EVALUATING THE GAINS TO COOPERATION IN THE G-3

Guglielmo Maria Caporale
South Bank University, London

Michael Chui
Bank of England

Stephen G. Hall
Imperial College, London

Brian Henry
Oxford University

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A model of the G-3 is introduced which has a transparent structure including a simple but analytically tractable supply side. New optimising techniques are used to conduct extensive policy experiments on this multicountry model (including full Nash solutions and a fully cooperative solution). In the case of a fiscal shock originating in the US we find evidence of significant spillovers to other countries, which can only be ameliorated in the fully cooperative regime.

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Corresponding author: Professor Guglielmo Maria Caporale, South Bank University, Business School, 103 Borough Road, London SE1 0AA, UK. Tel. +44 (0)20 7815 7012. Fax: +44 (0)20 7815 8226. E-mail: g.m.caporale@sbu.ac.uk

1. Introduction

The background to the present study is the widespread view that the gains to policy coordination are small. The theoretical literature suggests that there is a distinct possibility of Pareto improving gains from international coordination (see, e.g., Hamada (1976)). However, most empirical studies reach the conclusion that the spillovers from one country's policy actions to another country's economic performance are small, and a general view has developed that, in practice, policy coordination is unlikely to be of much benefit to the international community. This paper argues that spillovers may be larger than often thought, the main reason for this being that policy reactions between countries need to be considered in addition to the traditional international transmission mechanisms, such as trade links.

More accurately, the existing empirical literature on the size of spillovers is characterised by some variability of findings. Partly, this reflects a diversity in empirical modelling methods, various calibration and estimation techniques being used, so it is not surprising that the estimated responses to exogenous shocks should differ between them. Most studies, though, conclude that large gains are not likely to be obtained. For instance, in their seminal paper Oudiz and Sachs (1984) estimated that the gains from cooperative versus non-cooperative policy might be of the order of 0.5 percent of real GDP, or less. Qualitatively similar results are reported by, inter alia, Hughes Hallett (1986), Currie, Levine and Vidalis (1987), and Currie, Holtham and Hughes Hallett (1989), although the exact estimated size is sensitive to the model being used. Despite this general consensus in the empirical literature, Canzoneri and Henderson (1991) take the view that "the jury is still out", since theory suggests the possibility of larger gains.

The present paper revisits this question by distinguishing between the effects of exogenous shocks and policy induced changes. More specifically, much previous empirical work has concentrated on exogenous shocks to a given country, which produce effects on domestic output and inflation, and in turn produce spillovers through price changes, alterations in bilateral exchange rates, and changes in net trade. We argue that this kind of analysis is incomplete, because asymmetric shocks initially impinging upon one country will affect policy setting not only there, but also in other countries. By incorporating both optimal policy responses by countries and strategic interactions our approach differs in a substantial way from other studies of international policy coordination. In order to undertake this kind of policy analysis, we estimate an empirical model for the G-3 economies which incorporates a consistent supply side and fiscal and monetary policy rules. This enables us to investigate the consequences of policy shocks originating from one country and then having an impact upon the aggregate supply curve of other countries, such supply-side spillovers not having been thoroughly investigated in previous studies. In addition, we introduce a new technique involving antithetic errors to substantially reduce the number of replications needed to compute optimal policy reaction functions of the proportional, integral and derivative (PID) sort, which are used to achieve model closure.

The layout of the paper is as follows. Section 2 briefly reviews some of the previous findings in the literature on policy coordination. Section 3 outlines a new econometric model of the G-3 economies. Section 4 discusses the methodology applied when conducting policy analysis. The policy simulations are presented in Section 5. Some concluding remarks are offered in Section 6.

2. Previous studies on the role of policy coordination

There are two main approaches to evaluating the welfare effects of policy cooperation. The first is based on fully optimal policies which draw on the full information set available to policy-makers, whilst the second compares alternative feedback rules which draw on some subset of the full information set but are easier to implement and to monitor.

The policy optimisation approach aims to measure the size of potential gains generated by moving from a Nash non-cooperative game to Nash bargaining, so is an application of game theory to economics. Studies of this type include, in addition to those cited earlier, Sachs and McKibbin (1985), Ishii, McKibbin and Sachs (1985), and others (see Caporale (1996) for a review). The second approach evaluates the welfare effects of alternative international regimes, which are characterised in terms of policy rules (see, e.g., Currie and Wren-Lewis (1989, 1990), McKinnon (1984, 1988), McKibbin and Sachs (1991), Williamson and Miller (1987), Frankel (1991), Hughes Hallett, Holtham and Hutson (1989), Christodoulakis, Currie and Garratt (1996)). Of particular interest is the work of Taylor (1989, 1993), who developed a simple model of the world economy with staggered wage-setting, a linkage system with perfect capital mobility as in the Mundell-Fleming model, and time-varying risk premia in foreign exchange and capital markets. He compared policy rules using historical shocks, i.e. using the estimated variance-covariance matrix, which shows a high degree of correlation between shocks in different countries and sectors, in order to conduct empirical policy analysis. Taylor concluded that fixed rates are preferable to flexible rates, and that gains from coordination in the design of nominal GNP rules are insignificant. The main drawback of his approach is that the policy rules to be evaluated are chosen in an arbitrary manner - the reaction function (and its parameters) are not derived optimally from a loss function, but are *ad hoc*. This means that no distinction can be made between the types of game structure which may give rise to a particular rule, e.g. does the rule represent co-operative behaviour or unco-ordinated Nash behaviour. By contrast, we calculate fully optimal rules within a stochastic environment and are therefore able to fully investigate the implications of differing game structures and forms of co-operation (see Section 4).

