Monetary stabilisation policy in a monetary union: some simple analytics

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Abstract

We do two things in this paper. First, we look at some simple models of monetary decision-making in a monetary union and ask how much more variable a country's output and inflation is likely to be if it joins the union. We answer this analytically and then go on to 'calibrate' the simple model. The model has few structural equations, but it is useful in allowing us to examine how the variability of output and inflation are likely to change as key parameters change. Our conclusions, in this respect, are likely to be sensitive to model specification. However, we also identify a second-best issue concerning the optimal make-up of the monetary union which is likely to be more robust: namely that only when all members of the union have the same structural parameter values (and shocks are perfectly correlated) will it be optimal for a new member to have these same structural parameter values.

Introduction

There are many potential economic costs of and benefits to joining a monetary union. The debate surrounding the desirability or otherwise of European Monetary Union (EMU) emphasised a number of these. One of the more talked about benefits was that of reduced exchange rate volatility. On the downside, monetary union requires a common monetary policy (one official interest rate). In the absence of full factor mobility, that may entail some countries setting their official interest rate at a level that they would not otherwise have wanted (when, for example, countries wish to stabilise idiosyncratic shocks, or when they find themselves at a different stage of the economic cycle).

We make no attempt to analyse or quantify all these costs and benefits. This paper is not a cost-benefit analysis of monetary union from the standpoint of any specific country. Rather we focus on the stabilisation policy issue. First, we look at some simple representations of the decision-making process under monetary union, and ask how much more variable output and inflation are likely to be should a country choose to join with a large group. We can, and do, answer this question analytically, but to make the results more tangible we also 'calibrate' our simple model to derive estimates of this welfare loss. These results are undoubtedly model-specific (and our model has so little structure that we make no strong claim as to its 'realism'). Second, we identify a second-best problem relating to the optimal composition of a monetary union. We find that only when supply shocks are perfectly correlated across countries will it necessarily be optimal for all members of the union to have the same transmission mechanism and the same preference parameters. This result is likely to be more general.

We focus on stabilisation policy in response only to real shocks, a choice that we justify on both practical and theoretical grounds.[(1)] Bayoumi and Eichengreen (1994) use the structural VAR method of Blanchard and Quah (1989) to identify and then compare primitive shocks to demand and supply in a number of different economies. Although the

(1) We ignore any stabilisation from fiscal policy, and the possibility that after EMU both the transmission mechanisms and correlation between supply shocks across countries may change.

application and interpretation of SVARs is not without its critics – see, for example, Buiter (1995) and Rudebusch (1996) – a concern has emerged from that literature that supply shocks may be important. And within Europe, there is some evidence that real shocks (outside a core group of countries) may be largely asymmetric. In our calculations we use two alternative sets of (we hope) plausible values for the size and the degree of symmetry of the shocks. It turns out, not surprisingly, that our conclusions are sensitive to these numbers, and primarily to the size of the shocks.

In terms of the theoretical framework that we adopt, it would be straightforward to extend the model in a number of more realistic directions, for example to incorporate money demand shocks (see Persson and Tabellini (1995b)), but that would make the calculations in the second part of the paper rather unwieldy, and our conclusions less sharp. However, ignoring this extension may not affect our qualitative results too much. It is well known, following the analyses of Poole (1970) and Boyer (1978) and much subsequent work, that in the face of such shocks, what is optimal for countries separately (namely nominal interest rate pegging, or exchange rate pegging) remains so for all countries jointly.(2) Supply shocks, then, seem to be an interesting focus for the current paper.

One final word of caution. Although the framework that we use is simple and transparent, and leads to fairly sharp conclusions, it is open to serious criticism. For instance, some will feel uncomfortable with the lack of microfoundations. And as Obstfeld and Rogoff (1996) suggest, it is not clear, in a general equilibrium set-up, even one with Keynesian features, that the conclusions of the policy coordination/stabilisation literature which we implicitly draw upon (see, for example, Canzoneri and Henderson (1991)), will be robust. Such general equilibrium analyses have not yet, to our knowledge, been carried out. Others may feel that the shocks we use are not a good representation of the actual shocks that policy-makers face in their regular deliberations on the conduct of monetary policy. Still others might feel that stabilisation policy is only of second-order importance in welfare terms (see, for

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(2) What matters then is the total joint money stock, and not the countrywise decomposition.

example, Lucas (1987) or Atkeson and Phelan (1994)). These points are clearly important, and we could at best offer only a partial defence. Our principal justification for proceeding as we do is that the model we use is still popular, particularly amongst economists with an explicit policy slant to their analyses.(3) That being the case, the quantitative implication of these models would appear to be of interest.

In Section 1 we set out a simple model of optimal domestic monetary policy. In Section 2 we look at monetary policy in two characterisations of EMU. We then compare welfare across these three regimes. In Section 3 we discuss the selection of plausible values for each of our model parameters. In Section 4 we set out an intuitive metric for comparing welfare across different monetary policy regimes, based on equivalent falls in GDP below the natural rate. In Section 5 we present our baseline results, and in Section 6 we extend these by asking what factors influence the optimal structure of monetary union. In our model the answer, perhaps rather obviously, is that in an ideal world all member countries are identical in all respects (they have identical transmission mechanisms, identical preferences and face, period by period, an identical supply shock). Perhaps less obvious is that, where one member differs in some respect from the others (perhaps because it faces a different supply shock), it is most likely optimal for it to differ in other respects also. This is an application of the theory of second best. Section 7 summarises and concludes.

(3) See, for example, recent papers by Walsh (1995), Svensson (1997), Persson and Tabellini (1993) and King (1997).

