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PARTICIPATION IN A CURRENCY UNION

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ABSTRACT

When countries of different sizes participate in a cooperative agreement, the potential gain from deviation determines the minimum power that each country requires in the common decision-making.

This paper studies the problem in the context of a monetary union - multiple countries sharing a common currency - whose very existence requires coordination of monetary policies. In the presence of externalities in the decentralized equilibrium with national currencies, it is shown that a small economy will in general require, and obtain, more than proportional power in the agreement. With a common currency, this is equivalent to a transfer of seignorage revenues in its favor. With national currencies such transfer would not obtain, and the small country would be even more demanding. Without additional unconstrained fiscal instruments it would be impossible to sustain coordination with fixed exchange rates. When the number of potential countries in the union is large, it is not generally possible to prevent deviations from individual countries or from coalitions. The currency union might emerge as a mixed strategy equilibrium, but the probability of deviation rises sharply with the number of countries and of possible coalitions.

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1. Introduction

Western European countries discussing prospects for monetary integration share a fundamental concern about the inevitable constraints on national autonomy. The problem arises, of course, because countries generally differ in their economic policy needs, while a common currency requires the deferral of all monetary policy decisions to an international Central Bank (Casella and Feinstein 1989). The debate has usually focussed on the possibility (or impossibility) of maintaining the necessary independence through fiscal policy (see for example Eichengreen 1989 and Cohen and Wyplosz 1988), but it has ignored the study of the institutional features of this international monetary agency.

The main goal of this paper is to stress the importance and the urgency of this approach, and to provide an initial example. More precisely, the paper addresses the problem of the distribution of power within the common Central Bank. Whether or not the Central Bank is independent from national governments, it will need to define the monetary policy of the union, taking into consideration, and weighing, the demands of the different countries. The ranges of admissible weights and the parameters that determine them are the focus of this work.

These questions were introduced in Casella and Feinstein (1989). The model discussed there, however, was not appropriate to capture differences in countries' sizes, and thus the problem of different countries' influence in the international Central Bank could not be addressed satisfactorily.

It is interesting to see how member countries share control of common decisions in the current institutional framework of the European Economic Community. The final power in the Community rests with the EEC Council of Ministers, formed by representatives of the twelve countries. Since the enactment of the Single European Act in July 1987, most provision can be passed with the approval of a qualified majority - replacing the previous unanimity requirement - and each country has been assigned a given number of votes on the basis of its economic size and population (see Table 1). Even though the switch to majority rule has obviously reduced the power of the smaller countries, it is still true that the influence they can exert is more than proportional to their size. This is indeed a notable feature of Table 1: for example, there are several coalitions of small countries that could organize a blocking minority while controlling only approximately 10% of the Community's GDP and less than 15% of its population. The organization of a common Central Bank is a more restricted problem and our analysis highly stylized, but we do reach the same conclusion: if participation is voluntary, a cooperative agreement that successfully constrains the actions of its members must give more than proportional representation to the weaker partners.

The paper starts from two observations. First, if each country is free to abandon the monetary union, the potential gain from deviation should determine the minimum power required in the common decision-making. Second, while it is true that all monetary interventions must be coordinated (i.e. decided together by all members), a common currency per se does not imply that monetary policy cannot address different national needs.

This second point is important, and has been typically neglected - or denied - in the current debate. The main cause has been the misleading identification of a common currency with a regime of fixed exchange rates. Fixed exchange rates require consistent monetary policies in all countries and, it is argued, since a common currency must be equivalent to permanently fixed rates the same conclusion necessarily holds. The argument is not correct: with a unique currency, the exchange rate is fixed by convention and imposes no constraints on money supplies in different parts of the union (exactly as in the case of perfectly substitutable currencies (Kareken and Wallace 1981)).

TABLE 1

Division of power in the EEC Council of Ministers since July 1987

Country	Votes	% total votes	% required majority	% EEC GDP 86	population
West Germany	10	13.2	18.5	25.8	61.2
France	10	13.2	18.5	20.9	55.6
Italy	10	13.2	18.5	17.3	57.4
United Kingdom	10	13.2	18.5	15.8	56.9
4 largest	40	52.6	74	79.8	231
Spain	8	10.5	14.8	6.6	38.8
5 largest	48	63.1	88.8	86.4	270
Netherlands	5	6.6	9.3	5.1	14.7
Belgium	5	6.6	9.3	3.2	9.9
Greece	5	6.6	9.3	1.1	10.0
Portugal	5	6.6	9.3	0.8	10.2
Denmark	3	3.9	5.5	2.4	5.1
Ireland	3	3.9	5.5	0.7	3.6
Luxembourg	2	2.6	3.7	0.1	0.4
7 other	28	36.9	51.9	13.6	54

Total 76
Required majority 54 votes (71%).

Unanimity is still required for some decisions (for example, tax laws, agreements between the Community and other countries, workers' rights, free movement of people).

Sources: The Economist, 2/25-3/3, 1989; Eurostat, 1988; World Bank Development Report, 1989. Population is in millions, in 1987.

Monetary injections can thus in principle differ in different economies. But since inflation is common to all countries in the union, this is equivalent to a transfer of seignorage revenues: monetary policy becomes an instrument of international wealth redistribution. The degree to which a country is able to target monetary interventions to its needs is linked to the share of seignorage revenues it succeeds in controlling, and depends on its influence on the union.

As is clear from these observations, a model studying these issues requires a few fundamental assumptions: (1) Monetary policy must be an important policy tool. (2) Countries must have different policy needs. (3) They must be able to abandon the union (or refuse to join it). (4) Since monetary decisions are centralized, countries are renouncing, at least in part, monetary control. They must have a reason to do so: it must be that the decentralized equilibrium with national currencies is sub-optimal.

The simple set-up built in this paper is designed to capture these aspects. In each country, consumers' utility depends on the consumption of a private and a public good. The private good, in different varieties, is supplied by domestic and foreign firms, while the public good is provided by the domestic government, and financed with lump-sum taxes and monetary issues. Governments decide the amount of public good supplied and its financing so as to maximize their citizens' utility. Finally, countries differ in their endowments, and this leads them to differ in the desired levels of the public good. Notice that without coordination each country provides an excessive amount of the public good, as it ignores the effect on the foreigners of withdrawing resources from private production. The model is a modified version of Casella and Feinstein (1989), with the added assumption of differentiated private goods (Dixit and Stiglitz 1977, Krugman 1981). As in Canzoneri and Rogers (1989), the question of the optimal monetary regime is studied from a public finance perspective.

When countries belong to a monetary union, the amount of common money injected in each economy and financing the public good is decided by a common Central Bank maximizing a weighted sum of the utilities of each country's citizens (there is no equilibrium with decentralized policies). The minimum weight each country demands is determined by the welfare it can achieve in a Nash equilibrium with national currencies and non-coordinated policies.

We reach three main conclusions. First, if countries do not have access to alternative and unconstrained sources of financing, they will in general require different monetary interventions. In particular, a small country will demand, and obtain, more than proportional representation in the union, and thus larger per-capita money injections and a transfer of seignorage revenues in its favor. The union is really a vehicle for solving the public goods externality, but the small country must play a larger role than is warranted by its size if it is to benefit from the cooperation more than it loses in autonomy.

However, and this is the second point, the union is not equivalent to cooperation under national currencies. In this model, cooperation under fixed exchange rates would not be feasible, since it would not allow differences in monetary injections. In addition, since monetary policy cannot generate transfers of wealth when there are national currencies and no rigidities, under flexible exchange rates the small country would demand even larger influence on the common decision-making.

Finally, supporting the currency union becomes increasingly difficult as the number of countries rises. Each single economy is then small with respect to the total, and demands additional influence on the common policy. In the aggregate, this is in general unfeasible. The union might emerge as an equilibrium in mixed strategies, but for each economy the probability of deviation increases sharply with the number of countries and of possible coalitions.

The paper proceeds as follows. Section 2 presents the model and the solution of the private sector's decision problem. The following sections derive optimal policies under national currencies (Section 3) and a common money (Section 4). Section 5 studies the allocation of power in a currency union with two countries, and Section 6 extends the analysis to a larger number of countries. Section 7 concludes.

2. The Model

To formalize the problem, we need a simple framework where differences in economic size can be easily represented. Standard models of imperfect competition when consumers "love variety" (Dixit and Stiglitz, 1977) are appropriate to this goal, since the size of a country translates immediately in the number of goods produced domestically, with no counterbalancing effect on the terms of trade. Thus, we will follow closely Krugman (1981), modifying his set-up to include optimal provision and financing of a public good.

The world is composed of two countries, Red (R) and Blue (B). Total population is normalized to 2, with $(2-\sigma)$ consumers living in R and σ in B. Individuals like variety in consumption of private goods and need a public good provided by the domestic government. Their utility functions are:

$$U_R = (1-g)\ln(\sum_{i=1}^{n} c_i^{\theta})^{1/\theta} + g\ln\Gamma_R$$
$$U_B = (1-g)\ln(\sum_{i=1}^{n} c_i^{\theta})^{1/\theta} + g\ln\Gamma_B \qquad (1)$$

where n is the total number of varieties of private goods available, c_i is the consumption of variety i and Γ is the public good. The parameter g (<1) represent the relative need for the public good, and $1/(1-\theta)$ (>1) is the elasticity of substitution between different varieties of the private good (and the elasticity of demand, if the number of varieties is large). Two observations are in order: (1) Constraining g to be equal in the two countries will make the analytical results more transparent, and is a reasonable initial assumption. When relevant, the implications of a more general set-up will be discussed. (2) As will be clear, θ is the crucial parameter in this formulation. When it approaches 1, the two economies approach perfect competition and no trade: the monetary regime and the opportunity for international cooperation become irrelevant.

All varieties of the private good, both in R and in B, share the same technology:

$$l_i = \alpha + \beta x_i \qquad i=1,..,n \tag{2}$$

where l_i is labor employed in the production of the ith variety and x_i is the quantity produced. There is a fixed cost α which guarantees that each firm will specialize in the production of one variety.

Entry in the market is free, and in equilibrium each firm makes zero profits.

