Participation in a Currency Union

By Alessandra Casella*

In any voluntary cooperative agreement, the potential gain from deviation should determine the minimum influence required over common decision-making. This paper begins by observing that a highly asymmetrical distribution of power between two partners is not sustainable if the choice variables are strategic substitutes. It then studies a simple general-equilibrium model of a monetary union and shows that a small economy will not take part in the agreement unless it can secure influence that is more than proportional to its size and a transfer of seigniorage revenues in its favor. (*JEL* F33, F42)

Western European countries discussing prospects for monetary integration share a fundamental concern about the inevitable constraints on national autonomy. The problem arises 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. The debate has focused on the possibility (or impossibility) of maintaining the necessary independence through fiscal policy (see e.g., Daniel Cohen and Charles Wyplosz, 1988; Barry Eichengreen, 1990) but has neglected the study of the institutional features of the international monetary agency.

The main goals of this paper are to stress the importance of such an approach and to provide an initial example. More precisely, the paper addresses the problem of the distribution of power within the common central bank. Even a central bank independent of national governments will need to define the monetary policy of the union taking into consideration, and weighing, the demands of the different economies. This paper focuses on the range of admissible weights and the parameters that determine them.

In particular, the paper studies the relationship between a country's influence in the cooperative agreement and its economic size. The provisional statute of the European Central Bank, drafted by the Committee of Governors of the central banks of the European Community (EC) member states in November 1990, suggests that most (though not all) decisions will be taken on the basis of simple majority voting by the bank's council. The council will be formed by the 12 governors of the national central banks, plus six executive directors appointed by the European Council of Ministers (the executive branch of the European Community), and probably representing the interests of the larger countries. At this stage, details are naturally left vague, and it is difficult to conclude how much influence the different countries will indeed exercise.

In general, it has often been noted that smaller countries tend to have more than proportional power in international organizations. For example, within the Council of Ministers of the European Community there are several coalitions of small countries that could block a deliberation while controlling only approximately 10 percent of the Community's GDP and less than 15 percent of its population. The leading explanation for this finding rests on the public-good nature

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of the functions fulfilled by international organizations and stresses the possibility for small countries to free-ride on the other members (Mancur Olson and Richard Zeckhauser, 1966).

The starting point of this paper is simpler: in a cooperative agreement, if power were proportional to size, small countries would have very little control over common decisions; they would be bound by the discipline of the accord without being able to address their own specific interests. Consider a partnership that has been formed between two agents to solve an externality. If one of the two alone determines the outcome of the cooperation, the other may well be worse off than in an equilibrium with independent choices. If participation is voluntary, it may be in the interest of both to share power more equally. Indeed this must be the case if the choice variables are strategic substitutes and the reaction functions are negatively sloped; this is the first result of the paper.

In a currency union, all monetary interventions must be decided together by all members, but they can differ in different economies, even though this will cause a transfer of seigniorage revenues. The influence that each country exerts on the union determines the degree to which it is able to address its own monetary needs. As in the discussion above, the possibility of abandoning the union, combined with the strategic interaction between the monetary policies of the member countries, must set boundaries on the feasible distribution of power. The paper presents a simple two-country general-equilibrium model with the purpose of understanding how tight these boundaries are and how they relate to countries' sizes.

The model, describing trade between two imperfectly competitive economies, is adapted from Paul Krugman (1981) and has the very convenient feature that national incomes are easily parametrized and independent of equilibrium policies. 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 monetary issues. Governments decide the amount of public good supplied 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 and thus in the optimal monetary issues.

When countries belong to a monetary union, the amount of common money injected in each economy and financing the public good is decided by an international central bank maximizing a weighted sum of the utilities of each country's citizens. The utility weights are interpreted as effective power: they determine the extent to which the specific interests of one country, possibly in direct conflict with the interest of the other, are taken into account by the common central bank. The minimum weight each country demands is determined by the welfare it can achieve in a Nash equilibrium with national currencies and noncoordinated policies.

In this model, an increase in money supply abroad reduces world private production and increases world inflation, reducing desired money supply at home: money injections are strategic substitutes. Confirming the previous result, a sufficiently small country will require and obtain more than proportional representation in the union (i.e., a weight in the common decision-making larger than its size). This is the main conclusion of the paper. Notice that the focus is not on a bargaining game between the members of the union (as in Roberto Chang [1991]), but on the lower bound of the power that the small country must be given in *any* equilibrium if deviation is allowed and cooperation is to be sustained.