1 Optimal domestic policy

In this section we derive the expected loss under the optimal domestic monetary policy rule. We use the simplest possible model of the policy trade-off facing a monetary authority in the face of shocks to the supply side of the economy. The set-up of the model is fairly standard. At the beginning of each period agents enter into (sticky) nominal wage contracts. Subsequently a supply-side shock is realised. The policy-maker, who we assume has no inflation bias, observes the supply shock perfectly. He may choose partly to offset this. In general, a positive supply-side shock will drive inflation below, and push output above, target. Fully offsetting the inflation surprise allows the authorities to meet their inflation objective, but it entails the full effect of the shock feeding through to output. Optimally, the policy-maker will balance the loss from both targets. This trade-off is implicit in the quadratic loss function (L), and is represented by the parameter f.

$$L_t = 0.5(1-f)(p_t - \bar{p})^2 + 0.5f(y_t - \bar{y})^2 \qquad \textbf{(1)}$$

Time t output in the home country (y_t) is equal to a constant ($\bar{y}$) plus some proportion of an inflation surprise (p - p^e), and a mean zero shock, e_t. This can be viewed as either one-off or permanent. The key point is that the effect is temporary since next period agents can correct for the 'error'. That is,

$$y_t = \bar{y}_t + a\left(p_t - p_t^e\right) + e_t \qquad \textbf{(2)}$$

We assume that the authority controls the inflation rate directly. Minimising **(1)** subject to **(2)** yields the authority's reaction function:

$$p_t = \frac{1-f}{1+a^2 f - f}\bar{p} + \frac{a^2 f}{1+a^2 f - f}p^e - \frac{a f}{1+a^2 f - f}e_t \qquad \textbf{(3)}$$

p^e is the rate of inflation expected by the private sector when wage contracts are set. Taking rational expectations across **(3)** and rearranging, we find that $p^e = \bar{p}$ (the intuition is that, on average, output is equal to the desired rate so there is no inflation bias). Using this result and substituting in **(2)** gives the optimal outturns $\hat{p}_t$ and $\hat{y}_t$ for inflation and output respectively:

$$\hat{p}_t = \bar{p} - \frac{a\,f}{1 + a^2 f - f} e_t \qquad \textbf{(4)}$$

$$\hat{y}_t = \bar{y} + \frac{1 - f}{1 + a^2 f - f} e_t \qquad \textbf{(5)}$$

So long as the authority puts some weight on output ($f > 0$) and output is responsive to inflation surprises ($a > 0$), then the coefficient on e_t in **(5)** is less than unity. By implication, some of the effects of an adverse supply shock will take the form of higher-than-expected inflation.

The expected loss under optimal domestic policy follows immediately:

$$E(L) = \frac{f(1 - f)}{2(1 + a^2 f - f)} s_e^2 \qquad \textbf{(6)}$$

(6) gives the cost of output/inflation variability when a country is free to conduct optimal stabilisation. It is the benchmark against which loss functions associated with alternative forms of EMU will be compared. It is clear that there is no mention here of the exchange rate or indeed any other international considerations (such as factor mobility). We need to justify this position, and we do so on practical grounds. To calibrate a model of the policy-making problem as simply as possible we need to minimise the number of parameters for which we need to find values. By excluding equations for PPP and UIP (and keeping the loss function as a function of only output and inflation, and not exchange rates) we achieve this. Fortunately, this may not be such a harmful simplification as it first appears.

While theoretical analyses (eg Canzoneri and Henderson (1991)) tend to suggest that countries should set policy co-operatively, empirical analyses indicate that the incremental benefit to such co-operation over the welfare outcome associated with the best non-cooperative policies is probably positive but also likely to be limited. There are two basic reasons for this. First, the linkages between economies are generally such that the spillover effects are small. Second, empirical work suggests that poor economic performance in the past often has at its root poorly designed domestic policies, and has not primarily resulted from a lack of policy coordination across countries. In other words, **(6)** may be a fair approximation of the best achievable outturn. At any rate, we proceed on this basis. (4)

2 Two models of EMU

In this section we consider two alternative specifications for the preferences of our hypothetical European monetary authority (or EMA). In model 1, the authority chooses an inflation rate to minimise the weighted sum of each country's own loss function. This is analytically analogous to a situation where the governor of each central bank votes according to the optimal policy in his or her own country, based on their own unique transmission mechanism and output/inflation preferences. In model 2, we envisage a union where committee members no longer have explicit regional commitments, but focus instead on deviations in aggregate EU output from target. It is clear that both models are stylised representations (or even caricatures?) of any actual or proposed monetary union decision-making structures. Nevertheless, they highlight some interesting interactions. For instance, as we shall see (in Section 6), models 1 and 2 have quite different implications for the treatment of asymmetric shocks when structural parameters differ.

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(4) See Hughes-Hallet (1986, 1987, 1993) for detailed analyses of these issues, including the benefits of coordination. Nolan and Schaling (1996) provides a brief review of the theoretical and empirical policy coordination literature.

2.1 EMU model 1

There are *n* member states indexed by *i*. Each has a loss function (L_i) where:

$$L_i = 0.5(1 - f_i)(p - \bar{p})^2 + 0.5 f_i (y_i - \bar{y}_i)^2 \qquad \textbf{(7)}$$

The fact that there is no *i* subscript on p or $\bar{p}$ implies that all members have a common inflation rate (because there is only one monetary policy[(5)]) and a common inflation target. Output in each country is given by a Phillips curve:

$$y_i = \bar{y}_i + a_i \left(p - p^e\right) + e_i \qquad \textbf{(8)}$$

No restrictions are placed on $E(e_i e_j)$ $\forall$ i,j. If these terms are large (*i.e.*, there is a high degree of 'commonality' between supply shocks), we would conclude that spillover effects are favourable. Member states would tend to want similar stabilisation policies, period by period, thus reducing the welfare cost of EMU.