The government produces the public good with a simple constant returns to scale technology:

$$\Gamma_j = l_{\Gamma j} \qquad j=R,B \tag{3}$$

where $l_{\Gamma j}$ is domestic labor employed in the production of the public good. To finance its labor costs, the government prints money and collects lump-sum taxes from its citizens:

$$w_j l_{\Gamma j} = M_j + T_j \tag{4}$$

where w is the nominal wage, M are issues of money and T are nominal taxes.

All transactions are assumed to require monetary exchanges.

The economy evolves as follows. Consumers live two periods. In the first period they work either for private firms or for the government and receive their salaries. In the second period they pay taxes and consume their disposable income. Money is the only asset in the economy, and therefore real income is reduced by inflation. Private firms pay their workers with current revenues, while the government finances its labor costs with taxes collected from the older consumers and with new issues of fiat money. Firms set prices to maximize profits; consumers decide which varieties of the private good to consume and in what amount so as to maximize their utility; governments choose taxes and money supply to maximize the discounted welfare of present and future generations of their citizens.

Solution

The problem faced by the private sector is identical to the one discussed by Krugman. Its solution, adapted to the present setting, is reproduced below.

Since technology is identical, we can focus on the symmetrical equilibrium where all varieties produced in the same country will be sold at the same price

$$p_j = (\beta/\theta)w_j \qquad j=R,B \tag{5}$$

The zero-profit condition determines the scale of production:

$$p_j x_{ij} = w_j l_{ij} = w_j(\alpha + \beta x_{ij}) \tag{6}$$

or, substituting (5) in (6),

$$x_{ij} = \frac{\alpha\theta}{\beta(1-\theta)} = x \tag{7}$$

The utility function is such that consumers will spend the same amount on each variety of the private good available in the market, whether it is produced in country R or B.

$$e p_B x_{iB} = p_R x_{iR} \tag{8}$$

where e is the exchange rate (defined as units of Red currency for one unit of Blue). Given (5) and (7) this yields

$$e w_B = w_R \tag{9}$$

As long as technology is the same in the two countries and there are zero profits everywhere, wages (and prices) will be equalized, independently of mobility and size of the labor force.

Price and wage flexibility insures full employment

$$\begin{aligned} n_R l_R &= n_R(\alpha + \beta x) = (2-\sigma) - l_{\Gamma R} \\ n_B l_B &= n_B(\alpha + \beta x) = \sigma - l_{\Gamma B} \end{aligned} \tag{10}$$

where n_R (n_B) is the number of varieties of the private good produced in the Red (Blue) country. Substituting (3) and (7) in (10) and ignoring integer constraints, we derive:

$$\begin{aligned} n_R &= (2-\sigma-\Gamma_R)(1-\theta)/\alpha \\ n_B &= (\sigma-\Gamma_B)(1-\theta)/\alpha \end{aligned} \tag{11}$$

Since all varieties have the same price, consumers will spend their disposable income equally on all. Per capita consumption of each differentiated product is then

$$c_R = \left(\frac{w_{R-1} - T_R/(2-\sigma)}{p_R}\right)/(n_R + n_B)$$

for a Red consumer, and (12)

$$c_B = \left(\frac{w_{B-1} - T_B/\sigma}{p_B}\right)/(n_R + n_B)$$

for a Blue consumer.

Finally, we must insure that markets are in equilibrium, or that the production of each variety equals its total demand

$$x = (2-\sigma)c_R + \sigma c_B$$

Using (7), (11) and (12), we can rewrite this as:

$$2 - m_R - m_B = (2-\sigma)\left(\frac{w_{R-1}}{w_R}\right) + \sigma\left(\frac{w_{B-1}}{w_B}\right) \tag{13}$$

Once the monetary regime is specified, this last equation will determine inflation rates in the two countries, as function of government policies. It will then be possible to express c_R and c_B in terms of taxes and money supplies, and to derive the indirect utility functions $U_R(m_R, m_B, t_R, t_B)$ and $U_B(m_R, m_B, t_R, t_B)$ (where m_j and t_j are real money injections and real taxes in country j, deflated by domestic wages). The governments' problem is then:

$$\max_{\{m_{Rt},\, t_{Rt}\}} \sum_{t=0}^{\infty} \delta^t\, U_{Rt}(m_{Rt}, m_{Bt}, t_{Rt}, t_{Bt})$$

$$\max_{\{m_{Bt},\, t_{Bt}\}} \sum_{t=0}^{\infty} \delta^t\, U_{Rt}(m_{Rt}, m_{Bt}, t_{Rt}, t_{Bt})$$

where δ is the discount factor.

This is an ∞-horizon repeated game, and as usual multiple equilibria will be sustainable with appropriate punishment schemes. We will concentrate on the simplest sub-game perfect equilibrium, where the two governments repeat each period their optimal one-shot strategy, taking foreign policy decisions as given. In other words, each government will, every period, decide taxes and money supply so as to maximize the utility of the current generation of domestic consumers. We will study the Nash equilibrium that follows from such strategy.

In all that follows, the policy makers' objective function will be the welfare of a representative domestic consumer, and the parameter representing a country's population will be interpreted as endowment, or generally as economic size. It should be clear that all conclusions would be exactly identical were the analysis in aggregate rather than per capita terms.[1]

3. National Currencies

If domestic transactions in the two countries take place in two different national currencies, international trade requires a market for foreign exchange. Assuming that goods produced in one country must be purchased with that country's national currency, the equilibrium condition on the foreign exchange market is given by:

$$\sigma p_R n_R c_B = (2-\sigma) e p_B n_B c_R \tag{14}$$

Total expenditure on Red products by Blue consumers must equal total expenditure on Blue products by Red consumers. Equation (14) determines the nominal exchange rate, if flexible, or the relationship between the two countries' monetary policies, if the exchange rate is fixed.

Substituting (11) and (12) and recalling $p_R = ep_B$, equation (14) can be written as:

$$\sigma(2-\sigma-\Gamma_R)\left(\frac{w_{B-1} - T_B/\sigma}{w_B}\right) = (2-\sigma)(\sigma-\Gamma_B)\left(\frac{w_{R-1} - T_R/(2-\sigma)}{w_R}\right) \tag{15}$$

Together with (13), this implies

$$\frac{w_R}{w_{R-1}} = \frac{2-\sigma}{2-\sigma-m_R} \qquad \frac{w_B}{w_{B-1}} = \frac{\sigma}{\sigma-m_B} \qquad \frac{e}{e_{-1}} = \frac{w_R/w_{R-1}}{w_B/w_{B-1}} \tag{16}$$

where $m_j=M_j/w_j$.[2]

In each country, inflation depends on the percentage of domestic labor force whose salary is paid with new issues of money. The exchange rate insures that total national purchasing power cannot be increased by issuing fiat money.

Substituting (16) and (11) in (12), we can write per capita consumption of each variety of the private good by Red and Blue consumers as

$$\begin{aligned} c_R &= \frac{\alpha\theta(2-\sigma-\Gamma_R)}{\beta(1-\theta)(2-\sigma)(2-\Gamma_R-\Gamma_B)} \\ c_B &= \frac{\alpha\theta(\sigma-\Gamma_B)}{\beta(1-\theta)\sigma(2-\Gamma_R-\Gamma_B)} \end{aligned} \tag{17}$$

Since consumption levels are equal for all varieties, the utility function of the current generation simplifies to:

$$U_R = (1-g)\ln[(n_R+n_B)\ c_R^{\theta}]^{1/\theta} + g\ln\Gamma_R$$

$$U_B = (1-g)\ln[(n_R+n_B)\ c_B^{\theta}]^{1/\theta} + g\ln\Gamma_B$$

and can be expressed as

$$\begin{aligned} U_R &= K_R + [(1-g)(1-\theta)/\theta]\ln(2-\Gamma_R-\Gamma_B) + (1-g)\ln(2-\sigma-\Gamma_R) + g\ln\Gamma_R \\ U_B &= K_B + [(1-g)(1-\theta)/\theta]\ln(2-\Gamma_R-\Gamma_B) + (1-g)\ln(\sigma-\Gamma_B) + g\ln\Gamma_B \end{aligned} \tag{18}$$

where

$$K_R = [(1-g)(1-\theta)/\theta]\ln[(1-\theta)/\alpha] + (1-g)\ln[\theta/\beta(2-\sigma)]$$

$$K_B = [(1-g)(1-\theta)/\theta]\ln[(1-\theta)/\alpha] + (1-g)\ln(\theta/\beta\sigma)$$

We can immediately observe:

1. The choice between lump sum taxes and money printing is irrelevant. Only their total affects utility. Government policies enter utility through three channels: supply of the public good, impact on the number of varieties of the private good produced in the world and effect on personal disposable income. The first two clearly depend only on total resources devoted to public good production, whether financed by money or taxes. The last effect depends on the monetary regime: with different national currencies, taxes and money injections cause an identical one-to-one reduction in disposable income. Therefore, they are exactly equivalent.[3]

2. Since there are no rigidities and sufficient policy tools, fixed exchange rates lead to the same allocation and the same welfare obtaining under flexible rates. (This is a version of Helpman's (1981) result on the neutrality of monetary regimes).

When the exchange rate is fixed, inflation rates - or, equivalently, per-capita money injections - must be equal in the two countries. However, since welfare only depends on total government expenditure, it is not affected by this constraint on monetary printing. Each government will set taxes optimally and will replicate exactly the allocation under flexible exchange rates, even though with possibly different inflation. Notice, in passing, that the difficult question of the sharing of the burden of adjustment always implied by fixed exchange rates is here irrelevant. Whether one country dominates the agreement, or both share the responsibility of maintaining coherent their monetary policies has no impact on welfare.

3. In this model, uncoordinated policies under different national currencies yield inefficient allocations, as long as θ is less than 1.

There are two reasons for this result, both evident in the first term of the indirect utility functions (18). The first follows directly from the externality that public goods provision creates between the two countries. Each government supplies more of the public good than is socially optimal, since it ignores the negative effects on the foreigners of withdrawing resources from private production. This inefficiency would be solved by cooperation.