To summarise, the available empirical evidence does not suggest very large gains from international economic policy coordination. Although there is a wide range of estimates, depending on various assumptions about the behaviour of policy-makers and private agents, and the nature of policy games, the general finding is that the gains are not of the order of magnitude one would anticipate given the game-theoretic approach to macroeconomic policy coordination. In our opinion, one possible explanation is that the existing literature has overlooked some important spillovers operating through changes in real interest rates [i], which affect decisions, and in turn the capital stock, the economy's aggregate supply, and the short-run inflation-output tradeoff as well.

3. A model of the G-3 economies

This section outlines the main features of the model of the G-3 which we use to conduct the policy simulations; full estimation details (including diagnostics) can be found in Caporale et al (1997a,b). Germany was chosen as representative of Europe, since this country was the "anchor" of the EMS (see, e.g., Fratianni and von Hagen (1990)), and the design of EMU institutions has been strongly influenced by the German model (see von Hagen (1997)). The theoretical setup combines a supply side which is based consistently upon assumptions about technology (a Cobb-Douglas production function is used for simplicity, but the model may be readily extended to other technologies (see Allen and Nixon (1995)), and a simplified, but realistic demand side. The factor demand equations and price equations are specified in a theoretically consistent way with the production function embodying all the cross equation restrictions implied by the theory (unlike the IMF's MULTIMOD or the McKibbin-Sachs model, for example). Our setup has ingredients both from New Keynesian theories and the neo-classical synthesis. Imperfect competition is assumed at the microeconomic level and wages are set by a union-firm bargain. The structure, as it is based on imperfect competition, does not determine aggregate output from the production function, but aggregate supply decisions instead determine aggregate prices relative to wages (usually referred to as the "markup" of prices on wages – see Layard, Nickell and Jackman (1991)).

To be more specific, the model comprises three country blocks, which are essentially similar in structure, although they differ by virtue of their estimated parameters of course. A distinguishing feature of the model is essentially to blend econometric estimation with a consistent and rigorous treatment of the supply side of the economy. The demand side is broadly conventional, consisting of a set of reasonably standard aggregate demand components, which sum to produce total demand. The supply side then is based around a production function and the corresponding derivation of factor demand equations and wage and price equations. The model equations embody the full set of cross equation restrictions implied by a profit maximising firm working within a constraint on total output coming from the demand side of the economy.

The methods used to estimate the model exploit systems approaches to estimating Vector Error Correction Models (VECMs). An important characteristic that we exploit is that of the reduced rank characteristic of such systems. In brief, for a set of non-stationary variables let m cointegrating vectors (CVs) exist, then we may write the model as,

$$\Delta Y_t = \boldsymbol{q}(L)\Delta Y_{t-1} + \boldsymbol{ab}' X_{t-1} + \boldsymbol{e}_t \qquad (1)$$

Where b 'X_t is the set of CVs, where X=(Y,Z), and the variables are partitioned into endogenous (Y) and weakly exogenous variables (Z). The CVs do not enter the dynamic equations for the weakly exogenous variables. Equation (1) above is then the conditional model. There is an accompanying marginal model (which we do not state here). The adjustment matrix a is of dimension n x m, but it is not typically diagonal: each dynamic equation may include more than one CV.

A schematic version of the supply side of the model is then:

(a) Long Run Equations:

$$Y = f(E, K) \qquad (2)$$

$$F_L' = W / P \qquad (3)$$

$$F_K' = r \qquad (4)$$

$$W / P = S - a_1 U \qquad (5)$$

(b) Dynamic Equations

$$\boldsymbol{q}_{11}(L)\Delta W = \boldsymbol{q}_{12}(L)\Delta P + \boldsymbol{a}_{11}(F_E^{'} - W / P) + \boldsymbol{a}_{12}(W / P + \boldsymbol{a}_1 U - S) \qquad (6)$$

$$\boldsymbol{q}_{21}(L)\Delta P = \boldsymbol{q}_{22}(L)\Delta W + \boldsymbol{a}_{21}(F_E^{'} - W / P) \qquad (7)$$

$$\boldsymbol{q}_{31}(L)\Delta E = \boldsymbol{q}_{32}(L)\Delta(W / P) + \boldsymbol{a}_{31}(F_E^{'} - W / P) + \boldsymbol{a}_{32}(Y - f(E, K)) \qquad (8)$$

$$\boldsymbol{q}_{41}(L)\Delta K = \boldsymbol{q}_{42}(L)\Delta r + \boldsymbol{a}_{43}(F_K^{'} - r) \qquad (9)$$