The European monetary authority (as social planner) assigns a weight g_i to country *i*'s utility such that $\sum g_i = 1$. Now the aggregate loss under model 1 $\left(L_{EMU1}\right)$ is given by:

$$\begin{aligned} L_{EMU1} &= \sum_{i=1}^{n} g_i L_i \\ &= 0.5 \sum_{i=1}^{n} g_i (1 - f_i)(p - \bar{p})^2 + 0.5 \sum_{i=1}^{n} g_i f_i (y_i - \bar{y}_i)^2 \end{aligned} \qquad \textbf{(9)}$$

(5) Strictly, a common monetary policy is not a sufficient condition for a single inflation rate (as measured by, for example, the CPI). We must assume also that the law of one price holds and that each country consumes an identical basket of goods.

As before, there is no output bias so $p^e = \bar{p}$. Using this in **(9)** the EMA must solve:

$$\min_{p} L_{EMU1} = 0.5\sum_{i=1}^{n} g_i (1 - f_i)(p - \bar{p})^2 + 0.5\sum_{i=1}^{n} g_i f_i \left[a_i (p - \bar{p}) + e_i\right]^2 \qquad \textbf{(10)}$$

Differentiating with respect to p and rearranging yields the optimal inflation rate under model 1 $(\hat{p}_{EMU1})$:

$$\hat{p}_{EMU1} = \bar{p} - \frac{\sum_{i=1}^{n} a_i f_i g_i e_i}{1 + \sum_{i=1}^{n} a_i^2 f_i g_i - \sum_{i=1}^{n} f_i g_i} \qquad \textbf{(11)}$$

Putting **(11)** in **(8)** gives the per-period level of country 1 output under model 1, $y_{1,EMU1}$:

$$y_{1,EMU1} = \bar{y}_1 - a_1 \left[\frac{\sum_{i=2}^{n} a_i f_i g_i e_i}{1 + \sum_{i=1}^{n} a_i^2 f_i g_i - \sum_{i=1}^{n} f_i g_i} \right] + \left[1 - \frac{a_1^2 f_1 g_1}{1 + \sum_{i=1}^{n} a_i^2 f_i g_i - \sum_{i=1}^{n} f_i g_i} \right] e_1 \qquad \textbf{(12)}$$

Note that so long as country 1's output is responsive to inflation surprises ($a_1 > 0$), it puts some weight on the output target ($f_1 > 0$) and its welfare counts in the EMA decisions ($g_1 > 0$), then country 1's shock will be at least partly stabilised (the coefficient on e_1 lies between zero and unity). Putting **(11)** and **(12)** into country 1's loss function and taking expectations we obtain the expected loss:

$$E\left(L_{1,EMU1}\right)=\frac{1-f_1}{2(1+r)^2}\sum_{i=1}^{n}\sum_{j=1}^{n}a_i a_j f_i f_j g_i g_j s_{e_i e_j}+$$

$$\frac{f_1}{2(1+r)^2}\left[\begin{array}{l}\left(1+r-a_1^2 f_1 g_1\right)^2 s_{e_1}^2\\ -2a_1\left(1+r-a_1^2 f_1 g_1\right)\sum_{i=2}^{n}a_i f_i g_i s_{e_1 e_i}+\\ a_1^2\sum_{i=2}^{n}\sum_{j=2}^{n}a_i a_j f_i f_j g_i g_j s_{e_i e_j}\end{array}\right] \qquad \textbf{(13)}$$

where $r=\sum_{i=1}^{n}a_i^2 f_i g_i-\sum_{i=1}^{n}f_i g_i$ is a constant and $s_{e_i e_j}$ gives the covariance between country *i* and country *j* supply shocks (or the variance of country *i* shocks when *i* = *j*).

(13) looks a rather unwieldy expression, but does in fact have a rather intuitive interpretation. The first term (not in square brackets, and pre-multiplied by 1 - f_1) gives the welfare loss arising from inflation variability. This varies directly with the degree of correlation amongst supply shocks. That is because, in this model, monetary policy is more likely to be activist when there is a high degree of consensus (so the $s_{e_i e_j}$ terms are large and most of the union wants stabilisation to go in the same direction).

The second term (in square brackets, and pre-multiplied by f_1) gives the welfare loss arising from output variability. This is high when $s_{e_1}^2$ is high and g_1 is low (in other words, when country 1 shocks are large but it has little influence over EMA choices). The second and third parts state that losses from output variability will be higher still when: (i) $s_{e_1 e_i}$ is low for all *i* (country 1 shocks do not covary with other countries'), but (ii) $s_{e_i e_j}$ is high (for $i, j \neq 1$) so that other countries' shocks do covary amongst themselves. In that kind of set-up, country 1 would consistently be outvoted by a core group of countries who have all suffered a similar shock and hence want a broadly similar monetary policy. Note that this effect is mitigated when a_1 is small, since country 1 output would be insulated from inflation surprises (we look in some detail at the importance of the a parameter in Section 6).