With a common currency, the more-than-proportional influence of the small country is equivalent to a transfer of seigniorage revenues in its favor. The transfer works to mitigate its demands: in a cooperative agreement with national currencies, where monetary policy does not generate redistribution of wealth, the small country would require even larger influence.

The results extend to a monetary union involving several countries. However, in this case each single economy tends to be small with respect to the total and wants "extra" influence on the common policy. In the aggregate, this is generally unfeasible, and the union cannot be sustained without credible punishment schemes.

The paper is linked to different strands of literature. In modeling the currency union from a public-finance perspective, it adopts the same approach as Matthew B. Canzoneri and Carol A. Rogers (1990) and Anne Sibert (1990). However, it does not share their central concern with the impact of the union on fiscal distortions, focusing instead on the sustainability of the agreement when the member countries have different policy needs.

From this latter point of view, the closest link is with the international-trade literature on tariff wars, starting with Harry Johnson (1954). Wolfgang Mayer (1981) and John Kennan and Raymond Riezman (1988), among others, study the relative gain from a cooperative agreement on trade policy when countries' sizes differ. In their competitive models, foreign policy measures affect the domestic country through terms-of-trade effects, whereas in this paper, with imperfect competition, the channel runs through the number of varieties of the private good available for consumption. The two effects are parallel, and the difference in modeling strategies should not influence the answer to the question. Instead, the results of this paper suggest that the distribution of the gains from cooperation may depend in general on the sign of the strategic interaction between the policy variables.

Finally, the issues studied in this paper were introduced in Casella and Jonathan Feinstein (1989). The model discussed there, however, was not appropriate for capturing differences in countries' sizes, and thus the problem of different countries' influence in the international central bank could not be addressed satisfactorily.

The paper proceeds as follows. Section I discusses the intuition behind the main result of the paper; Section II presents the model and the solution of the private sector's decision problem; Sections III and IV derive optimal policies under national currencies and a common money; Section V studies the allocation of power in a currency union, and conclusions are presented in Section VI.

I. The Intuition

In its most general interpretation, this paper asks whether a partner to an agreement will deviate if his interests are given very low weight in the common decision-making. In problems of international coordination, a small country will find itself in this position if its influence is proportional to its size and may therefore prefer to revert to independent policy decisions. In the presence of externalities, it may be in the interest of the large country to "bribe" the small one into compliance by accepting a more equalitarian division of power.

The intuition underlying the results of this paper is easily seen in a very simple two-player game. Consider two agents A and B; A takes action z_A, B takes action z_B, and their payoff function V depends on both z_A and z_B and on a parameter σ_j ($j = A, B$):

$$(1)\qquad V_A = V(z_A, z_B, \sigma_A)$$
$$V_B = V(z_B, z_A, \sigma_B).$$

The two variables z_A and z_B must lie in a feasible set bound by 0 and z_A^{max} and z_B^{max}. V is assumed to be twice continuously differentiable and strictly globally concave. In addition, the spillovers between the two players, V_A^B and V_B^A, are assumed to be everywhere finite and different from 0, where a superscript $j = A, B$ denotes the partial derivative with respect to z_j.

The Nash equilibria of this game (z_A^*, z_B^*) are the intersections, possibly multiple, of the two reaction functions implicitly defined by

$$(2)\qquad V_A^A(z_A, z_B, \sigma_A) = 0$$
$$V_B^B(z_B, z_A, \sigma_B) = 0.$$

Assume that at least one equilibrium exists and that all equilibria are interior.