The second problem stems from the difference in size between the two economies. Suppose, for simplicity, that public goods enter utility in per-capita terms (with log utility, this does not alter the marginal conditions). Then it becomes clear that, since utility functions are identical, is optimal to have each consumer in either country consume the same amount of private and public goods, and this can only happen if each country devotes to public good production the same share of its resources. Indeed, this will be the case if σ equals 1. But if σ (and θ) differ from 1, concern for the availability of a sufficient number of varieties of the private good must lead the larger country to collect for public good production a smaller fraction of its endowment (and viceversa for the small country). The allocation of resources between private and public goods is distorted. This problem would be solved by an optimal transfer between the two countries.[4] It requires more than cooperation with the policy tools we have allowed so far, since with different national currencies such tools cannot affect international distribution. In fact, as shown by equations (11) and (17), total real consumption is determined only by each country's labor endowment and does not depend on policy variables. In labor units:

$$(2-\sigma)(n_R+n_S)c_R + \Gamma_R = 2-\sigma \qquad\qquad \sigma(n_R+n_S)c_S + \Gamma_S = \sigma$$

Notice that a transfer from the large to the small country can raise welfare in both economies. The small country would directly benefit from the transfer;

the large one would benefit from the increased production for private consumption that would take place in the smaller economy.

As mentioned, both distortions follow from θ different from 1. θ is thus an index not only of imperfect competition and gains from trade (as in Krugman), but also of the imperfections arising from the presence of public goods, and therefore of the countries' willingness to consider an alternative international arrangement.

Even in its very simple form, the governments' game does not have a simple closed form solution. Numerical simulations were run for a variety of parameters values, and provide the background for the welfare comparisons that follow. Table 1A in the Appendix presents the simulations' results for the representative case $g = 0.1$, $\alpha = \beta = 0.1$, $\theta = 0.2$, for different distributions of world endowment.

4. Common Currency

When the two countries share a common currency, we can set $e = 1$ in every period. As with fixed exchange rates, this will imply equality of the two inflation rates. However, the constraint on the foreign exchange market is now meaningless, and the monetary regime does not impose discipline on each country's economic policy. From a policy perspective, this is the fundamental difference between a common currency and fixed exchange rates. The crucial point is that the same currency is now used for all transactions, both outside and inside the country. Of course, all agents are still individually bound by their budget constraints, but the concept of a balance of payments, as an account measuring international monetary transactions that need to be balanced, has lost its significance.

Given the common inflation rate, goods market equilibrium (equation (13)) yields:

$$\frac{w}{w_{-1}} = \frac{2}{2-m_R-m_B} \tag{21}$$

Inflation now depends on total money injections, relative to world resources.[5]

Per capita consumption of each variety of the private good is then given by:

$$\begin{aligned} c_R &= \frac{\theta}{\beta}\left(\frac{2-m_R-m_B}{2} - \frac{t_R}{2-\sigma}\right)\frac{\alpha}{(1-\theta)(2-\Gamma_R-\Gamma_B)} \\ c_B &= \frac{\theta}{\beta}\left(\frac{2-m_R-m_B}{2} - \frac{t_B}{\sigma}\right)\frac{\alpha}{(1-\theta)(2-\Gamma_R-\Gamma_B)} \end{aligned} \tag{22}$$

and each generation's utility is:

$$\begin{aligned} U_R &= K_R' + [(1-g)(1-\theta)/\theta]\ln(2-\Gamma_R-\Gamma_B) + (1-g)\ln[(2-m_R-m_B)/2 - t_R/(2-\sigma)] + g\ln\Gamma_R \\ U_B &= K_B' + [(1-g)(1-\theta)/\theta]\ln(2-\Gamma_R-\Gamma_B) + (1-g)\ln[(2-m_R-m_B)/2 - t_B/\sigma] + g\ln\Gamma_B \end{aligned} \tag{23}$$

where $t_j = T_j/w_j$ and

$$K_R' = K_R + (1-g)\ln(2-\sigma)$$

$$K_B' = K_B + (1-g)\ln \sigma$$

Not very surprisingly, in this regime no equilibrium exists when monetary policies are not coordinated. For given level of total expenditure, each government would give unbounded subsidies to its citizens, financing itself completely through money creation (for given Γ_j, U_j is decreasing in t_j), and generating infinite inflation. The intuition is straightforward. Disposable income is affected differently by taxes and money supplies: while taxes translate into one-for-one changes in disposable income, money creation has a smaller effect, since the loss of purchasing power now depends on the increase in total world money supply relative to world endowment. Thus, for given money supply abroad, disposable income at home can be raised by subsidies financed through money printing. (Of course, this reduces disposable income abroad). This type of inflationary bias has been often noticed in the literature (see, among others, Buiter and Eaton (1983), Casella and Feinstein (1989), and Aizenman(1989)).

The important conclusion is that coordination is essential to the very existence of a monetary union. The presence of a common currency creates an externality between the two countries that results in unbounded "beggar-thy-neighbour" policies. This holds whether or not other externalities are present between the two economies.

Suppose now that an international Central Bank is created, responsible for monetary decisions in the two countries. The Central Bank decides money injections in R and B so as to maximize a weighted sum of utilities:

$$\max_{m_R,\ m_B} \quad (2-\gamma)U_R(m_R,\ m_B,\ t_R,\ t_B) + \gamma U_B(m_R,\ m_B,\ t_R,\ t_B)$$

where utilities are given by equations (23). The two national governments retain control over their tax policies. There is now an additional game being played between the two governments and the international Central Bank, and again we will restrict attention to the static one-shot equilibrium.

In this model, the problem is not well defined. It is trivial to show that with a common currency welfare depends on three variables only: total government spending in the two economies (Γ_R and Γ_B) and the difference in per capita real money stocks ($m_R/(2-\sigma) - m_B/\sigma$) (or, equivalently, the difference in per capita taxes). National governments and the Central Bank have different targets for total public spending - a disagreement caused by the public good externality - and their reaction functions are therefore parallel. No Nash equilibrium exists for the game described above. To analyze this regime, we have to decide which agency is ultimately responsible for determining the amount of resources devoted to production of the public good.

Two opposite scenarios are of special interest. In the first one, the Central Bank targets relative money injections in the two countries, but sets their absolute values infinitesimally close to zero (not exactly at zero if σ differs from 1, since, as will be clear, the Central Bank tries to use monetary policy to affect international distribution). The supply of the public good is decided by the two national governments and is (almost) entirely financed by lump-sum taxes. Such supply is excessive from the point of view of the Central Bank, but since money issues cannot be negative, it has no means of reducing it. This equilibrium tends in the limit to the allocation generated by decentralized policies with flexible exchange rates.

Alternatively, we may assume that financing of the public good is controlled by money supplies. This would be the case, for example, if participation in the union required some institutional commitment from the two countries, and in line with current policy discussions such commitment took the form of a constraint on public spending. For simplicity, assume that taxes are set to zero. This equilibrium, while admittedly extreme, has for our purposes two important advantages: it focuses all attention on monetary policy, and thus on the monetary regime, and it does so in a very simple fashion. In the rest of the paper we will concentrate on this case.[6]

With zero taxes, equations (23) simplify to:

$$\begin{aligned} U_R &= K_R' - (1-g)\ln 2 + [(1-g)/\theta]\ln(2-m_R-m_S) + g\ln m_R \\ U_S &= K_S' - (1-g)\ln 2 + [(1-g)/\theta]\ln(2-m_R-m_S) + g\ln m_S \end{aligned} \tag{24}$$

and the first order conditions for the Bank's problem yield:

$$m_R = \frac{(2-\gamma)g\theta}{1-(1-\theta)g}$$

$$m_s = \frac{\gamma g \theta}{1-(1-\theta)g} \tag{25}$$

Table 1A in the Appendix presents realized values for money supplies and the other relevant variables in the case $g=0.1$, $\alpha=\beta=0.1$, $\theta=0.2$, $\gamma=1$, as functions of the distribution of endowments. Figure 1 compares a country's welfare under this regime (for the two cases $\gamma=1$ and $\gamma=\sigma$) to utility under flexible exchange rates.

The parameter γ represent the relative power of the two countries in influencing the policy of the Central Bank. If γ equals 1, the two countries are given equal weight, independently of their size, and the same supply of the public good is financed everywhere. More generally, relative money injections equal the relative power of the two economies:

$$\frac{m_s}{m_R} = \frac{\gamma}{2-\gamma}$$

This is important, because the crucial characteristic of this equilibrium is the potential for international wealth redistribution. Total consumption in each economy is now affected by money printing, and the country with higher per capita money injections is effectively increasing its share of world resources. Using equations (11) and (22), and setting taxes to zero:

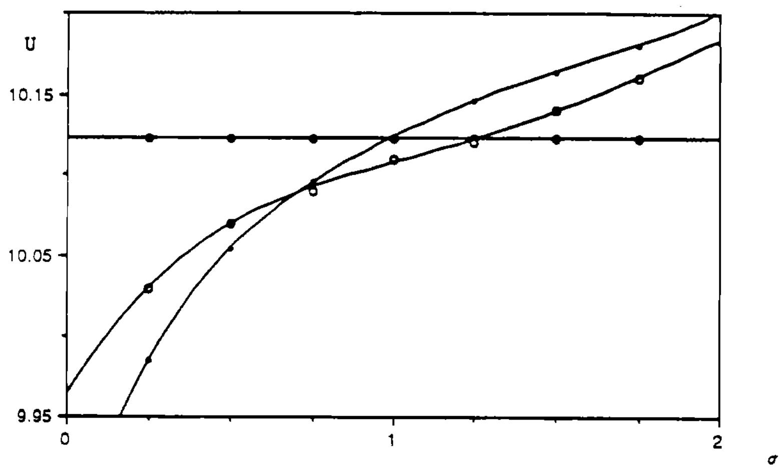
$$(2-\sigma)(n_R+n_s)c_R + \Gamma_R = (2-\sigma) + [(\sigma/2)m_R - ((2-\sigma)/2)m_s]$$

$$\sigma(n_R+n_s)c_s + \Gamma_s = \sigma - [(\sigma/2)m_R - ((2-\sigma)/2)m_s]$$

With a common currency, issues of money generate inflation everywhere, independently of where they are spent. However, money spent domestically provides public good production, partly compensating for the reduction in disposable income. If monetary injections are equal in per capita terms, the positive public

Figure 1

Two countries. Welfare comparisons
$\alpha=\beta=0.1$ $\theta=0.2$ $g=0.1$



- ● Utility under flexible exchange rates and uncoordinated policies
- • Utility under a common currency and the Central Bank, $\gamma=1$
- ○ Utility under a common currency and the Central Bank, $\gamma=\sigma$

good effect exactly compensates the negative effect on private consumption originating from inflation. From a different point of view, when per-capita monetary injections are larger in one country than abroad, such country consumes more than its own resources, and runs a trade deficit financed by seignorage revenues. It is indeed trivial to show that in this regime imbalances in the trade account must occur whenever per-capita monetary issues differ between the two countries (substitute equations (11) and (22) in (14)).

