UKvEA} + p_t^{EA} - p_t^{UK}
\]

\[
et_{t}^{UKvROW} = ert_{t}^{UKvROW} + p_t^{ROW} - p_t^{UK}
\]

The bilateral nominal exchange rates \((et_{t}^{UKvEA})\) and \((et_{t}^{UKvROW})\) are defined by identity:

• in the case when the UK is inside EMU, the nominal exchange rate is held constant at unity (zero in logarithms).

**Real interest rates:**

\[
r_t^{UK} = i_t^{UK} - d_{pt+1}^{UK} \tag{7a}
\]

\[
r_t^{EA} = i_t^{EA} - d_{pt+1}^{EA} \tag{7b}
\]

**A13** Real interest rates \((r_t^{BE})\) are defined in forward-looking terms, i.e. as the difference between the nominal interest rate \((i_t^{BE})\) and a forward-looking measure of expected inflation \((d_{pt+1}^{BE})\).

**Nominal interest rate reaction functions:**

When the UK sets monetary policy independently:

\[
i_t^{UK} = dp_{t+1}^{UK,v} + cr_1^{UK}(dp_t^{UK} - dp_t^{UK,v}) + cr_2^{UK}(y_t - y_t^{UK}) + ishock_t^{UK} + ishock_t^{UK,v} \tag{8a}
\]

\[
i_t^{EA} = dp_{t+1}^{EA,v} + cr_1^{EA}(dp_t^{EA} - dp_t^{EA,v}) + cr_2^{EA}(y_t - y_t^{EA}) + ishock_t^{EA} + ishock_t^{EA,v} \tag{8b}
\]
When the UK is in EMU:

\[
\tilde{i}_t^{UK} = \tilde{i}_t^{EA} \quad [8a']
\]

\[
\tilde{i}_t^{EA} = w.d_{t+1, e}^{EA} + (1-w).d_{t+1, e}^{UK} + w[cr_1^e(dp_t^{EA} - dp_t^{ARG}) + cr_2^e(y_t^{EA} - y_t^{ARG})] \\
+ (1-w).[cr_1^e(dp_t^{EA} - dp_t^{ARG}) + cr_2^e(y_t^{EA} - y_t^{ARG})] \quad [8b']
\]

where \( w \) is the share of UK GDP in euro area GDP post entry.

**A14** The policy rule for nominal interest rates will depend on whether the UK is in EMU or not:

- outside EMU, nominal interest rates \( (\tilde{i}_t^{UK}) \) are set according to a Taylor-type rule responding to deviations in UK inflation from target and in the UK output gap (with coefficients \( cr_1^{UK} \) and \( cr_2^{UK} \) respectively); and

- inside EMU, UK nominal interest rates are set equal to interest rates in the euro area, which are now assumed to be set by the ECB in response to an appropriately weighted average of inflation deviations and output gaps in the euro area including the UK (and where the Taylor rule parameters and inflation target for the euro area are assumed to be unaffected by UK entry to EMU).

**Model solution**

**A15** The model is programmed up in the Winsolve modelling package (see Pierse, 2000). It is solved using a Gauss-Newton solution method. All forward-looking expectations in the model are solved using a stacked Newton method under the assumption of model consistent expectations with conventional terminal conditions.

**Calibration of the model**

**A16** The model is calibrated in order to reproduce in a realistic but inevitably rather stylised manner, the dynamic properties of the UK and euro area economies and their interaction with the rest of the world. As such, parameter values have largely been chosen to provide response patterns that are consistent with SVAR responses and with those observed in larger empirically based macromodels.

**A17** In describing the calibration of the model for the UK and euro area equations, it is useful to separate the model’s parameters into three categories, ‘long-run structural’, behavioural and policy-related.

**A18** Long-run structural parameters relate to features of the economy that tend to be measured, here based on national accounts statistics for GDP and expenditure shares, rather than estimated. As such, they are unlikely to be altered in the short-to-medium term by the monetary regime in place. These are detailed in the table below:

<table>
<thead>
<tr>
<th>Structural parameters</th>
<th>UK</th>
<th>Euro area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Openness defined as average of import and export to GDP ratio</td>
<td>( open^{UK} = 0.33 )</td>
<td>( open^{EA} = 0.165 )</td>
</tr>
<tr>
<td>Trade shares ( (r^A = \text{share of A in B’s trade}) )</td>
<td>( r^{UK} = 0.5 )</td>
<td>( r^{EA} = 0.18 )</td>
</tr>
<tr>
<td>( r^{UK} ) = 1-0.5=0.5</td>
<td>( r^{EA} ) = 1-0.18=0.82</td>
<td></td>
</tr>
<tr>
<td>Domestic content of CPI</td>
<td>( \mu^{UK} = 0.8 )</td>
<td>( \mu^{EA} = 0.9 )</td>
</tr>
<tr>
<td>Share of GDP in world output</td>
<td>( w^{UK} = 0.04 )</td>
<td>( w^{EA} = 0.16 )</td>
</tr>
<tr>
<td>Share of GDP in output of euro area plus UK</td>
<td>( w = w^{UK} / (w^{UK} + w^{EA}) )</td>
<td>( 1-w = 0.8 )</td>
</tr>
</tbody>
</table>

\[ w = 0.2 \]
Behavioural parameters relate to features of the economy that tend to be estimated or calibrated. These parameters may be more likely to alter endogenously once monetary union begins. Details are given in the table below:

<table>
<thead>
<tr>
<th>Behavioural parameters</th>
<th>UK</th>
<th>Euro area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity of trade to real exchange rate</td>
<td>$\gamma^u = -1.5$</td>
<td>$\gamma^e = -1.5$</td>
</tr>
<tr>
<td>Degree of pricing to market</td>
<td>$ptm^u = 0.25$</td>
<td>$ptm^e = 0.25$</td>
</tr>
<tr>
<td>Degree of inertia in output</td>
<td>$\sigma^u_{lag} = 0.5, \sigma^u_{lead} = 0$</td>
<td>$\sigma^e_{lag} = 0.5, \sigma^e_{lead} = 0$</td>
</tr>
<tr>
<td>Interest sensitivity of output</td>
<td>$\gamma^u = -0.2$</td>
<td>$\gamma^e = -0.2$</td>
</tr>
<tr>
<td>Degree of forward-lookingness in price setting</td>
<td>$cp^1_1 = 0.25$</td>
<td>$cp^1_1 = 0.25$</td>
</tr>
<tr>
<td>Output sensitivity of price setting</td>
<td>$cp^6_0 = 0.25$</td>
<td>$cp^6_0 = 0.25$</td>
</tr>
</tbody>
</table>

As in previous studies that have adopted small stylised models to conduct policy analysis (e.g. Blake and Westaway, 1996, and Batini and Haldane, 1999), these behavioural parameters are calibrated partly on the basis of single equation estimates, partly by attempting to match the simulation responses of existing empirically based models (for example, those of NiGEM, IMF Multimod or the Bank of England’s medium term macroeconomic model; see NIESR, 2003; Laxton et al., 1998; and Bank of England, 1999). The following assumptions are worthy of note:

- the sensitivity of trade to the real exchange rate ($\gamma^u$ and $\gamma^e$) is calibrated so that the aggregate reduced form elasticity of UK demand to the real exchange rate (i.e. $cy^u_2 + cy^u_3 = -0.7425$) is comparable to that adopted in Batini and Haldane (1999) where the long run elasticity is $-1$ (though the short-run elasticity adopted there is lower at $-0.2$ compared to $-0.37$ in the ‘Three Bears’ model);

- the degree of pricing to market ($ptm^u$ and $ptm^e$) is broadly consistent with empirical estimates contained in macroeconomic models. The estimate of 0.25 adopted here is slightly lower than that in the HM Treasury public model but higher than the assumption of zero long-run pricing to market in the Bank of England’s medium-term macroeconomic model (see Bank Of England, 1999);

- the backward-looking inertia ($\sigma^u_{lag}$ and $\sigma^e_{lag}$) is slightly less that assumed in Batini and Haldane (1999) and Blake and Westaway (1996) although sensitivity analysis of this assumption is carried out in Section 4;

- the sensitivity of demand to the real interest rate ($cy^u$ and $cy^e$) is comparable to previous studies in terms of its impact elasticity ($-0.1$ here compared to $-0.2$ in Blake and Westaway, 1996, and Batini and Haldane, 1999) but lower in terms of its long run impact ($-0.2$ compared to $-1$, for example in Batini and Haldane, 1999). This assumption, which is varied in the sensitivity analysis of Section 6, is adopted in order to preserve the stability properties of the model inside EMU. A higher assumed value for this parameter, in conjunction with the assumption that demand responds to short-term interest rates, gives rise to implausibly oscillatory dynamics for the UK inside EMU;

- the degree of forward-lookingness in price-setting ($cp^1_1$ and $cp^1_1$) is the same as that previously assumed in Blake and Westaway (1996) and is broadly consistent with estimates for the US in Fuhrer (1997); and
the responsiveness of real wages to output ($cp^{wk}_6$ and $cp^{ma}_{lag}$), here assumed equal to 0.25, is comparable to that adopted in previous studies (for example 0.2 adopted in Batini and Haldane, 1999) but somewhat larger that empirical estimates for the US and the euro area reported in Fuhrer (1997) and Coenen and Wieland (2000) respectively.

A21 Policy-related parameters relate

• to the feedback responses of monetary policy in the ‘Taylor’ specification; and

• to the responsiveness of fiscal policy comprising two components; first, the automatic stabiliser component involving a response coefficient of 0.5 to output changes (see Van den Noord, 2000); and second, an additional discretionary feedback element to inflation deviations and the output gap. This may be required inside EMU to compensate for the loss of independent monetary policy as an adjustment mechanism.