From **(13)** the welfare cost implications for country 1 (or any country in the union) of expanding the union (raising n) are uncertain. First, adding an extra country would probably lower g, which captures the importance of country1 in the social planner's welfare function, thus making EMU less attractive. Second, and perhaps more importantly, it would give us a whole new set of covariance parameters. Let the new country be indexed by c. If country c were 'close' to country 1 ($s_{e_1 e_c}$ large) that would tend to depress the net cost of EMU. If country c were 'distant' from country 1 and 'close' to other members ($s_{e_1 e_c}$ small but $s_{e_i e_c}$ large for 1 < i < c) that would tend to raise the net cost of EMU.

2.2 EMU model 2

Now the focus is on aggregate output. The loss function is written as:

$$L_{EMU\,2} = 0.5\frac{1}{n}\sum_{i=1}^{n}(1-f_i)(p-\bar{p})^2 + 0.5\frac{1}{n}\sum_{i=1}^{n} f_i\left[\sum_{i=1}^{n} d_i\left(y_i-\bar{y}_i\right)\right]^2 \qquad \textbf{(14)}$$

The EMA's weight on output is a simple average of the f parameters in each member state. d is a country's share in union-wide GDP. Then, if y_i and $\bar{y}_i$ are measured in natural logs, the term in square brackets will give the percentage deviation of total EU output from target. To see this, note that a 10% shock to country 2 output coupled with a 4% shock to country 1 output would raise EU output by approximately 8% *if* country 2 were twice the size of country 1 $\left(0.10 * \frac{2}{3} + 0.04 * \frac{1}{3} = 0.08\right)$.

The Phillips curves are as before:

$$y_i = \bar{y}_i + a_i\left(p - p^e\right) + e_i \qquad \textbf{(15)}$$

Using the fact that $p^e = \bar{p}$ in **(15)** and substituting into **(14)** the EMA must solve:

$$\min_{p} L_{EMU2} = 0.5\frac{1}{n}\sum_{i=1}^{n}(1 - f_i)(p - \bar{p})^2 + 0.5\frac{1}{n}\sum_{i=1}^{n} f_i\left[\sum_{i=1}^{n} d_i a_i(p - \bar{p}) + d_i e_i\right]^2 \qquad \textbf{(16)}$$

Differentiating with respect to p and rearranging yields the optimal inflation rate across the union under model 2 $\left(\hat{p}_{EMU2}\right)$:

$$\hat{p}_{EMU2} = \bar{p} - \left(\frac{f_a a_w}{1+q}\right)\sum_{i=1}^{n} d_i e_i \qquad \textbf{(17)}$$

where $q = \frac{1}{n}\sum_{i=1}^{n} f_i \sum_{i=1}^{n} d_i a_i^2 - \frac{1}{n}\sum_{i=1}^{n} f_i$ is a constant

$f_a = \frac{1}{n}\sum_{i=1}^{n} f_i$ is the average f parameter

and $a_w = \sum_{i=1}^{n} d_i a_i$ gives the impact on aggregate EU output of a unit shock to inflation

There is some symmetry between **(17)** and **(4)**, the optimal domestic policy rule (note that $\Sigma\, d_i e_i$ is the shock to aggregate EU output). That is to be expected, since in model 2 the union is behaving as a single country, rather than a set of governors representing member states each with a different vote.

Putting **(17)** in **(15)** gives the per-period level of country 1 output, y_1:

$$y_1 = \bar{y}_1 - a_1 \left[\left(\frac{f_a a_w}{1+q} \right) \sum_{i=2}^{n} d_i e_i \right] + \left[1 - \left(\frac{f_a a_w}{1+q} \right) d_1 \right] e_1 \qquad \textbf{(18)}$$

It is interesting to compare the coefficient on the e_1 term in each of models 1 and 2 (equations **(12)** and **(18)**). In model 2, total EU output (rather than welfare in each individual country) is the focus. For that reason, stabilisation of the country 1 shock does not depend solely on the country 1 preference parameter f_1, and the response of country 1 output to inflation surprises (a_1), but rather on a weighted average of these parameters in all countries (f_a and a_w).

Finally, putting **(17)** and **(18)** into the country 1 loss function and taking expectations gives the expected country 1 loss under model 2.

$$E\left(L_{1,EMU\ 2}\right) = \frac{1-f_1}{2(1+q)^2} \left[f_a^2 a_w^2 \sum_{i=1}^{n} \sum_{j=1}^{n} d_i d_j s_{e_i e_j} \right]$$
$$+ \frac{f_1}{2(1+q)^2} \left[\begin{array}{l} (1+q - a_1 f_a a_w d_1)^2 s_{e_1}^2 \\ - 2a_1 (1+q - a_1 f_a a_w d_1) f_a a_w \sum_{i=1}^{n} d_i s_{e_1 e_i} \\ + a_1^2 f_a^2 a_w^2 \sum_{i=1}^{n} \sum_{j=1}^{n} d_i d_j s_{e_i e_j} \end{array} \right] \qquad \textbf{(19)}$$

As with equation **(13)**, the first term (pre-multiplied by 1- f_1) gives the welfare loss arising from inflation variability. The second term (pre-multiplied by f_1) gives the welfare loss arising from output variability. The intuition is broadly as before. The inflation cost will be high when shocks covary. The output cost will be high if country 1 were to find itself on the periphery of a tightly defined core ($s_{e_1 e_i}$ is small $\forall i \neq 1$ and $s_{e_i e_j}$ is large $\forall i,j \neq 1$), but low if its economy were well integrated with the other members.