Since money injections in the two economies are determined by their relative influence on the Central Bank, we reach the conclusion that unless the power of each country is equal to its share of world endowment ($\gamma=\sigma$), any decision of monetary policy in the union will involve a transfer between member countries.

5. Participation in a Currency Union. Two Countries

In this section, we assume that each country is free to decide whether to join the common currency agreement or maintain control of its economic policy. If the currency union is to be implemented, therefore, both countries must individually gain from belonging to the agreement. In other words, the existence of the union depends on the existence of a set of weights γ such that welfare is everywhere not inferior to welfare under national currencies.

The small country might have problems accepting a small γ, since it implies a low supply of the public good, possibly much lower than the one enjoyed under decentralized policy decisions. The large country might object to giving more than proportional power to the small country, and especially so since this entails a transfer from its citizens to foreigners.

Given the Central Bank decision rule (equation 25), it is trivial to calculate utilities as a function of γ.[7] Given welfare under national currencies, we can then solve for each country's minimum required weight, for different endowments. For the case $\alpha=\beta=0.1$, $\theta=0.2$, $g=0.1$, the results are presented in Figure 2a. The minimum required weight (in percentage terms) is plotted against the country's economic size (again, as a percentage of world resources).

When the country is relatively small - less than 37% of the world in this example - it demands more than proportional power to participate in the union. If this were not the case, the control exercised by the larger economy would result, from the point of view of the small country, in a very partial solution of the externality problem, together with hard discipline on its own supply of the public good. In other words, if the power of the large country is not mitigated, the small country ends up facing the costs of the coordination without reaping enough of the benefits. On the other hand, the large country is indeed willing to take part in the union even when it is given less power than its share of world resources. This is of course the other side of the same issue: up to a certain point, the large country can reduce its influence and still gain from the discipline imposed on its partner more than it loses in control of domestic policies. In any acceptable distribution of power, the amount of resources devoted to public good production in the small economy is less than it would be under flexible exchange rates. As more workers are employed in the private sector, more varieties of the private good are produced, and this benefits consumers everywhere. It is this feature that makes the union viable at all.

It is interesting to compare the minimum power required to participate in the monetary union to the power the two countries would demand to agree on coordinated policies under flexible exchange rates. The comparison is in Figure 2b. With a common currency a larger than proportional γ implies, as an added bonus, a transfer of seignorage revenues, and this acts to mitigate the demands of the small country. Not so with different national currencies. Here, monetary policies <u>per</u>

Figure 2a

Minimum percentage weight in the Central Bank and economic size
$\alpha=\beta=0.1 \quad \theta=0.2 \quad g=0.1$

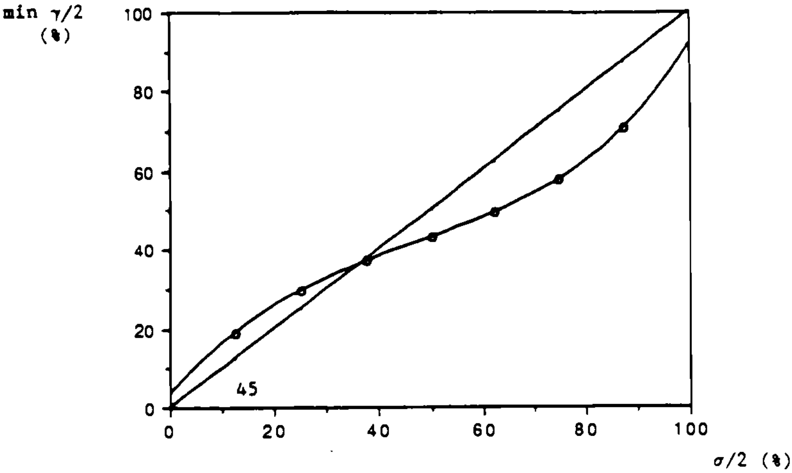
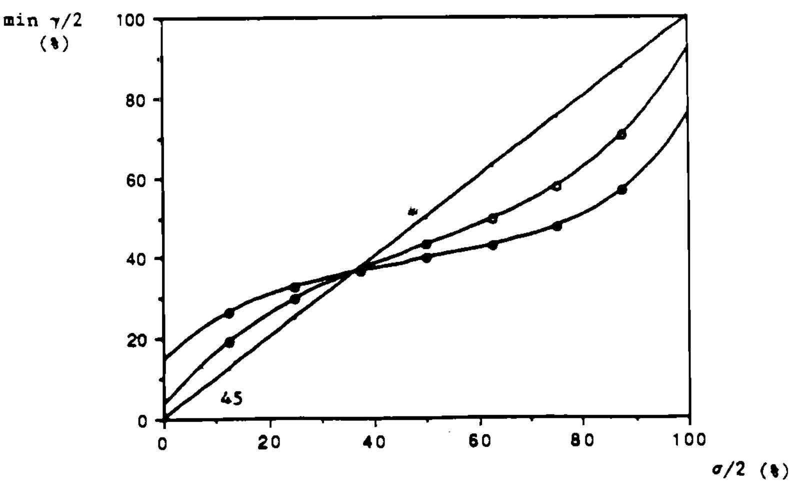


Figure 2b

Minimum percentage weight in cooperative agreement and economic size
$\alpha=\beta=0.1 \quad \theta=0.2 \quad g=0.1$



o Minimum percentage weight in the currency union

• Minimum percentage weight in cooperation with national currencies *se* cannot cause international transfers, and a country's weight in the aggregate welfare function does not influence the distribution of resources in the world. It follows that in any acceptable distribution of power the bias in favor of the small country (in relative terms) must be even stronger than the one characterizing a currency union.

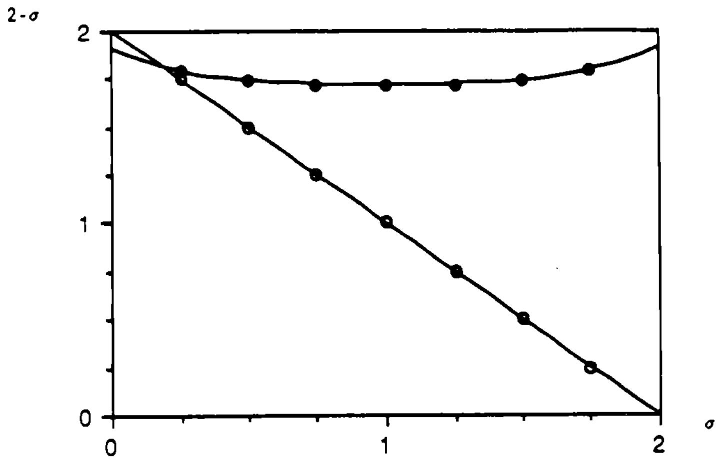
If the distribution of power were exactly proportional to size, coordination of monetary policies with national currencies would lead to equal per-capita money injections, equal inflations, and fixed exchange rates. But such arrangement is, as we showed, unacceptable, and the more than proportional weight required by the small country translates in higher inflation, and a depreciating exchange rate. We can conclude that if differences in economic size are at all relevant, in the presence of a constraint on fiscal policies coordinated monetary policies with fixed exchange rates are *not* a viable option. This ceases to be true if the two currencies are perceived as perfect substitutes, and used indifferently for both foreign and domestic transactions. But in this case of course they amount to a unique currency.

The real question then is whether a currency union can be supported, i.e. whether it is at all possible to satisfy simultaneously the requirements of the two countries. In Figure 3, the negatively sloped line gives the possible distributions of endowments. The curve at the top of the figure is the sum of the minimum weights required by the two countries at the corresponding distribution to be willing to take part in the monetary union. If such curve went above 2, the agreement would not be sustainable. The curve has a minimum at $\sigma=1$, because the gain from cooperation is maximum when the two economies have equal size. As is clear from the diagram, with 2 countries and the parameters values assumed in these calculations, the union can be supported. Indeed, the distance between the curve and the horizontal line at 2 indicates that there are some degrees of free-

Figure 3

Two countries. Sustainability of the currency union

$\alpha=\beta=0.1$ $\theta=0.2$ $g=0.1$



● Sum of the minimum weights required by the two countries at the corresponding distribution of endowments dom in the allocation of power. The whole gap could be arbitrarily divided between the two countries in any fashion without compromising the existence of the agreement. In other words, such distance is a measure of the Pareto superiority of the common currency regime.[8]

Sensitivity analysis

The parameters of the production technology, α and β, do not enter any decision rule. They appear in the constant term in utility, and exactly in the same way under flexible rates or a common currency. Thus, they have no effect on the conclusions.

The parameter θ is the index of the severity of distortions under decentralized policy decisions and national currencies. At larger θ, the gain from cooperation is smaller, and smaller is the potential role for a transfer. Any acceptable allocation will be closer to the equilibrium with uncoordinated policies and national currencies. As less varieties need to be produced, the large country can devote an increasing share of its resources to the public good, and money printing tends to become exactly proportional to size as θ goes to 1. The end result is that the curve in Figure 2a tilts and loses curvature at higher θ, approaching the 45° line as θ approaches 1, and the allocation becomes identical to flexible exchange rates. Figure 4a depicts the results of simulations with θ=0.2, 0.4, 0.8 (and usual values for the other parameters). As long as θ is different from 1, it continues to be true that the division of power required to support the union will attribute a more than proportional weight to the small country.