In these equations (2) is a production function depending on employment (E) and capital (K). (3) and (4) are the marginal conditions for employment and capital respectively. (5) is a representation of union ("supply of labour") factors, where U is unemployment and S is a vector of factors affecting the supply of labour by workers. Equation (6) - (9) are then the relevant dynamic equations. The other equation to note is the employment equation (8), where both the marginal product and the production function potentially enter. This can be accounted for by assuming that some firms are not output constrained; hence they employ workers according to a neo-classical demand function. Other firms exist which are output constrained, hence implicitly assuming that they meet the output target by varying their labour input, given K.

Short and long run and indeed aggregate supply and demand are linked through investment decisions. Capital is treated as fixed in the short run, when firms and unions make their price and wage decisions. The capital stock adjusts according to a separate equation for investment (although this is dependent on the same technology assumptions as made elsewhere in the model). A transmission mechanism of changes in monetary and fiscal policy is that they affect investment and, by the familiar accumulation equation, the capital stock and the model's supply side. Cross-equation restrictions are imposed to ensure that the capital stock does not determine the model's equilibrium level of unemployment.

The demand side follows the neo-classical synthesis. Investment is modelled as a function of the assumed technology, expected demand and the cost of finance. Consumption depends upon disposable income, interest rates and wealth, and net trade upon relative (to trading partner country's) income and competitiveness. The trade sector implements a symmetric structure, with two bilateral export equations for each country, imports for each country being given by the other countries' exports. The single asset price is the nominal exchange rate (actually, two bilateral rates between the dollar and the Yen, and the dollar and the DM), which is modelled as a "jump" variable (see Dornbusch (1976)). [ii] Hence the model exhibits overshooting in the real exchange rate (or in competitiveness) due to the combination of backward looking elements in the aggregate price setting (e.g. due to the adjustment costs of changing prices) and the forward looking behaviour of the exchange rate (see Hall (1987)).

The model is closed by fiscal and monetary policy rules. Forward-looking macro models require fiscal solvency rules and interest rate reaction functions in order to yield theoretically coherent solutions. They can only contain a rational expectations equilibrium if an intertemporal budget constraint is imposed so as to prevent a debt explosion, which is bound to occur if increases in spending are not matched by higher receipts and the nominal interest rate exceeds the growth rate of the economy. The constraint is therefore that the discounted present value of spending must equal the current stock of wealth plus the discounted value of receipts (taxes). If the constraint is violated, forward-looking agents perceive a higher default risk, and this brings about a rise in interest rates and a financial crisis, although agents also foresee that the government will not be able to deviate from a sustainable path indefinitely. Even in the presence of forward-looking behaviour, though, a solvency rule is still required, because liquidity constraints invalidate Ricardian equivalence, and hence a higher debt stock results in higher long rates and lower financial wealth held by the private sector.

The solvency rule and interest rate reaction function we use follow a general P.I.D form, the former being given by:

$$\Delta t_t = \mu_1 (x^*_{t-1} - x_{t-1}) + \mu_2 \Delta (x^*_{t-1} - x_{t-1}) + \mu_3 \Delta^2 (x^*_{t-1} - x_{t-1}) \tag{10}$$

where t is the tax rate, the μ_i (i = 1, 2, 3) are control parameters, and x and x^* are the actual and target debt to GDP ratio respectively. This rule uses direct taxes as an instrument to stabilise deviations of the budget debt stock from target. (For a full analysis of the stabilisation properties of such a rule see Bryant (1995)).The behaviour of the monetary authorities is modelled by using an inflation targeting rule, which has a proportional p, an integral i and a derivative d control element. Feedback rules, which can be seen as a restricted form of the full optimal control solution, are now widely used in macro models - their advantage is that they are simple and easy to interpret, although they are not generally robust to uncertainty (see Nixon and Hall (1996)). The rule is specified in terms of real interest rates, and hence, whenever inflation rises, the short-term interest rate also rises, therefore we have

$$\Delta r_t = \mu_\pi \, \Delta \, \varepsilon_{t-1} + \mu_i \, \varepsilon_{t-1} + \mu_d \, \Delta^2 \, \varepsilon_t \qquad (11)$$

where r is the real interest rate, $\varepsilon_t = \pi_t^* - \pi_t$ is the deviation of actual from desired inflation π, and μ's are the control parameters. The rule avoids the instability which typically occurs when nominal interest rates are fixed; in this case, expansionary policies lead to a rise in inflation and a fall in real rates, which causes a further rise in demand and inflation, and a further decrease in real rates, generating instability in the model (unless there are offsetting wealth effects). However, even a constant real interest rate policy is not necessarily stabilising; for instance, any attempt to bring the real rate back to its base value can generate instability if a fiscal shock hits the economy and results in a change in savings and in the long-term real interest rate.