3 Calibrating the model

The models set out above allow us to compare output/inflation variability under three alternative monetary regimes. To derive numerical estimates of this variability for countries using the above framework, we must first assign values to each of the structural parameters (a_i, f_i, g and $s_{e_i e_j}$ for $i,j = 1, ..., n$). These are discussed in detail below, but briefly, in order to obtain plausible parameter values for the calibration we use estimates based on recent empirical studies of the United Kingdom and other countries. In what follows we take the United Kingdom as the reference for country 1 parameter values. We note here, however, that either implicitly, as in our choice of the value of the preference parameter in the loss function, or explicitly, as in our use of estimates from an empirical study for values of the slope of our supply schedules, the ranges of uncertainty around these values are considerable. And indeed the Lucas critique also imparts major uncertainty into a study such as this. When we calculate the value of our loss functions below we vary substantially the value of these parameters in order, we hope, to take account of at least some of this uncertainty.

3.1 The output response to inflation surprises

Swank (1997) estimates Phillips curves for 16 economies. For example his equations imply that the UK a (a_1), is quite low relative to other countries (see Table A1.1, Appendix 1). The result that both French and German output are more responsive to inflation surprises is consistent with other empirical work.(6) It also has some intuition if we accept that a longer history of credible monetary policy has encouraged more workers to lock themselves in to longer nominal wage contracts, in the manner suggested by Gray (1978). However, the slope of the short-run Phillips curve will depend on many factors in addition to this.

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(6) See for example Ball, Mankiw and Romer (1988), and Britton and Whitley (1997).

3.2 Output/inflation preferences

Each f_i is the preference parameter of a particular monetary authority. For $f_1 = 0$, country 1 puts no weight on output. For $f_1 = 1$ country 1 puts no weight on inflation.

There is no single best way to measure deep preference parameters like f_i. We could take an empirical approach. Swank (1997) sets up a model, similar to ours, of a monetary authority that responds to supply shocks (taking the Phillips curve as given) and uses past output and inflation outturns to provide econometric estimates of f (he obtains $f_1 =$ 0.83 for the United Kingdom). At a more theoretical level, we might use work by Feldstein (1996) which looks at the welfare costs of small positive rates of inflation (as distinct from price stability). A recent Bank of England paper – Bakhshi, Haldane and Hatch (1997) – applies this method to the UK economy.(7) They suggest that cutting inflation by 1 percentage point would, by removing tax distortions, raise output by 0.25% in steady state. That is consistent with a f_1 close to 0.8. Such derivations are vulnerable to criticism on the grounds that 'true' preferences cannot necessarily be read off an empirical measure of the costs of inflation. We nevertheless set $f_1 = 0.8$ as our benchmark. This figure was also used in King (1996).(8) For reasons of symmetry, we set $f_i = 0.8$ in all cases. It might be argued that other countries (and notably Germany) place more weight on deviations from the inflation target than the United Kingdom ($f_i < f_1$), but there is little evidence to support this.(9) Nevertheless, as a diagnostic, we consider a range of values for the f parameters.

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(7) Bakhshi, Haldane and Hatch (1997) 'Some costs and benefits of price stability in the United Kingdom'. Paper presented at the NBER conference on price stability (also available in the *Bank of England Working Paper* series, No 78).
(8) King (1996) 'How should central banks reduce inflation? - conceptual issues', in *Achieving price stability*, Federal Reserve Bank of Kansas City.
(9) See Alesina and Summers (1993).

3.3 Relative bargaining strength

If the European monetary authority (EMA) is modelled as a benign social planner, one might take the view that g reflects the size of the country's economy relative to all countries participating in EMU. Then g_i in model 1 would take on the same values as d_i in model 2 (but models 1 and 2 still have important differences, as we demonstrate below). Another possibility is that g_i depend on the number of votes given to each member state at the Council of Ministers.(10)

3.4 Variances and covariances of supply shocks

Bayoumi and Eichengreen (1994), hereafter BE, provide estimates of structural vector auto regressions (SVARs) in output and prices for a number of EU countries. By comparing their time series for UK and other supply shocks (identification is based on the assumption that supply shocks have a permanent effect on output) we obtained estimates of $s_{e_i e_j}$ for $i, j = 1,...,n$. These are presented in Table A1.2 (Appendix 1). We note that BE, who use data prior to German reunification, find that UK supply shocks are (i) larger and (ii) less well correlated with the EU core than is found in a more recent paper by Chadha and Hudson (1998). Such differences, as we discuss below, have important implications for the cost estimates in section 5.

(10) In the event, these two alternative definitions gave almost identical results. Not surprisingly, a country's share of the vote at the Council of Ministers appears closely related to its share of EU-wide GDP.

4 From 'utils' to GDP space

Armed with a range of values for the structural parameters we can now estimate the net cost of EMU in terms of utils. Clearly this is not 'user-friendly'. We can provide a more intuitive metric against which to gauge the 'cost' of EMU (ie the additional volatility of output and inflation that derives from differential responses across regimes to primitive supply-side disturbances). We do this by asking what permanent reduction in expected output below $\bar{y}$ would cause a level of disutility equivalent to joining EMU (under model 1 or model 2). That is, the reduction in utility is measured in output space whereas clearly in actuality output will on average be at its natural rate, whether in or out of EMU. In other words, money is neutral 'in the long run' in this model.