Changes in the parameter g have a similar, but much less pronounced effect on Figure 2a. As we said, with flexible exchange rates and decentralized policies, distortions are caused by the public good externality and by the difference in

Figure 4

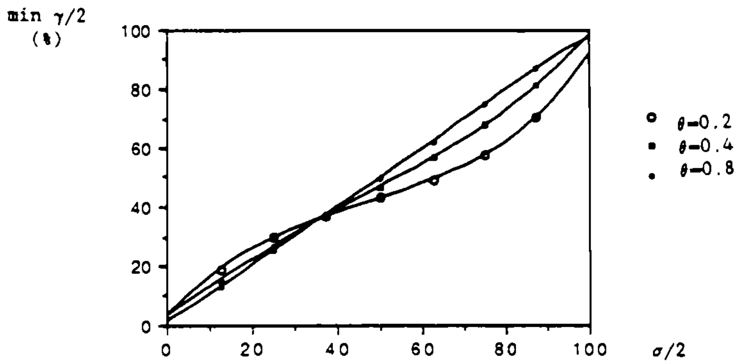
Sensitivity to parameters values

Minimum percentage weight in the Central Bank and economic size

$\alpha=\beta=0.1$

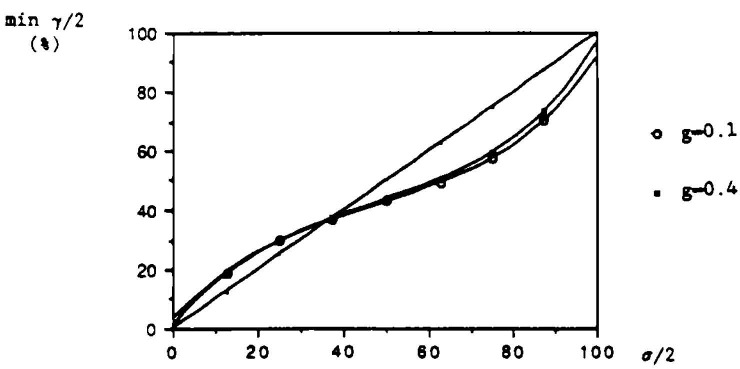
(a)

g=0.1



(b)

$\theta=0.2$



size between the two economies. This second problem arises from the tension between the effect of monetary injections on domestic inflation and on the total number of varieties produced in the world, and is independent of g (the relative utility weight of the two terms - the first and second in equations (18) - is always 1). However, at higher g private consumption is less important, and so is the excess in the resources devoted to public goods production in the two countries: the public good externality leads to less inefficiency. In summary, at higher g the attractiveness of a currency union is reduced, but only very slightly. Again, the curve in Figure 2a tends to flatten towards the 45° line, and again it continues to be true that the small country must enjoy more than proportional weight in the management of the union. However, the effect is extremely small. Figure 4b shows the results of simulations for g=0.1 and g=0.4. The parameter θ is set equal to .2, but the effect of changing g is almost identical at any other θ value.

Finally, g could differ between the two countries. In this case the Central Bank policy is given by:

$$m_R = \frac{(2-\gamma)2r\theta}{2-(1-\theta)[(2-\gamma)r + \gamma b]}$$
$$m_B = \frac{\gamma 2b\theta}{2-(1-\theta)[(2-\gamma)r + \gamma b]} \tag{26}$$

where r and b are the utility weights of the public good in the Red and Blue country respectively.

When γ equals 1, monetary injections still differ, as the Central Bank takes into account the specific relative needs for the public good. How much of this different need is accommodated depends on the parameter θ. As θ goes to 1, and the importance of diversified production disappears, the difference is reflected exactly in money supplies, and a union with proportional weights ($\gamma=\sigma$) once again replicates the flexible exchange rates equilibrium. When on the contrary θ is low, the Central Bank will not be ready to satisfy the larger public good demand in one of the two countries, since this would be too costly in terms of private production. We expect that in this case the economy most dependent on the public good will require a larger weight to participate in the union. This intuition is confirmed by numerical simulations. If diversification is important and it is the small country that has a higher relative need for the public good, all the previous conclusions are reinforced. If instead the relative dependence on the public good is higher in the large country, then, at low θ, the large country will be the one demanding more than proportional representation in the Central Bank. As θ rises, both effects tend to reverse themselves. [9]

In synthesis, if it is assumed that the relative need for public v/s private goods is equal in the two countries, independently of their size, then a currency union is sustainable and, in this model, Pareto superior to decentralized policies under flexible exchange rates (for $\theta<1$). If there are large differences in economic size, the small country will be given more power in the union than is warranted by its economic importance. This result is robust to changes in the parameters of the model.

If the relative need for public goods is larger in the small country, the conclusion above continues to hold and is reinforced, as long as θ is low. Again, it is robust to changes in the other parameters. If, however, there are differences in the two countries' need for the public good, but either θ is high or the large country is the one most dependent on public goods, the results are modified in important ways.

In the rest of the analysis, it will be assumed that the parameter g is the same in all countries, and this last alternative scenario will be ignored. Since the very significance of the model depends on the assumption that θ is low, and since no empirical basis suggests a systematically larger relative dependence on public goods for richer countries, we feel justified in doing so. These qualifications however will continue to hold.

6. Participation in a Currency Union. N Countries

The results obtained so far provide all the tools needed to investigate whether a currency union is sustainable in a world with more than two countries.

The extension is not trivial. From the point of view of a single country, the temptation to deviate unilaterally becomes stronger: if the other countries are committed to a common currency, the outsider benefits from the discipline that the Central Bank imposes on its trading partners without deferring control of its own policy decisions. In addition, countries can form coalitions and gather in partial unions, where the number of partners and their economic size are chosen optimally. Even if the global union were a Nash equilibrium, it could still be defeated by coordinated deviations of subgroups of countries.

We define the game as following: the number of countries, the distribution of endowments and the relative power of each country are given exogenously. Countries can communicate but not make binding commitments, and their strategies are the decisions to take part or not in a currency union involving any of the other countries. More formally, each country independently names its partners, if any. Currency unions are then formed between the countries in agreement. As before, we concentrate on the repetition of the static game and ask the questions: (1) Under what conditions on the distribution of endowments and of power is a global currency union involving n countries a Nash equilibrium? (2) If the union is a Nash equilibrium, is it also robust to concerted deviations by coalitions of countries?

We restrict attention to "self-enforcing" deviations, i.e. deviations that are themselves robust to further deviations by a subset of members of the original coalition. In other words, we require the currency union to be coalition-proof in the sense of Bernheim, Peleg and Whinston 1987).[10]

By focussing on the sustainability of the global union, both questions address one aspect of the more general problem: If the model is extended to n contries with possibly different endowments, which monetary arrangements can emerge in equilibrium? A discussion of the framework needed to study this point concludes this section.

The intuition providing the answer to the first question is very simple. Since policy decisions are centralized, any group of countries linked by a common currency and having flexible exchange rates with respect to the rest of the world behaves exactly like a unique larger country. The problems of distribution existing within the union are irrelevant outside.[11] Figure 2a therefore describes generally the minimum power required by any subgroup of countries with respect to its complement, as a function of the relative share of world resources. Thus it also describes the minimum power required by one country to take part in a union with <u>any</u> number of partners as a function of its endowment relative to the total size of all countries in the agreement. When the number of countries is larger, each single economy tends to be smaller with respect to the whole, and therefore to require more power relative to its size. The end result is that, in the static game, the union might be impossible to sustain. This captures the strong temptation to unilateral deviation mentioned before. Belonging to the union without substantially influencing its policy is not desirable. With a large number of countries, each one tends to be pushed in this position, therefore demanding "extra" power and contributing to requests of control that become in the aggregate unfeasible.

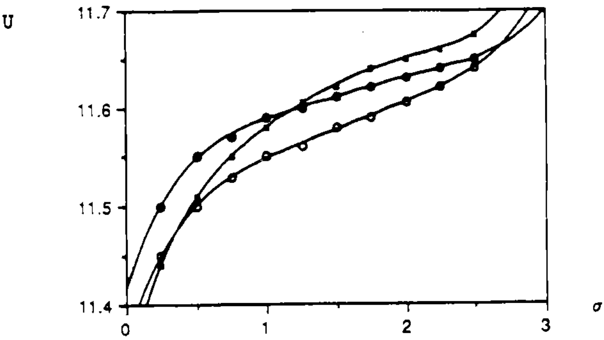
However, increasing the number of countries should also have an effect in the opposite direction. With more independent policy makers, the cost of the externality when countries issue national moneys and decisions are not coordinated is more severe. We expect that if other countries deviate, a partial union might be preferable to reverting to flexible rates. This suggests that it might be possible to support a global union as a Nash equilibrium in mixed strategies, even when it cannot be supported by pure strategies.

To verify these intuitions, we have analyzed several 3-country examples. With three countries, the model and its solution are straightforward extensions of the equations discussed before. The details and the simulations' results are in the Appendix. Figure 5 presents welfare comparisons under different regimes, as a function of a country's endowment, when total world resources are normalized to 3. As expected, when policies are not coordinated the public good externality is made more severe. In fact, if the only alternative to the currency union were uncoordinated policies everywhere, in this model there would always exist a distribution of power (a set of weights) that supports the union as a Nash equilibrium in pure strategies, and the agreement would be easier to reach than in the two-country case (i.e. countries of all sizes would demand less relative power in the international Central Bank) (see Figure 6). In addition, welfare in each country depends now not only on its own economic size, but also on the distribution of endowments between its trading partners. Since large countries cause less distortion, proportionately, than smaller countries, uncoordinated flexible exchange rates are more desirable when the rest of the world is more asymmetrical.