4. The methodology of policy analysis

In this section we outline the optimising techniques used to do this multi-country exercise. The techniques we describe are discussed in greater detail in Hall (1997). In brief, we wish to choose the parameters of a set of rules so as to minimise the variance of the economy when it is subject to a particular set of stochastic shocks. Moreover we do this in a game setting which might involve successive optimisations over a number of players. The problem, in compact notation is then,

$$\min \ \text{var} \ (C) = \text{var}(\sum_{t=1}^{T} \Phi_t \sum_{i=1}^{n} \Theta_i Y_{it}) \tag{12}$$

$$Y_{it} = g(e,u)$$

where e is a matrix of k stochastic terms over the T periods of the model solution which have a given covariance matrix Ω_t, Y is the vector of endogenous variables in the model, Φ and Θ are weights in the cost function and u is a vector of control variables which in our case are the parameters of a control rule. In a policy game each player would have an objective function of this form.

The computational burden of this form of problem is considerable; to evaluate the variance alone needs a stochastic simulation involving thousands of conventional model solutions. This kind of solution would have to be calculated many hundreds of time during a conventional numerical optimisation. It seems that, for this reason alone, researchers have not pursued this approach to policy formulation. The innovation we propose is a simplification of the problem which will yield an identical solution for most forms of nonlinearity which are observed in large macro models. The idea here is based on the notion that any monotonic transformation of the cost function will yield an identical solution for the control variables. So if we minimise the variance of the cost function (V(.)) with respect to a set of variables u then we will have exactly the same solution for u as if we minimised a monotonic transformation of V (e.g. log (V) or V^2). We use these propositions to substantially reduce the computational problem in minimising V(.), using a special transformation based on two elements: the first is the technique of anti-thetic errors used in stochastic simulation, the second constructs a minimum set of replications which exactly reproduce the covariance matrix of the stochastic process.

Anti-thetic Errors

Anti-thetic errors are a well-known Monte Carlo technique. The basic idea is the following: instead of drawing a sequence of completely random sets of shocks, the sets of shocks are chosen in symmetric pairs so that two replications from a stochastic simulation represent an exactly symmetric pair, in terms of the shocks being applied to the model. This technique increases the efficiency of stochastic simulations enormously but even one pair gives a lot of information. For example if the model is linear then the resulting average of the endogenous variables from the two solutions will be identical to the deterministic model solution, hence any divergence from the deterministic solution is an absolute sign of non-linearity.

Minimum Set of Replications

For the moment let's assume that we are dealing with a single stochastic error term. In that case the following objective function would be our monotonic transformation of (12):

$$\min\ C^{*} = \sum_{t=1}^{t} \Phi_t \sum_{i=1}^{n} \Theta_i \left(\,|\, g(e,u) - g(0,u) \,|\, + \,|\, g(-e,u) - g(0,u) \,|\, \right) \qquad (13)$$

This objective function minimises the absolute deviation from the no shock solution after applying an arbitrary size shock to the model. The antithetic errors are represented by the two terms with plus the shock and minus the shock. Our claim is that there is a monotonic transformation between this objective function and (12). Hence the resulting optimal u will also be the solution to (12).

If we were dealing with a single error this would obviously be sufficient to give the solution we require. However, there is a further complication when the vector of errors is larger than a single scalar. The problem is that any single draw of the error vector cannot be representative of the whole distribution of errors, so it cannot represent the covariance matrix. A scalar error can have a value equal to its standard error but a vector cannot have both variances and covariances equal to the full covariance matrix. This point can be seen by considering the bivariate case. Let the covariance matrix be:

$$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \tag{14}$$

Now any single pair of shocks cannot give both the variance and covariances simultaneously. For example (1,1) has unit variances for both errors but a unit covariance, (1,0) would have a zero covariance but the variance on e_2 would also be zero. In fact, in this case it takes two sets of shocks to exactly replicate the covariance matrix. The required shocks are (1,-1), (1,1), which have unit variances for both errors and zero covariance. The anti-thetic pair corresponding to this would be (-1,1), (-1,-1). So if we were interested in solving the problem for a vector of two stochastic shocks we could do this by evaluating

$$\min \; C^* = \sum_{j=1}^{k} \; \left(\sum_{t=1}^{t} \Phi_t \sum_{i=1}^{n} \Theta_i \left(\, | \, g(e^j, u) - g(0,u) \, | + | \, g(-e^j, u) - g(0,u) \, | \, \right) \right) \tag{15}$$

where k=2 and where the two vectors of shocks (e^j) are given as above. So in this case, instead of carrying out many thousand replications to estimate the variance of c, (VAR(C)) we can achieve the same object by calculating C* based on only four model solutions. This clearly brings the possibility of using optimal control within the bounds of computational feasibility, even in a game context.