Let l be the reduction in output that is equivalent to this additional volatility. In this case, then, we need to solve, for l, the following expression:

$$E(L_E) = E\left[\frac{1-f_1}{2}(\hat{p}-\bar{p})^2 + \frac{f_1}{2}(\hat{y}-\bar{y}-l)^2\right] \qquad \textbf{(20)}$$

L_E is the loss under EMU, $\hat{p}$ and $\hat{y}$ are, respectively, the optimal inflation rate and output level when a country is free to stabilise (these depend on e_1). Substituting from **(4)** and **(5)** for $\hat{p}$ and $\hat{y}$ we note that, since the expected value of the cross product terms in the second expansion is zero, this reduces to:

$$E(L_E) = E(L_D) + \frac{f}{2}l^2$$

$$l = \sqrt{\frac{2[E(L_E)-E(L_D)]}{f}} \qquad \textbf{(21)}$$

L_D is the (minimised) loss under optimal domestic policy. So the 'GDP cost' of EMU is a non-linear transformation of the additional expected loss in util terms.

5 Results

Table 1
Estimates of welfare loss from additional output and inflation variability due to loss of monetary autonomy

Share of GDP (per cent)

EMU model 1	**Baseline[(a)]**	**1.16**
Range	Upper[(b)]	1.79
	Lower[(b)]	0.68
EMU model 2	**Baseline[(a)]**	**1.08**
Range	Upper[(b)]	2.06
	Lower[(b)]	0.62

Notes: (a) All parameters are as shown in Appendix 1
(b) a parameters may vary from one half to double their estimated value. f parameters in countries other than the United Kingdom may vary from 0.7 to 0.9. The set of other members is assumed to include at least France and Germany, but then may include any combination of the other nine countries listed in Appendix 1, Table A1.2.

Table 1 gives a range of estimates for the permanent reduction in GDP that is equivalent to the additional output/inflation variability associated with the two alternative forms of EMU outlined above. Of course this range is not in any sense a 'complete' measure of the cost of monetary union since we do not vary the structure of the model that we use, nor do we try to assess any of the other costs associated with EMU.[(11)] Our

(11) In particular we note that ignoring demand shocks and a role for fiscal stabilisation policy are important omissions from our simple analysis.

benchmark calculations assume that country 1 joins with a group of eleven countries. Given the uncertainties surrounding the chosen parameter values, we would not want to place much weight on these point estimates. At this stage we note simply that the cost to country 1 of joining under model 2 looks to be a little lower than under model 1. This result is discussed in Section 6.

We also derive a range of values for the country 1 stabilisation cost by allowing some variation in both the structural parameters (a and f) *and* the set of other members. On this basis, the cost looks to be equivalent to a permanent reduction in GDP of between 0.6% and 2.0%. In this paper, we do not present results based on alternative estimates of the variance-covariance matrix of supply shocks. However some recent internal Bank work finds that the size of the UK shock may be a little smaller than in Bayoumi and Eichengreen (1994). Using this alternative figure lowers the stabilisation cost quite considerably. Losing the ability to stabilise one's own economy is obviously less burdensome if supply shocks are small.

6. An 'ideal' European monetary authority?

An obvious question to ask is 'who would make the best partner in a monetary union?'. Here we show that the first-best solution would be a partner who was identical in all respects. However, when that partner differs in any one respect it need not be desirable, and in general will be undesirable, for them to be alike in any remaining aspects. This is an example of a second-best problem. We then go on below to look at a simple two country monetary union where, for sake of argument, country 1 joins with one other country alone. That makes it easier to provide intuitive answers to questions, involving these second-best issues, such as: 'How should policy decisions be taken (ie do we prefer model 1 or model 2)?' and 'other things constant, what is the optimal structure of a monetary union?'.

With only two economies we can think of the two shocks e_1 and e_2 as the sum of common (h) and idiosyncratic (e_i) components. That is:

$$e_1 = h + e_1 \quad \textbf{(22)}$$

$$e_2 = h + e_2 \quad \textbf{(23)}$$

Where $\quad E(h.e_1) = E(h.e_2) = E(e_1.e_2) = 0 \quad$ **(24)**

The three variance parameters $\left(s_{e_1}^2, s_{e_2}^2 \text{ and } s_h^2\right)$ can easily be recovered from the time series properties of the BE shocks (e_1 and e_2) by squaring **(22)** and **(23)**, taking expectations and using the orthogonality condition **(24)**. For the remainder of this paper, we shall use the [e_1, e_2] and [h, e_1, e_2] notation interchangeably. Observing that e_1 and e_2 were perfectly correlated we would, in the new terminology, find that both $s_{e_1}^2$ and $s_{e_2}^2$ were zero (there were no idiosyncratic components). Observing that e_1 and e_2 were completely unrelated, we would find that s_h^2 was zero (there was no common component).

Putting the new shock notation in **(11)** and **(12)** and setting $n = 2$, we obtain expressions for the common inflation rate and country 1 output under EMU model 1:

$$\hat{p}_{EMU1} = \bar{p} - \left[\frac{(a_1 f_1 g_1 + a_2 f_2 g_2)h + a_1 f_1 g_1 e_1 + a_2 f_2 g_2 e_2}{1 + a_1^2 f_1 g_1 + a_2^2 f_2 g_2 - f_1 g_1 - f_2 g_2}\right] \quad \textbf{(11')}$$

$$y_{1,EMU1} = \bar{y}_1 - a_1\left[\frac{(a_1 f_1 g_1 + a_2 f_2 g_2)h + a_1 f_1 g_1 e_1 + a_2 f_2 g_2 e_2}{1 + a_1^2 f_1 g_1 + a_2^2 f_2 g_2 - f_1 g_1 - f_2 g_2}\right] + h + e_1 \quad \textbf{(12')}$$