Figure 2a shows that a distribution of power that will keep all three countries in the union might fail to exist. Even though each country's requests can be satisfied _vis a vis_ the rest of the world, taken as a whole, this latter fictional economy is in fact composed of two countries, each demanding the relative

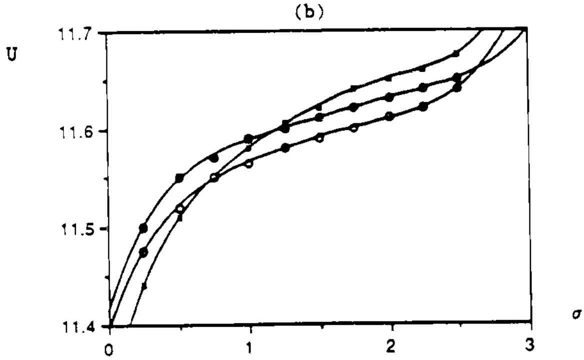
Figure 5
Three countries. Welfare comparisons
$\alpha=\beta=0.1 \quad \theta=0.2 \quad g=0.1$

(a)



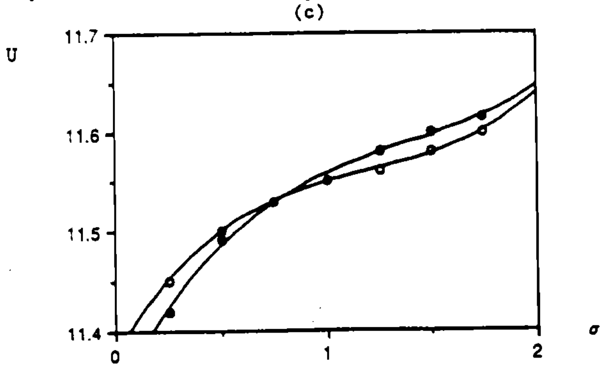
- ° Utility under flexible exchange rates, with symmetrical foreign countries
- • Utility from unilateral deviation
- ▪ Utility under a common currency and a Central Bank, $\gamma=\sigma$

(b)



- ° Utility under flexible exchange rates, with asymmetrical foreign countries
- • Utility from unilateral deviation
- ▪ Utility under a common currency and a Central Bank, $\gamma=\sigma$

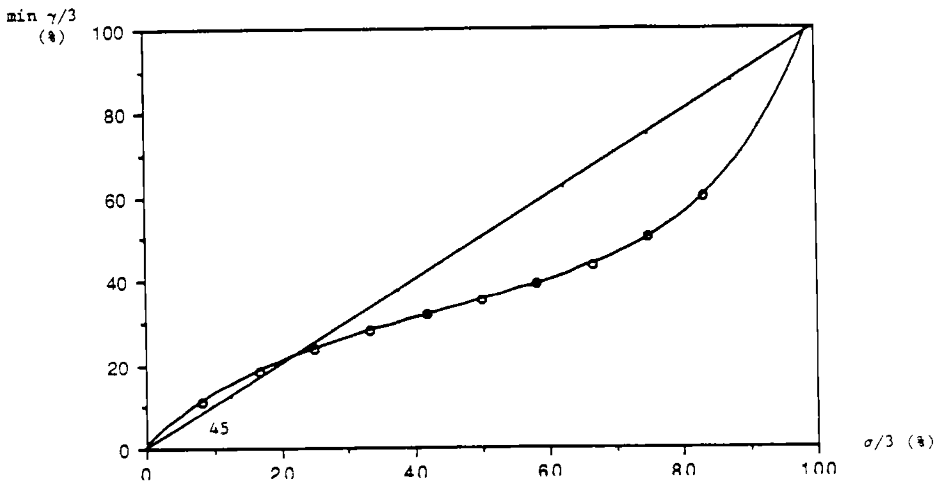
(c)



- ° Utility under flexible exchange rates, when third country has size 1
- • Utility from a partial union, when outsider has size 1

Figure 6

Three countries
Minimum percentage weight in the Central Bank (vs 3-country flexible rates)
$\alpha=\beta=0.1 \quad \theta=0.2 \quad g=0.1$



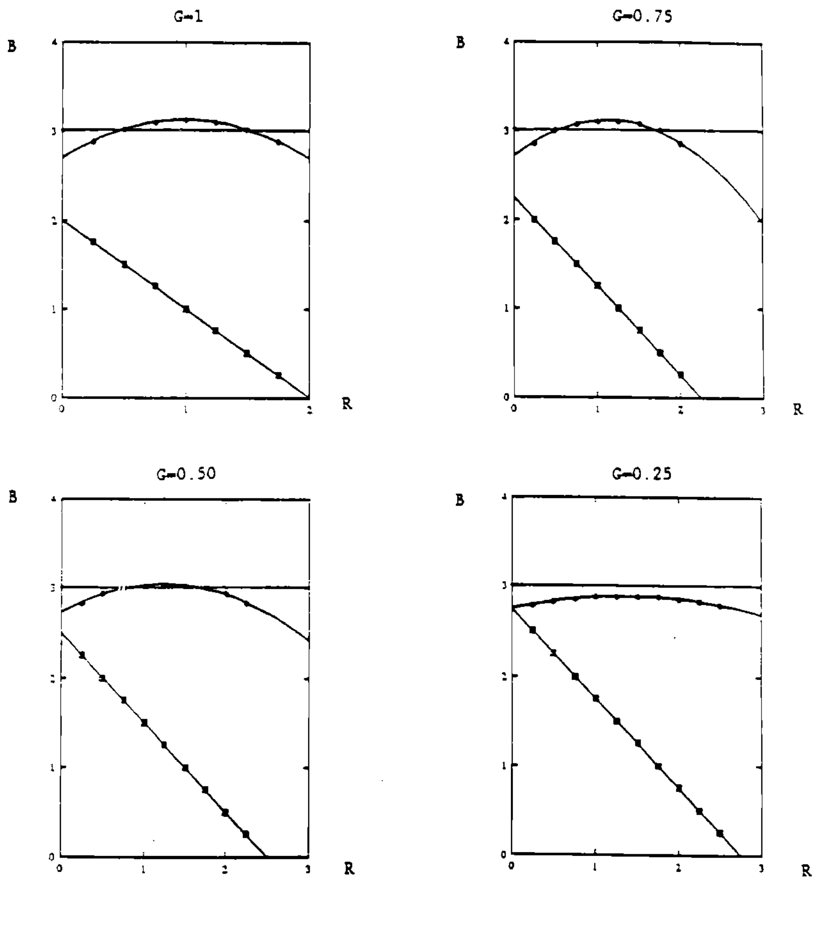
power depicted in Figure 2a. As shown by Figure 7, for certain distributions of endowments, the currency union is not a Nash equilibrium in pure strategies. In general, the agreement is easier to support the more asymmetrical is the distribution. The reason is once more the willingness of the large country to give transfers to smaller economies as a price to sustain the union. As the countries become more symmetrical, the advantage from the union decreases, and the temptation to deviate rises.

However, it is still possible to support the union as a Nash equilibrium in mixed strategies. The simplest example is the case of complete symmetry, when the three countries have the same size. With the usual parameters values, even though each of them has 33% of world endowment, each requires 35% of total power to participate in the union, an obviously impossible arrangement. Still, since each country prefers the discipline of a partial union to complete lack of coordination, there is an equilibrium where each period each economy randomizes between staying in the union and deviating. The requirement that expected utility be equal under the two courses of action determines the probability. For example, given the usual parameters values, a symmetrical equilibrium with equal probabilities for all countries will have each staying in the union with probability .86 and issuing a national currency with probability .14 every period. The union will have an expected life of 1.75 periods. Clearly this is not the only equilibrium - in this simple example, a 2-country union with no randomization is also sustainable - but it is the only one that allows for the existence of a global union.

In general, which equilibria can be supported is determined by the distribution of endowments, and the weight that each country is given both in the larger and the smaller union. We have analyzed in detail two additional examples where the 3-country union is not a pure-strategy equilibrium. The goal was to investi-

Figure 7

Three countries. Sustainability of the currency union
$\alpha=\beta=0.1$ $\theta=0.2$ $g=0.1$



• Sum of the minimum weights required by the three countries at the corresponding distribution of endowments gate which conditions are required on the distribution of power between countries of different sizes if the global agreement is to be at all possible, even in a probabilistic sense. For simplicity, two additional assumptions were made: (1) If two countries agree on a limited union, while one deviates, they maintain v/s one another the relative power they had in the previous global Central Bank. (2) If two countries have the same size they are given equal power and they deviate with equal probability (symmetrical equilibrium). The results are reported in Table 2.

In these examples, the Red and Blue countries have equal size and are treated symmetrically, while the third country (Green) differs. When the Green country's relative power (γ_G) is too low, maintaining the common currency is a dominant strategy for Red and Blue. This leads to a unique equilibrium with Red and Blue belonging to a limited union, and Green issuing a national money. When γ_G is high, staying in the union becomes the dominant strategy for Green. This leads Red and Blue to deviate (together, since communication is possible). However, if γ_G is between these two extremes, a mixed strategy equilibrium can exist. Near the lower bound of the interval, Green's temptation to deviate unilaterally is very strong, but it still prefers a limited union to uncoordinated flexible rates. The Green country is willing to randomize (instead than deviating) only if there is a nonnegligeable probability that Red (or Blue) might also deviate. At higher γ_G, Green's temptation to deviate is smaller, and randomization can be supported by lower probabilities of Red (or Blue) deviating. Exactly the same argument holds from the point of view of the Red or Blue country: for any division of power within the interval we can derive the probability of Green staying in the union that is necessary to support randomization by Red and Blue. Such probability is higher at higher $\gamma_{R,B}$ (lower γ_G).

Notice that in the interval where a mixed strategy equilibrium exists, the

TABLE 2

Three Countries.
Equilibria of the Static Game. Dependence on Power Allocation.
Two Examples
$g=0.1$, $\alpha=\beta=0.1$, $\theta=0.2$

Case 1				
Endowments	G	R	B	
	.5	1.25	1.25	
Equilibrium	If $\gamma_G < .665$,			G deviates, R and B form a partial union
	If $\gamma_G \epsilon$ [.665, .69],			there exists a mixed-strategy equilibrium. In this interval, the probability that R or B remain in the union rises from .9 to .99, while the probability that G remains falls from .99 to .9.
	If $\gamma_G > .69$,			R and B deviate together
Case 2				
Endowments	G	R	B	
	1.5	.75	.75	
Equilibrium	If $\gamma_G < 1.13$,			G deviates, R and B form a partial union
	If $\gamma_G \epsilon$ [1.13, 1.29],			there exists a mixed-strategy equilibrium. In this interval, the probability that R or B remain in the union rises from .13 to .99, while the probability that G remains falls from .99 to .7.
	If $\gamma_G > 1.29$,			R and B deviate together

smaller economies are again given more than proportional power.

Once identified when the currency union is a Nash equilibrium, it is possible to verify that in such cases it is also coalition-proof. The principle behind this result is simple: When a country deviates as part of a coalition, it is bound by the discipline of the agreement, while the third country can indulge in public good production and hurt the coalition through this externality. It is preferable to deviate alone, and especially so if the country is small and cannot exert controlling influence on either the global or the limited union. In other words, in this model preventing every single country from abandoning the common currency agreement is a sufficient condition for preventing coalitions.