The above case is an example of how the proposed procedure would work for a case of two shocks. In the general procedure we choose a set of k vectors of shocks such that

$$\Omega = \sum_{i=1}^{k} e_i e_i \tag{16}$$

This will generally involve approximately n=k sets of shocks where n is the number of stochastic elements in the model being examined. The reason why this is only approximate is that the relationship is different for an even and odd number of shocks. The above formulae gives an exact determination of the shocks when n is odd but when it is even we need some extra conditions to uniquely determine the shocks. In the bivariate case above, for example, there are actually an infinite number of pairs which would give the required covariance matrix. This can be seen by writing out the problem in full:

$$\begin{aligned} \Omega_{11} &= e_{11}^2 + e_{21}^2 \\ \Omega_{12} &= e_{11}e_{12} + e_{21}e_{22} \\ \Omega_{22} &= e_{12}^2 + e_{22}^2 \end{aligned} \tag{17}$$

This yields 3 equations in four unknowns and so we need to impose an extra condition to uniquely determine the shocks. We propose simply setting $e_{11}^2 = \Omega_{11}$ as the extra required restriction. For an odd number of shocks we exactly determine the k vectors of errors.

The following table gives the relationship between n, the dimension of the covariance matrix, k, the minimum number of sets of shocks and r, the number of extra sets of restrictions required.

N	K	R
1	1	0
2	2	1
3	3	3
4	4	6
5	5	10
6	6	15
7	7	21

So in general, given the extra effect of the antithetic errors, we will need approximately twice the number of replications as the dimension of the covariance matrix. If we wish to calculate an optimal policy rule for a country's monetary policy given shocks to both the exchange rate in that country and shocks to the exchange rate in two other countries, we would therefore need six model solutions to evaluate the objective function we need to maximise.

The Monotonic Transformation

This proposed technique will not always give exactly the same answer as (3) above - it is possible that for a sufficiently non-linear model the mapping between (3) and (6) would cease to be monotonic and hence they would have different solutions. However, our argument is that this would require an extremely perverse and unusual form of non-linearity to be present which is not typical of any macroeconomic model.

The essence of the monotonicity assumption is that if we have any two sets of control variables, u^1 and u^2, such that

$$C^*(u^1) > C^*(u^2) \tag{18}$$

(that is, a deviation in C from its deterministic value is larger for the set of control variables u^1 than u^2), then monotonicity between the two objective functions means that

$$\mathrm{var}(C(u^1)) > \mathrm{var}(C(u^2)) \tag{19}$$

This simply amounts to the assumption that if one set of control produces larger deviations in the model variables from their deterministic values, then it will also lead to a larger variance. In our view it is almost inconceivable to think of an economic model where this would not be true.

5. The policy coordination exercises

In these exercises we consider the optimal responses to a demand shock in the US under a range of different forms of policy co-ordination for the period 1984-1994. Four quite separate forms of solutions are then compared. In the first each country reacts optimally in terms of its own monetary policy (interest rates) under the assumption that interest rates in the other two countries remain fixed.

We then investigate the consequences of implementing these three rules together. That is, each country operates on the assumption that the others will not respond but in fact they actually do. This is exactly what would happen in the international context if countries based their policy on single country domestic models, which essentially hold the international environment fixed. The third case is where each country optimises in the light of, and the knowledge of optimal behaviour in each other country - a Nash solution. In the last case we have a fully co-operative solution with equal weights on each country. In what follows we refer to the first as single country optimising, the second as multicountry I (where each of the country assumes no policy reaction from the other). The third is multicountry II (Nash) and the last is multicountry III which is a fully co-operative solution. All solutions are for the period 1984-1994.

(a) Single country optimising

In this alternative, each national authority optimises the weights of its PID monetary rule, in order to minimise the deviations of inflation from its base following the demand shock in the US. But in these exercises, in each country, policy actions are governed by the national monetary rule, and there is no policy reaction from the other countries. There are consequences for each country which flow from the actions of the others nevertheless. These take the form of the first of the spillover effects noted in our introductory section. That is, there are orthodox trade quantity and trade price effects affecting, in this case, Germany and Japan, following the US fiscal expansion. These operate through net trade and the real exchange rate. But as monetary policy in the US is tightened to counteract the inflationary effects of the fiscal stimulus there, we assume that interest rates (and hence real interest rates) do not rise elsewhere. Case (ii) introduces this further effect as explained in the introduction, and these interest rate changes will then exert additional effects upon wages, prices and employment in the medium term, and hence the inflation-unemployment choices for the authorities. How important are these latter interest rate effects? We can consider the evidence on this in comparison between single country optimising and multicountry I.

Figure 1: Single country optimising: Output and inflation effects on US of US fiscal shock

(note to figure 1. The optimisations performed derive the optimal rule for a stochastic environment. To illustrate the effect of these rules in the figures we show the model response to a US demand shock equal to 1% of GNP)

Figures 1(*a*) and (*b*) show the output and inflation effects of the US fiscal shock accompanied by optimal single country monetary policy response in that country. Output growth increases by over 1% initially, but reduces to around 0.5% over the next 4 years as monetary is tightened. (Figure 1(*a*)). As Figure 1(*b*) shows, the policy correction is successful in reducing the inflationary impulse, and by the end of the simulation the rate of inflation has reached its base value.