A22 No attempt is made in the paper to choose policy-response coefficients that are ‘optimal’ in any sense.

### Policy rules

<table>
<thead>
<tr>
<th>Policy rules</th>
<th>UK</th>
<th>Euro area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monetary policy</td>
<td>$cr^1_{uk} = 0.5$</td>
<td>$cr^1_{ea} = 0.5$</td>
</tr>
<tr>
<td></td>
<td>$cr^2_{uk} = 0.5$</td>
<td>$cr^2_{ea} = 0.5$</td>
</tr>
<tr>
<td>Fiscal policy</td>
<td>$cf_{lag}^{AS}_{uk} = -0.5$</td>
<td>$cf_{lag}^{AS}_{ea} = -0.5$</td>
</tr>
<tr>
<td></td>
<td>$cf_{1,uk} = cf_{2,uk} = 0.0$</td>
<td>$cf_{1,ea} = cf_{2,ea} = 0.0$</td>
</tr>
</tbody>
</table>

A23 These 13 sets of parameters (five structural, six behavioural and two policy-related) completely define the coefficients of the model. All that remains is to express the reduced-form coefficients in the output and inflation equations in terms of these parameters. Details are given below:

### Output determination (IS curve)

<table>
<thead>
<tr>
<th>Degree of inertia</th>
<th>UK</th>
<th>Euro area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$cy_{lag}^{uk} = 0.5$, $cy_{lag}^{ma} = 0$</td>
<td>$cy_{lag}^{uk} = 0.5$, $cy_{lag}^{ma} = 0$</td>
</tr>
<tr>
<td>Interest sensitivity</td>
<td>$cy_{1,uk}^{uk} = -0.2$</td>
<td>$cy_{1,uk}^{uk} = -0.2$</td>
</tr>
<tr>
<td>Coefficients on</td>
<td>$cy_{2,uk}^{uk} = -0.37125$</td>
<td>$cy_{2,uk}^{uk} = -0.06683$</td>
</tr>
<tr>
<td>real exchange rate terms</td>
<td>$cy_{lag}^{uk} = -0.37125$</td>
<td>$cy_{lag}^{uk} = -0.30443$</td>
</tr>
<tr>
<td>(derivation given in 2)</td>
<td>$cy_{4,uk}^{uk} = 0.165$</td>
<td>$cy_{4,uk}^{uk} = 0.0297$</td>
</tr>
<tr>
<td>Foreign demand elasticity</td>
<td>$cy_{lag}^{uk} = 0.165$</td>
<td>$cy_{lag}^{uk} = 0.1353$</td>
</tr>
</tbody>
</table>

### Inflation determination (Phillips curve)

<table>
<thead>
<tr>
<th>Degree of</th>
<th>UK</th>
<th>Euro area</th>
</tr>
</thead>
<tbody>
<tr>
<td>forward-lookingness</td>
<td>$cp_{1,uk} = 0.25$</td>
<td>$cp_{1,ea} = 0.25$</td>
</tr>
<tr>
<td>Coefficients on</td>
<td>$cp_{2,uk} = 0.0469$</td>
<td>$cp_{2,ea} = 0.0075$</td>
</tr>
<tr>
<td>real exchange rate terms</td>
<td>$cp_{3,uk} = -0.141$</td>
<td>$cp_{3,ea} = -0.0225$</td>
</tr>
<tr>
<td>(derivation given below equation 3)</td>
<td>$cp_{4,uk} = 0.0469$</td>
<td>$cp_{4,ea} = 0.0342$</td>
</tr>
<tr>
<td></td>
<td>$cp_{5,uk} = -0.141$</td>
<td>$cp_{5,ea} = -0.1025$</td>
</tr>
<tr>
<td>Output sensitivity</td>
<td>$cp_{6,uk} = 0.25$</td>
<td>$cp_{6,ea} = 0.25$</td>
</tr>
</tbody>
</table>

Annex A: A Detailed Description of the ‘Three Bears’ Model
Arguably, the distinction between structural and behavioural parameters adopted here is slightly arbitrary. In particular, the parameters designated as ‘behavioural’ here would, in a model more rigorously based on optimising principles, be themselves determined by underlying structural characteristics such as the preferences of economic agents and the technological constraints that they face. But for the purposes of this study, these definitions are used to set up the benchmark calibration of the model where, for simplicity, all ‘behavioural’ parameters are assumed to be identical between the UK and euro area. This facilitates understanding of the simulation responses of the benchmark version of the model where the only asymmetries between the model structures are in terms of policy setting and long run structural differences reflecting country size and trade patterns. Having understood this benchmark version, the implications of variations in the specification of the model, the assumed policy setting and the shocks assumed to hit the model can easily be introduced.