Once again, this conclusion can be seen clearly in Figure 2a. Since the slope of the curve representing the minimum required weight is less than one, and since a coalition of countries is equivalent to a larger economy, it is always easier to prevent deviation by a coalition than by all the single countries, taken individually, that compose it. In the case of mixed strategies, it could be profitable for two countries to jointly decide to remain in the union with probability one, but this agreement is not a Nash equilibrium for the individual economies (each one will then prefer to abandon the union), and thus it is not self-enforcing.[12]

In conclusion, the analysis of a 3-country currency union has led to two observations. (1) A 3-country agreement can be sustained as a pure strategy equilibrium of the static game only when there is large asymmetry in the distribution of endowments. In these cases, it remains true that small countries must be given more than proportional weight in the international Central Bank. (2) When endowments are distributed more symmetrically, the 3-country union can only arise as the equilibrium of mixed strategies, where each country randomizes between remaining faithful to the agreement and deviating. The cases examined suggest that under reasonable assumptions the mixed strategy equilibrium might exist only when, again, the smaller countries are given more than proportional power.

It is not difficult to see what these results imply for larger n: (1) Supporting the union as an equilibrium in pure strategies becomes increasingly difficult as the number of countries rises. The asymmetry in endowments required for the outcome - with at least one country commanding a very substantial share of total resources - is more and more unprobable. (2) Supporting the union with mixed strategies also becomes harder. This happens not only, trivially, as the result of increasing the number of independent players, but because the probabilities of deviation become themselves higher, reflecting the larger potential gain. For example, in a 4-country symmetrical world with the usual parameter values, a mixed strategy equilibrium supporting the union will have each country remaining in the agreement with probability of only 0.24 each period.

These conclusions hold even though the distortions arising from lack of coordination are made more severe. While of course the specific numbers derived in the examples depend on the assumed values for the parameters, the qualitative results should hold generally, if the fundamental features of the model are accepted.

The discussion has been in terms of the currency union, and it is interesting to see how the results change when addressing the feasibility of policy coordination under flexible exchange rates. Since the difference between the two cases is given by the seignorage transfer typically characterizing the common currency regime, we can deduce the following regularities: (1) If the countries are equal and are given equal power, the two cases are identical. What has been said about the currency union applies exactly to the more general problem of sustaining coordination. (2) However, if the countries are not equal, equilibria with a common currency involve a transfer, and thus the analysis differs from a pure coordination problem. It has been shown before that with national currencies small countries demand more influence in the agreement than under a unique money. Since, with large n, more countries are small with respect to the total and it is the impossibility to prevent their deviation that eventually undermines the currency union, we expect this to be even more true with coordination under flexible exchange rates. That is, we expect the distributions of endowments consistent with coordination to be less frequent than the scenarios supporting the union. This intuition has been confirmed in a number of examples, but not verified in general.[13]

In either case, however, the focus on a global agreement is only one aspect of a wider problem: With n countries, what arrangements can emerge endogenously and be coalition-proof? Can they be ranked in terms of welfare? Extending the analysis in this direction is conceptually straightforward but for large number of countries with different endowments extremely cumbersome, since it requires studying all possible coalitions.

Formally, the problem is the following. The world, of total size n, consists of n countries, divided in z currency unions with $k_1, \dots, k_z$ members respectively ($\Sigma k_i = n$). A country with endowment J, belonging to a union of size k_i will be characterized by the following one-period indirect utility function:

$$U_J = K_J' + [(1-g)(1-\theta)/\theta]\ln(n - \sum_{s=1}^{n} m_s) + (1-g)\ln[(\sum_{J=1}^{ki} J - \sum_{J=1}^{ki} m_J)/(\sum_{J=1}^{ki} J) + g\ln m_J$$

and the first-order conditions:

$$\frac{[(1-g)(1-\theta)/\theta] \sum_{J=1}^{ki} m_J (\sum_{J=1}^{ki} J - \sum_{J=1}^{ki} m_J)}{g(\sum_{J=1}^{ki} J) - \sum_{J=1}^{ki} m_J} = n - \sum_{s=1}^{n} m_s$$

$$\gamma_v m_J = \gamma_J m_v \qquad \forall v \text{ belonging to the same coalition}$$

Equilibria will specify public and private goods production, inflation rates, welfare and, most interestingly, the number of different subunions, their sizes, and the boundaries on the power of the individual countries taking part in the agreements.

7. Conclusions

While the simple model studied in the paper has proven powerful and rich, two important limitations qualify the results.

First, even if the fundamental assumptions are accepted, the focus on the static game might be misleading. Implicitly, it requires that each country be allowed to abandon the union at any time with no punishment, issue a national currency and enforce its use in all purchases of national goods. In reality, even neglecting the feasibility of this option, if the punishment from deviation is anything more than a lump-sum penalty, it should be modelled explicitly, and the dynamic character of the game recognized. Policy-makers are undoubtedly aware of this aspect: if smaller countries are easier targets for punishments, their request for power should be more modest, and the likelihood of sustaining the union higher. The union itself would be a more complex, multidimensional agreement.

Second, while the paper has stressed the unique character of a common currency regime and its differences with respect to monetary policy coordination with national currencies, it has not derived endogenously the need for a unique money. If the underlying motivation is more than transaction costs, it will substantially affect the very problem we are studying, i.e. the division of power in the determination of the common policy. For example, if the important distinction were between tougher and softer countries, with the latter affected by a credibility problem in the conduct of their monetary policy, the very reason of existence for the union would demand that the softer countries renounce their influence. But then, of course, there could be no concern over the loss of national autonomy.

These caveats notwithstanding, the analysis has shed light on several issues. First, it has clarified the theoretical implications of a unique currency, stressing the possibility of active monetary policies and the inherent transfer of seignorage revenues. These observations should hold in general, for a wide range of models. In addition, it has emphasized the scarce attractiveness of belonging to a multi-country agreement without substantially affecting common decisions. Either directly or in a more complex fashion, the policies of a successful union must reflect the priorities of its weaker members.

Footnotes

1. The maximization problem faced by the domestic government is identical in the two cases, up to a constant scale parameter. When analyzing the equilibrium with coordinated policies, we will assume an international Central Bank maximizing a weighted sum of per-capita utilities, and ask whether the weights could be given by the two countries' populations. Whether per-capita or aggregate utilities are compared is irrelevant.

2. As noticed by Peter Kenen, inflation rates can be derived directly from the two money markets. Since all monetary transactions inside the country take place in domestic currency, $\sigma w_B = \sigma w_{B-1} + M_B$, or $w_B/w_{B-1} = \sigma/(\sigma - m_B)$ (and similarly for Red).

3. Note that in this model the inflation tax is not distortionary since it cannot affect any decision: labor supply is given, and money is the only asset in the economy.

4. In this model, the need for direct transfers between countries of unequal size occurs even when utility functions are not strictly identical and countries have different relative needs for the public good. Of course, there are parameter values such that the optimal transfer is zero, but so far we have not characterized the condition that must hold in general for this to be true.

5. Again, inflation can be derived directly from the monetary equilibrium, taking into account that domestic and international transactions take place in the same currency: $2w = 2w_{-1} + M_R + M_B$, or $w/w_{-1} = 2/(2 - m_R - m_B)$.

6. If taxes were decided optimally by a central authority, in this model they would clearly not be zero (fiscal transfers should be used to equalize resources between the two countries). The assumption is only made for simplicity. Alternatively, this equilibrium might emerge if we assume that taxes are less readily modifiable than money supplies. In this case, financing of the public good would be ultimately controlled by the Central Bank. If the Central Bank refused to support direct subsidies to the workers ($t<0$), the national governments would indeed set taxes to zero.

7. When the parameter g is equal in the two countries, the following simple relationships hold for different γ: $U_j(\gamma_j) = U_j(\gamma_j = 1) + g\ln(\gamma_j)$ and $m_j(\gamma_j) = \gamma_j m_j(\gamma_j = 1)$, where γ_j is the relative weight of country J in the welfare function of the union.

8. If the equivalent of Figure 3 is drawn for the case of cooperation under national currencies, it becomes apparent that such cooperation is easier to achieve than participation in the currency union (the sum of the minimum required weights is lower, for any distribution of endowments, as can be deduced from Figure 2b). However, for any distribution of endowments, there exists an acceptable division of power under the currency union such that welfare is in both countries superior to the welfare they can achieve in any acceptable coordination under national currencies (with the exception of $\sigma = 1$, when the two regimes are equivalent). Both results stem from the transfer inherent in the currency union (once $\gamma \neq \sigma$), together with the distortion caused by the difference in size between the two countries, and they would not hold if a direct transfer were part of the policy package dis-

cussed under cooperation with national currencies (But note that this would require the explicit consideration of an additional policy tool).

9. More precisely, the discussion in the text is correct for θ lower than a threshold value θ^*, where θ^* depends on the difference between r and b. When θ is large and there is a wide discrepancy between r and b, the union might not be sustainable: an example is r=0.4, b=0.1, θ=0.8.

10. Three points should be noticed: (1) The game described in the text (and coherent with the previous sections of the paper) is designed to investigate the feasibility of the union, for any possible division of power. A different game would model the division of power as the outcome of a bargaining process. (2) An alternative to the concept of "coalition-proof" equilibrium is the Strong Nash equilibrium. A Strong Nash equilibrium must be robust to <u>any</u> deviation by sub-coalitions, whether or not such deviation is self-enforcing. In practice, it seldom exists. While coalition-proof equilibria are also problematic, the requirements for their existence are less severe, and therefore they have been proved to exist in many games with no Strong Nash equilibrium (see the discussion in Bernheim, Peleg and Whinston 1987, and the examples in Bernheim and Whinston, 1987). (3) Coalition-proof equilibria are not properly defined in ∞-repeated games. In general, the players could reach a Pareto-superior point by sustaining cooperation through a punishment scheme. But once the deviation has occurred, the punishment is contrary to the interest of the group (the widest coalition), and thus will not be enforced, making impossible the cooperation and leading to an inefficient equilibrium, itself violating group rationality (again, see the discussion in Bernheim, Peleg and Whinston). The decision to focus on the repetition of the coalition-proof equilibrium of the static game seems reasonable, but cannot be rigorously defended.