Figure 2: Single country optimising: Output and inflation effects on Japan of US fiscal shock

If we reverse the roles next, and let Japan's monetary policy react optimally to the US shock we get the effects shown in Figures 2(*a*) and(*b*).

Output growth picks up steadily, but by small amounts, to reach 0.1% higher after about 8 years (Figure 2(*a*)) before falling. This stimulus operates through familiar net trade effects. There is a very small inflation effect from this. However, as Figure 2(*b*) shows, the authorities reduce inflation by a small amount from base (0.1% after 10 years), entailing a small gain in output with slightly lower inflation by the end of the simulation. A similar pattern emerges when Germany optimises monetary policy following the US expansion, with similar orders of magnitude but with some differences in timing. The differences overall are not significant enough to warrant separate treatment though. (Figures for Germany are therefore not included.) The optimal weights obtained in this set of single country exercises are then used in the next exercise, which begins the multicountry analysis proper.

(b) Multicountry I

We are now in a position to analyse, in a preliminary way, the optimal responses to the US demand shock on a proper multicountry basis. In this next exercise, all countries respond together, each country according to its own optimal monetary policy rule derived from the simple country optimising exercise above. It is a limited form of multicountry response: although each country follows a (national) optimal rule, it assumes that there will be no policy reaction in the other countries. This is an incorrect assumption to make, and we explore the effects of relaxing it in (*c*) below. However, the present exercise does introduce further forms of spillover compared with the traditional case (which came in (*a*) above). Firstly, there are effects between interest rates across countries due to the workings of interest arbitrage. Secondly, there are policy induced effects on interest rates, as each national authority seeks to offset the inflation consequences of the US demand shock, using its own monetary policy rule. For both reasons, there will be inflation and unemployment effects due to the effects of changing interest rates on expenditures, including investment, and thence the capital stock.

Figure 3: Multicountry I: Output effects of US fiscal shock

Figure 4: Multicountry I: Inflation effects of US fiscal shock

Even though each country is (in this limited sense) making an optimal response to the US shock, the effects of it on Germany and Japan are striking. Figure 3 shows the effects on growth, Figure 4 the effects on inflation. Growth in the US expands more than in the previous case. Inflation rises there too, but by only a small amount (Figure 4), peaking at less than 0.5% above base after 1.5 years. The repercussions in the other countries are profound, especially in Japan. Inflation picks up markedly over the first two years, and remains stubbornly high for a further 4 years, at something under 2% above base. The source is the appreciating dollar, and rising import price inflation in the two other countries. In consequence, monetary policy has to be tightened very sharply in both Japan and Germany.

This inflationary effect is compounded initially by the expansionary effect of the fiscal stimulus in the US on Japanese and German growth. After 2 years in the case of Germany, and 3.5 years in Japan, the strongly corrective monetary policy reduces growth. It proves difficult to reduce inflation in Japan and growth there is reduced substantially over most of the simulation period in the effort to contain the inflationary effects of the increased US deficit.

Although this exercise is obviously limited - it assumes that each country assumes the others will not react to its own policy changes, incorrectly - it indicates that the spillover effects of unilateral fiscal expansion can be very substantial indeed. Why does this finding differ so much from the typical finding of limited spillovers? There are two parts to the answer to this. The first is that the transmission mechanisms included in our exercise are more elaborate than normally used. In particular the emphasis we place upon the medium term effects of interest rate changes, the capital stock and the supply side gives added potency to the international transmission of fiscal shocks which themselves impinge upon interest rates (via orthodox crowding out *and* because the fiscal shock stimulates monetary responses through the monetary rule). The second is that monetary policy is an optimal policy aimed to squeeze inflation shocks out. In practice monetary reactions to inflation changes have not proved so severe.

Figure 5: Multicountry II: Output effects of US fiscal shock

(c) Multicountry II

One of the limiting assumptions in the previous exercise is now dropped, and we proceed to implement a full Nash solution on the optimisation. Allowing for each country to optimise, given that it assumes (correctly) that each of the other does the same, has evident consequences for the outcomes following the US fiscal shock. Figures 5 and 6 show the growth and inflation differences from base in this regime. As compared with the previous exercise, the growth effects - with one exception - are more constrained: the expansion in the US is less initially, and more stable; while Japan's experience is also much less severe, although it again has the same sort of prolonged growth recession as in the previous case, the fall in growth being about half that of the previous case at its worst. For both countries, the major gain in this exercise is on inflation. Unlike the Multicountry I, inflation in Japan is reasonably well contained, rising between 0.3-0.5% until the end of 1990, but is effectively squeezed out thereafter (Figure 6). Inflation in the US is broadly the same as in the earlier case. Hence, this case may be characterised as showing that better inflation can be achieved with smaller output losses when adopting Nash-type optimal strategic policies compared with single country optimising.