Putting the new shock notation in **(17)** and **(18)** and setting n = 2, we obtain expressions for the common inflation rate and country 1 output under EMU model 2:

$$\hat{p}_{EMU2} = \bar{p} - \left[\frac{0.5(f_1 + f_2)(d_1 a_1 + d_2 a_2)(2h + d_1 e_1 + d_2 e_2)}{1 + 0.5(f_1 + f_2)(d_1 a_1 + d_2 a_2)^2 - 0.5(f_1 + f_2)} \right] \qquad \textbf{(17')}$$

$$y_{1,EMU2} = \bar{y}_1 - a_1 \left[\frac{0.5(f_1 + f_2)(d_1 a_1 + d_2 a_2)(2h + d_1 e_1 + d_2 e_2)}{1 + 0.5(f_1 + f_2)(d_1 a_1 + d_2 a_2)^2 - 0.5(f_1 + f_2)} \right] \qquad \textbf{(18')}$$
$$+ h + e_1$$

6.1 The United Kingdom's preferred institutional structure

The results in Table 1 suggest that country 1 would be better off under model 2 where the EMA targets aggregate EU output. It turns out that this is driven primarily by the fact that country 1 output appears to be less responsive to inflation surprises than the norm (in fact the UK a, the baseline for country 1 parameter values, is estimated to be lower than the a parameter in all countries other than Ireland and Italy).

Consider the following scenario: let h = 0, e_1 = 0.01 and e_2 = -0.01 (there is no common shock, idiosyncratic shocks are equal and opposite). Moreover, assume that d_1 = d_2 = 0.5 (the economies are identical in size). Let a_2 = 1.367, the average across the group of eleven initial EMU members.

Putting these values into **(11')**, **(12')**, **(17')** and **(18')** we obtain the following expressions for the common inflation rate and country 1 output under EMU models 1 and 2.

$$\hat{p}_{EMU1} = \bar{p} - \left[\frac{0.01(a_1 f_1 g_1 - a_2 f_2 g_2)}{1 + a_1^2 f_1 g_1 + a_2^2 f_2 g_2 - f_1 g_1 - f_2 g_2} \right] \qquad \textbf{(11'')}$$

$$y_{1,EMU1} = \bar{y}_1 - a_1 \left[\frac{0.01(a_1 f_1 g_1 - a_2 f_2 g_2)}{1 + a_1^2 f_1 g_1 + a_2^2 f_2 g_2 - f_1 g_1 - f_2 g_2} \right] + 0.01 \quad \textbf{(12'')}$$

$$\hat{p}_{EMU2} = \bar{p} \quad \textbf{(17'')}$$

$$y_{1,EMU2} = \bar{y}_1 + 0.01 \quad \textbf{(18'')}$$

For $h = 0$, $e_1 = 0.01$ and $e_2 = -0.01$ there is a conflict of interest. Country 1 has suffered a positive supply shock and would like a tighter monetary policy. Country 2 has suffered a negative supply shock and would like a looser monetary policy. Whose preferences dominate?

Since our parameter estimates are such that $a_1 f_1 g_1 < a_2 f_2 g_2$, the social planner (model 1) would always push for a small rise above $\bar{p}$ (equation **(11'')**). The justification is simply that output would rise by more in country 2 than it would fall in country 1($a_2 > a_1$). Conversely, under model 2 we set $p = \bar{p}$ (equation **(17'')**) because there is no aggregate shock. While EMU model 1 is socially optimal (given the welfare weights implicit in g_i for $i = 1, \ldots, n$) country 1 will always lose out when shocks are offsetting and hence prefer the netting-out approach of model 2.[12]

6.2 Optimal degree of conservativeness in other countries

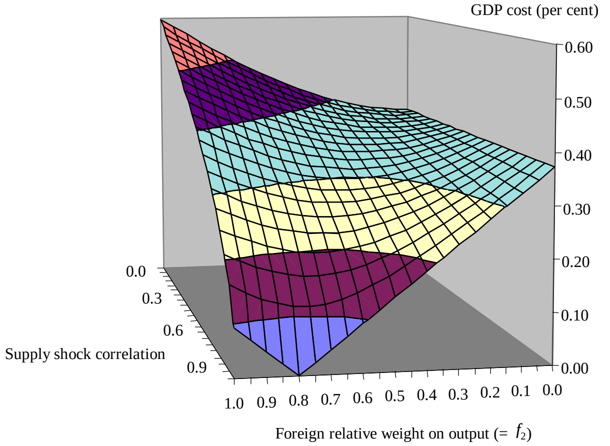
It is often argued that countries would prefer partners in a monetary union to have similar structural parameters (here a_i and f_i). In our work, as demonstrated above, this result emerges only as a special case. Consider a union between two almost identical economies which differ only in that supply shocks are (possibly) asymmetric and the preference parameters (possibly) differ. More precisely, let $a_1 = a_2 = 1$, $g_1 = g_2 = 0.5$ and $s_{e_1}^2 = s_{e_2}^2$ (so supply shocks, on average, are of the same magnitude). The first two assumptions make model 1 and 2

(12) Along with any other countries where output is not that responsive to inflation surprises (a_i is small).

identical, for present purposes. For simplicity we label country 1 'home' and country 2 'foreign'.

The three-dimensional chart below shows how the cost of joining EMU would, given the above set of parameters, vary with the foreign country's relative weight on output (which runs from right to left) and the correlation between e_1 and e_2 (which runs from back to front).