11. The same point, in a slightly different context, was made by Canzoneri and Henderson (1985).

12. Notice that if the distribution of power is given exogenously, the Nash equilibria in pure strategies supporting the union are also Strong Nash, i.e. are robust to deviations by any coalition. However, the mixed strategy equilibria are not Strong: the group (the coalition of the whole) should agree to stay in the union with probability one, since this would yield higher welfare for each member. But of course this is not an equilibrium, and thus no Strong Nash equilibrium exists for the game.

13. With national currencies, a group of countries of different sizes tied by a cooperative agreement is not equivalent to a unique larger country. Not only the distribution of new money among its members, but total money printing depends on the distribution of endowments and of power. Figure 2b therefore does not extend immediately to n>2.

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Appendix

Table 1A

Two Countries. Numerical Results
$g=0.1$, $\alpha=\beta=0.1$, $\theta=0.2$, $R+B=2$

	Red endowment						
	.25	.50	.75	1.00	1.25	1.50	1.75
	Red utility						
exible Exchange Rates coordinated policies	10.027	10.071	10.093	10.108	10.122	10.137	10.158
exible Exchange Rates ordinated policies ual weights	10.057	10.095	10.113	10.123	10.132	10.140	10.152
mmon Currency ntral Bank ual weights	10.123	10.123	10.123	10.123	10.123	10.123	10.123
	Red Money Injections						
exible Exchange Rates coordinated policies	0.017	0.027	0.032	0.036	0.038	0.040	0.042
exible Exchange Rates ordinated policies ual weights	0.013	0.018	0.020	0.022	0.023	0.023	0.024
mmon Currency ntral Bank ual weights	0.022	0.022	0.022	0.022	0.022	0.022	0.022

Table 1A cont.

	Red endowment						
	.25	.50	.75	1.00	1.25	1.50	1.7
Red Inflation (percent)							
Flexible Exchange Rates Uncoordinated policies	7.51	5.61	4.47	3.70	3.16	2.76	2.4
Flexible Exchange Rates Coordinated policies Equal weights	5.66	3.74	2.79	2.22	1.85	1.58	1.3
Common Currency Central Bank Equal weights	2.22	2.22	2.22	2.22	2.22	2.22	2.2
Varieties of private goods produced in the Red country							
Flexible Exchange Rates Uncoordinated policies	1.86	3.79	5.74	7.71	9.69	11.68	13.
Flexible Exchange Rates Coordinated policies Equal weights	1.89	3.86	5.84	7.83	9.82	11.81	13.
Common Currency : Central Bank Equal weights	1.83	3.83	5.83	7.83	9.83	11.83	13.

Nota Bene: (1) Money injections and inflation rates under flexible exchange rates been calculated assuming all government expenditure financed by money.

(2) In the two cases of coordinated policies, the results reported in t tables assume that the two countries are given equal weights in the aggregate welfar function, independently of their size. However in neither case is this arrangement ceptable when there is large asymmetry between the two economies. As reported in fo note 9, when there is a common currency the results are easily generalized by notici $U_j(\gamma_j) = U_j(\gamma_j=1) + g\ln(\gamma_j)$ and $m_j = \gamma_j m_j(\gamma_j=1)$.

Extension of the Model to Three Countries

The world is now composed of three countries: Red, Blue and Green. Total population is normalized to 3, and R, B, and G represent the number of consumers living in each country. Utility functions and technologies are the same everywhere, as given by equations (1), (2), and (3). Governments can print money and collect lump-sum taxes. The firm's problem is exactly as before, and as before the scale of production is constant and given by equation (7). This implies that wages will be equal in the three countries. The full-employment condition gives the number of varieties produced in each country ($n_J = (J-\Gamma_J)(1-\theta)/\alpha$), and each consumer divides his disposable income equally among all varieties.
Goods market equilibrium requires:

$$x = Rc_R + Bc_B + Gc_G \qquad \text{(A1)}$$

which can be written as:

$$3-m_R-m_B-m_G = R\left(\frac{w_{R-1}}{w_R}\right) + B\left(\frac{w_{B-1}}{w_B}\right) + G\left(\frac{w_{G-1}}{w_G}\right) \qquad \text{(A2)}$$

Flexible Exchange Rates

The equilibrium conditions for Blue and Green currencies are:

$$\begin{aligned} Bc_B\ (p_R n_R + e_G p_G n_G) &= e_B p_B n_B\ (Gc_G + Rc_R) \\ Gc_G\ (p_R n_R + e_B p_B n_B) &= e_G p_G n_G\ (Bc_B + Rc_R) \end{aligned} \qquad \text{(A3)}$$

where e_B (e_G) is the rate of exchange of Red currency into Blue (Green). Together, they imply equilibrium in the Red money market.
With equation (A2), they yield:

$$\frac{w_J}{w_{J-1}} = \frac{J}{J-m_J} \qquad J = R, B, G \qquad \text{(A4)}$$

Indirect utility can then be written:

$$U_J = K_J + [(1-g)(1-\theta)/\theta]\ln(3-\Gamma_R-\Gamma_B-\Gamma_G) + (1-g)\ln(J-\Gamma_J) + g\ln\Gamma_J$$
(A5)

where $K_J = [(1-g)(1-\theta)/\theta]\ln[(1-\theta)/\alpha] + (1-g)\ln[\theta/(\beta J)]$

Common Currency

Since $e_B = e_G = 1$, inflation is the same everywhere, and equation (A2) then implies:

$$\frac{w}{w_{-1}} = \frac{3}{3-m_R-m_B-m_G} \tag{A6}$$

Indirect utility is then:

$$U_J = K_J' + [(1-g)(1-\theta)/\theta]\ln(3-\Gamma_R-\Gamma_B-\Gamma_G) + (1-g)\ln[(3-m_R-m_B-m_G)/3 - t_J/J] + g\ln\Gamma_J \tag{A7}$$

where $K_J' = K_J + (1-g)\ln J$.

If taxes are set to zero, an international Central Bank maximizing a weighted sum of one-period utilities (where γ_J is the weight given to country J and $\Sigma\gamma_J=3$) will choose:

$$m_J = \gamma_J \frac{g\theta}{1-(1-\theta)g}$$

Limited Currency Union

Suppose now that R and B share a common currency, while G does not belong to the union. The exchange rate between Green money and the currency of the union is perfectly flexible. In this regime $e_B=1$,
while e_G clears the Green currency market:

$$Gc_G\ (p_R n_R + p_B n_B) = e_G p_G n_G\ (Bc_B + Rc_R)$$

This implies:

$$\frac{w_G}{w_{G-1}} = \frac{G}{G-m_G} \quad \text{and} \quad \left(\frac{w}{w_{-1}}\right)_{R,B} = \frac{B+R}{B+R - (m_R+m_B)} \tag{A8}$$

Indirect utility functions are then:

$$U_G = K_G + [(1-g)(1-\theta)/\theta]\ln(3-\Gamma_R-\Gamma_B-\Gamma_G) + (1-g)\ln(G-\Gamma_G) + g\ln\Gamma_G$$

$$U_J = K_J' + [(1-g)(1-\theta)/\theta]\ln(3-\Gamma_R-\Gamma_B-\Gamma_G) + (1-g)\ln[(R+B-m_R-m_B)/(R+B) - t_J/J] + g\ln\Gamma_J \tag{A9}$$

where J=R,B

If taxes are set to zero in the Red and Blue countries, and policy decisions are deferred to a common Central Bank, the one-shot Nash equilibrium will be characterized by:

$$\frac{[(1-g)(1-\theta)/\theta]\ m_G\ (G-m_G)}{gG - m_G} = 3 - m_R - m_B - m_G \tag{A10}$$

$$\frac{[(1-g)(1-\theta)/\theta\}\ (m_B+m_R)\ (R+B-m_R-m_B)}{g(R+B)\ -\ (m_R+m_B)} = 3 - m_R - m_B - m_G$$

$$m_B = (\gamma_B/\gamma_R)\ m_R$$

where γ_R (γ_B) is the weight of the Red (Blue) country in the limited currency union.

Table 2A

Three Countries. Numerical Results
$g=0.1$, $\alpha=\beta=0.1$, $\theta=0.2$, $R+B+G=3$

Common currency. Central Bank. Equal power.

Utility in each country: 11.583

Limited Union
Green issues green money, Red and Blue share a common currency.

Green endowment

.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50

Green utility

11.497	11.546	11.571	11.587	11.599	11.608	11.618	11.627	11.637	11.650

Blue and red utility. Equal power

11.598	11.581	11.568	11.558	11.548	11.539	11.529	11.517	11.502	11.477

Flexible Exchange Rates

Green utility \ Green endowment	.25	.50	.75	1.00
R = 1.50 B = 1.25	11.447			
R = 1.75 B = 1.00	11.449			
R = 2.00 B = .75	11.454			
R = 2.25 B = .50	11.462			
R = 2.50 B = .25	11.475			
R = 1.25 B = 1.25		11.499		
R = 1.50 B = 1.00		11.501		
R = 1.75 B = .75		11.505		
R = 2.00 B = .50		11.512		
R = 2.25 B = .25		11.524		
R = 1.25 B = 1.00			11.527	
R = 1.50 B = .75			11.530	
R = 1.75 B = .50			11.537	
R = 2.00 B = .25			11.549	
R = 1.00 B = 1.00				11.546
R = 1.25 B = .75				11.548
R = 1.50 B = .50				11.554
R = 1.75 B = .25				11.565

Green endowment

Green utility	1.25	1.50	1.75	2.00	2.25	2.50
R = 1.00 B = .75	11.563					
R = 1.25 B = .50	11.567					
R = 1.50 B = .25	11.578					
R = .75 B = .75		11.576				
R = 1.00 B = .50		11.579				
R = 1.25 B = .25		11.589				
R = .75 B = .50			11.591			
R = 1.00 B = .25			11.599			
R = .50 B = .50				11.605		
R = .75 B = .25				11.610		
R = .50 B = .25					11.623	
R = .25 B = .25						11.641