Figure 6: Multicountry II: Inflation effects of US fiscal shock

The exception to this is Germany, which appears to be the loser in this exercise. There is marked cyclicality in output responses and inflation, though being stabilised, is so very slowly, and again with marked oscillations.

(d) Multicountry III

Once a fully cooperative international policy regime is instituted the situation is transformed, showing substantial gains over the full Nash solution. Figures 7 and 8 give the growth and inflation differences from base for this case. Output is now increased substantially in each country compared with the Nash solution, and although inflation is higher in the US in the second half of the decade, it is just 0.2% above its rate in the previous exercise. The inflation outturns for the other two countries, meanwhile, is improved.

Figure 7: Multicountry III: Output effects of US fiscal shock

Figure 8: Multicountry III: Inflation effects of US fiscal shock

The most conspicuous effect is upon US growth which now is positive throughout and much more stable. Although not as high as initially in case (*b*) where there is no policy reaction at all from other country, in this case, there is a positive increment to growth throughout the period (and by the end of 1994 it is still 0.75% above base). Similarly, in the other two countries, the adverse effects on growth are minimised in this regime. The adverse effects on growth in Japan are much shorter lived than in both of the non-cooperative exercise, and are much less severe. Germany also has a short-lived fall in growth compared with base, but positive effects there after. (Figure 7).

Inflation is effectively contained in each country after some cycling in Germany. At the end, each has inflation some 0.3-0.4% above base. (Figure 8).

6. Conclusions

This paper has introduced a new global econometric model for the G-3 which has a transparent structure, with a clear form of supply side. It enables an extension to be made to the nature of spillovers which might occur between countries following a policy change or shock in one or all of the countries. This extension allows for effects from interest rate changes to a country's supply side, and hence its short- to medium-run inflation-output tradeoff. Also, as policy is conducted optimally throughout, any change to a country's inflation rate sets in train corrective monetary policy change.

We find that with these extensions in place, there appear to be substantial effects of unilateral policy changes in one country on the performance of the others. We consider the case of unilateral fiscal expansion in the US (mimicking the Reagan expansion of the early 1980s). Even where monetary policy in all countries responds optimally to this shock, its effects on Japan and Germany are profound, with significant output losses being needed to contain the inflationary effects, particularly in the case of Japan. Moving to a full Nash solution improves this outturn quantitatively, although it produces a similar qualitative outturn. Only in the case of a fully cooperative policy regime which simultaneously optimises all country objective functions is the outturn significantly improved. [iii]

References

Allen, Chris and Nixon, James, (1995), Two concepts of the NAIRU, Discussion Paper 28-95, Centre for Economic Forecasting, London Business School.

Bryant, Ralph C., (1995), *International Coordination of National Stabilisation Policies*, The Brookings Institute, Washington D.C.

Canzoneri, Matthew B. and Henderson, Dale W. (1991), *Monetary Policy in Interdependent Economies: A Game-Theoretic Approach*, MIT Press, Cambridge, Mass.

Caporale, Guglielmo Maria, (1996), International economic policy coordination: A brief survey of the literature, Discussion Paper 22-96, Centre for Economic Forecasting, London Business School.

Caporale, Guglielmo Maria, Chui, Michael, Hall, Stephen G. and Henry, Brian (1997a), Modelling the US economy, Discussion Paper 07-97, Centre for Economic Forecasting, London Business School.

Caporale, Guglielmo Maria, Chui, Michael, Hall, Stephen G., Henry, Brian and Rendu, Christel, (1997b), Modelling the German and Japanese economies, Discussion Paper 30-97, Centre for Economic Forecasting, London Business School.

Caporale, Guglielmo Maria, Chui, Michael, Hall, Stephen G. and Henry, Brian (2000a), Coordination and price shocks: an empirical analysis, Economic Modelling, forthcoming.

Caporale, Guglielmo Maria, Chui, Michael, Hall, Stephen G. and Henry, Brian (2000b), Fiscal consolidation: an exercise in the methodology of coordination, *Journal of Policy Modeling*, (website), forthcoming.

Christodoulakis, Nicos, Currie, David and Garratt, Anthony, (1996), 'Target zones and alternative proposals for G3 policy cooperation: an empirical evaluation using GEM', *Journal of Macroeconomics*, 18, 1, 49–68.

Cumby, Rober E. and Mishkin, Frederic S., (1986), "The international linkages of real interest rates: the European-us connection", *Journal of International Money and Finance*, 5, 1, 5–23.

Currie, David and Wren-Lewis, Simon, (1989), A comparison of alternative regimes for international macropolicy coordination, in Marcus Miller, Barry Eichengreen and Richard Portes, eds, "Blueprints for Exchange-Rate Management", Academic Press, London.

Currie, David and Wren-Lewis, Simon, (1990), "Evaluating the extended target-zone proposal for the G-3", *Economic Journal*, 100, 105–123.