Chart 1
Optimal degree of foreign inflation aversion (given $a_1 = a_2$)



We note three things in particular. First, at $f_2 = 0$, the cost of a monetary union is invariant to the degree of correlation between supply shocks. When the foreign country is infinitely conservative (and puts no weight on output), it will always vote against stabilisation. It makes no odds, from the home country perspective, whether the shock is common or not. The 'cost' of forming a monetary union would depend only on

$\sigma^2_{e_1}$ and bargaining strength (γ) in model 1, or the number of countries in the union in model 2. Second, the cost of monetary union is zero at ϕ_2 = 0.8 and a correlation coefficient of unity. Given the assumptions about α, γ and the magnitude of supply shocks, the economies are then identical. Losing monetary autonomy imposes no cost because the foreign country would want the same response period by period anyway. Third, as the degree of correlation falls towards zero we would like the foreign country to be more inflation averse (have a lower ϕ_2).(13) It is worth taking a moment to consider why we might prefer other countries to have differing views about the relative importance of output/inflation stabilisation.

One clear advantage in having an *ultra*-conservative partner is that the monetary authority will no longer be asked to stabilise foreign country specific shocks (ε_2 drops out of **(11')** and **(12')** as ϕ_2 tends to zero). Such stabilisations hurt the home country first as inflation moves away from $\bar{\pi}$ and second as output moves away from $\bar{y}_1$. The downside, of course, is that whenever ϕ_2 differs from ϕ_1, the foreign country will want a different response to the common shock. The trade-off apparent in the chart is merely reflective of the fact that, as ε shocks come to dominate (the correlation between home and foreign supply shocks falls), the benefits of a low ϕ_2 begin to outweigh the costs. The analysis is given an extra twist if we relax the $\alpha_1 = \alpha_2$ assumption. If α_1 falls significantly below α_2 the home country may ultimately want the partner to be less inflation averse. The reason is that, when foreign country output is *ultra*-responsive to inflation surprises (α_2 is large), the home country becomes concerned that the foreign country will vote for minimal stabilisation of the common shock (it gets more bang for its buck). This effect can be mitigated if ϕ_2 lies above ϕ_1, so that the foreign country places a higher weight on output deviations (and wants to offset a greater

(13) There is a sequence of minima across the three-dimensional surface (ie a valley) running from ϕ_2 = 0.8, correlation = 1 at the front to ϕ_2 = 0, correlation = 0 at the back. In fact, because of the enforced symmetry between the home and foreign countries, this valley is linear in ϕ_2/correlation space: the optimal foreign ϕ is given as 0.8 times the correlation between home and foreign shocks.

proportion of the common shock). Hence we drive a wedge between the preference parameters to correct for the $a_1 \neq a_2$ distortion.

Chart 1 illustrates a second-best problem. Ideally, (i) $s_{e_1}^2 = s_{e_2}^2 = 0$ (the supply shocks are perfectly correlated), (ii) $a_1 = a_2$ and (iii) $f_1 = f_2$. But whenever a single condition fails, it becomes optimal to modify one or both of the other two.

7 Summary and conclusions

Although a large degree of uncertainty must surround the precise numbers presented, our simple framework can be used as a basis for thinking about the choice of partners in a monetary union, and about the effects of different institutional structures. One conclusion to emerge, which is more likely than the numbers to be robust across models, is that only when existing members of the union have identical structural parameters, *and* supply shocks are perfectly correlated, will it necessarily be optimal for a new member to share those same structural parameters. This illustrates the problem of second best. In a first-best world: (i) supply shocks are identical, (ii) transmission mechanisms are identical, and (iii) output/inflation preferences are identical. But we know that (i) almost certainly does not hold, and it then becomes optimal to modify (ii) and (iii).

With regard to institutional structures, we found that when policy is decided by voting representatives (model 1), stabilisation will tend to favour those economies where output is most responsive to inflation surprises (and stabilisation is ‘cheap’). For that reason, we conclude (subject, of course, to our Phillips curve estimates) that the home country, along with other countries where output is not that responsive to inflation surprises, would prefer EMU model 2. In this model shocks are netted out across countries before policy decisions are taken; no reference is made to the ‘cheapness’ with which shocks can be offset on a country-by-country basis.

Appendix 1 : Miscellaneous tables

Table A1.1
Baseline parameter values

Country	*a*	*f*	*g*
UK	0.408	0.8	0.14
AU	3.464	0.8	0.03
BE	1.494	0.8	0.03
FI	0.718	0.8	0.01
FR	2.344	0.8	0.19
DE	2.690	0.8	0.31
IR	0.205	0.8	0.01
IT	0.376	0.8	0.14
NT	0.942	0.8	0.05
PR	0.815	0.8	0.01
ES	0.623	0.8	0.07

Table A1.2
Supply shock correlations and standard deviations

	UK	AU	BE	FI	FR	DE	IR	IT	NT	PR	ES
UK	1.80										
AU	-0.25	1.80									
BE	0.12	0.56	2.80								
FI	-0.04	0.11	0.06	1.80							
FR	0.12	0.50	0.53	0.12	3.40						
DE	0.12	0.32	0.36	0.22	0.30	2.20					
IR	0.05	0.08	0.02	0.23	0.21	0.00	2.10				
IT	0.28	0.06	0.00	0.32	0.28	0.21	0.14	3.00			
NT	0.13	0.29	0.52	0.25	0.34	0.54	0.11	0.39	3.30		
PR	0.27	-0.03	0.40	0.13	0.33	0.21	0.01	0.22	0.11	6.10	
ES	0.01	0.25	0.23	0.07	0.21	0.33	0.15	0.20	0.17	0.51	5.70

Notes: (a) Source: Bayoumi and Eichengreen (1994)
(b) Numbers down the leading diagonal give the standard deviation of supply shocks (as a percentage of quarterly GDP) in each country. Off-diagonal elements are the correlation coefficients.

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