Currie, David, Levine, Paul and Vidalis, Nic, (1987), International cooperation and reputation in an empirical two-bloc model, in Ralph Bryant and Richard Portes, eds, "Global Macroeconomic Policy Conflict and Cooperation", Macmillan Press, London.

Dornbusch, Rudiger, (1976), "Expectations and exchange rate dynamics", *Journal of Political Economy*, 84, 1161–76.

Frankel, Jeffrey A., (1991), "The obstacles to macroeconomic policy coordination in the 1990s and an analysis of International Nominal Targeting (INT)", Berkeley WP, 91–160, University of California.

Fratianni, Michele and Jurgen von Hagen (1990), "German dominance in the EMS: evidence from interest rates", *Journal of International Money and Finance*, 9, 358-375.

Hall, Stephen G., (1997), Modelling economic policy responses, Discussion Paper 08-97, Centre for Economic Forecasting, London Business School.

Hall, Stephen G. (1987),`A Forward Looking Model of The Exchange Rate' , Journal of Applied Econometrics, 2, 1, 47-60.

Hamada, Koichi (1976), A strategic analysis of monetary interdependence, *Journal of Political Economy*, 83, 677-700.

Hughes Hallet, Andrew, Holtham, Gerald and Hutson, Gary, (1989), Exchange rate targeting as a surrogate for international policy coordination, in Marcus Miller, Barry Eichengreen and Richard Portes, eds, 'Blueprints for Exchange-Rate Management', Academic Press, London.

Ishii, Naoko, McKibbin, Warwick and Sachs, Jeffrey, (1985), "The economic policy mix, policy cooperation, and protectionism: Some aspects of macroeconomic interdependence among the United States, Japan, and other OECD countries", *Journal of Policy Modeling*, 7, 533–572.

Layard, Richard, Nickell, Stephen and Jackman, Richard, (1991), *Unemployment - Macroeconomic Performance and the Labour Market*, Oxford University Press, Oxford.

McKibbin, Warwick and Sachs, Jeffrey, (1991), *Global Linkages: Macroeconomic Interdependence and Cooperation in the World Economy*, Brookings Institution, New York.

McKinnon, Ronald, (1984), *An International Standard for Monetary Stabilisation*, number 8, Policy Analyses in International Economics, Washington.

McKinnon, Ronald, (1988), "Monetary and exchange rate policies for international financial stability: a proposal", *Journal of Economic Perspectives*, 2, 83-103.

Nixon, James and Hall, Stephen G., (1996), Controlling inflation: Modelling monetary policy in the 1990s, Discussion Paper 04-96, Centre for Economic Forecasting, London Business School.

Oudiz, Gilles and Sachs, Jeffrey, (1984), "Macroeconomic policy co-ordination among industrial economies.", *Brookings Papers on Economic Activity* **Issue 1**, 1-64.

Sachs, Jeffrey and McKibbin, Warwick, (1985), Macroeconomic policies in the OECD and LDC external adjustment, Discussion Paper 25, Brookings Institution, Washington DC.

Taylor, John B., (1989), "Policy analysis wiht a mutlicountry model", in Ralph C. Bryant, David A. Currie, Jacob Frenkel, Paul R Masson and Richard Portes eds., *Macroeconomic Policy in an Interdependent World*, Brookings, CEPR and IMF.

Taylor, John B., (1993), *Macroeconomic Policy in a World Economy*, W.W. Norton, New York.

von Hagen, Jurgen (1997), "Monetary policy and institutions in the EMU", *Swedish Economic Policy Review*, 4, 1, 51-116.

Williamson, John and Miller, Marcus, (1987), *Targets and Indicators: A Blueprint for the International Coordination of Economic Policy*, number 22, Policy Analyses in International Economics, Washington.

[i] The international equality of real rates implied by perfect capital mobility is an important proposition in open economy financial market theory. This requires two international parity conditions to hold, namely uncovered interest parity (UIP) and relative purchasing power parity (PPP). The former is a key behavioural relationship in most models of exchange rate determination, and is also central to "orthodox" multi-country econometric models. Casual observation suggests that international financial markets have become more integrated, and this is thought to imply increasing equality in interest rates among countries. Various empirical studies have in fact found statistically significant linkages (see, e.g., the paper by Cumby and Mishkin (1986)).

[ii] Specifically, the real exchange rate is assumed to be a function of last period's rate, the rationally formed expectation of next period's bilateral rate, and the interest differential.

[iii] In two companion papers (see Caporale et al (2000a,b) we show that these conclusions on the sizeable gains from monetary policy cooperation are robust to the type of shock considered. In particular: (i) a striking improvement in the overall control of inflation and a reduction in output costs results from coordinated responses to temporary price shocks (see Caporale et al, 2000a); (ii) in the case of fiscal shocks, there are few externalities when only fiscal policy is coordinated, whilst coordination of both fiscal and monetary policy results in substantial externalities and welfare improvements (see Caporale et al (2000b)).