Since each agent ignores the effect of his action on the other player, these equilibria are inefficient. Pareto-optimal outcomes can be obtained through cooperation, maximizing jointly a weighted sum of the payoffs:

$$W = (2-\gamma)V_{\mathrm{A}}(z_{\mathrm{A}}, z_{\mathrm{B}}, \sigma_{\mathrm{A}}) + \gamma V_{\mathrm{B}}(z_{\mathrm{B}}, z_{\mathrm{A}}, \sigma_{\mathrm{B}}). \tag{3}$$

In the cooperative equilibrium, $z_{\mathrm{A}}^{**}(\gamma)$ and $z_{\mathrm{B}}^{**}(\gamma)$ will solve the following two conditions:

$$(2-\gamma)V_{\mathrm{A}}^{\mathrm{A}}(z_{\mathrm{A}}, z_{\mathrm{B}}, \sigma_{\mathrm{A}}) + \gamma V_{\mathrm{B}}^{\mathrm{A}}(z_{\mathrm{B}}, z_{\mathrm{A}}, \sigma_{\mathrm{B}}) = 0 \tag{4}$$

$$(2-\gamma)V_{\mathrm{A}}^{\mathrm{B}}(z_{\mathrm{A}}, z_{\mathrm{B}}, \sigma_{\mathrm{A}}) + \gamma V_{\mathrm{B}}^{\mathrm{B}}(z_{\mathrm{B}}, z_{\mathrm{A}}, \sigma_{\mathrm{B}}) = 0.$$

Since V is strictly concave, z_{A}^{**} and z_{B}^{**} are continuous functions of the parameter γ.

This formulation spans all Pareto optima of the game. The two weights γ and $2-\gamma$ affect the distribution of payoffs. For any γ, the cooperative equilibrium cannot be improved upon for both players; however, for some γ, deviating may be profitable for one of them. In particular, a very asymmetrical distribution of weights may be unacceptable. The following proposition makes this point precise.

PROPOSITION 1: *If the two actions z_{A} and z_{B} are strategic substitutes ($V_{\mathrm{A}}^{\mathrm{AB}} \leq 0, V_{\mathrm{B}}^{\mathrm{BA}} \leq 0$), then there exists a minimum weight $\bar{\gamma} > 0$ such that no cooperative agreement can be sustained with $\gamma < \bar{\gamma}$.*

The content of Proposition 1 becomes clear when the problem is represented in a figure. In Figure 1, $R_{\mathrm{A}}(z_{\mathrm{B}})$ is the reaction function of agent A (and similarly for B), $\bar{V}_{\mathrm{A}}$ and $\bar{V}_{\mathrm{B}}$ are isoprofit lines, point N is the Nash equilibrium (for simplicity unique), and all cooperative equilibria, for all γ, lie on the contract curve between points A and B. Along each reaction function, the change in payoff depends only on the sign of the spillover: in the figures, $V_{\mathrm{A}}^{\mathrm{B}}$ and $V_{\mathrm{B}}^{\mathrm{A}}$ are taken to be negative, and V_{A} falls along R_{A} as z_{B} rises (and similarly for V_{B}). The shaded area between the two isoprofit curves to the

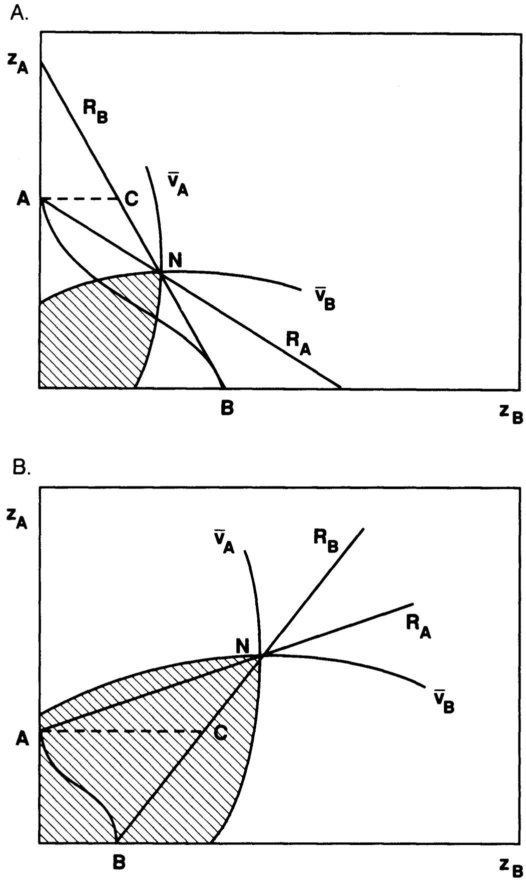

FIGURE 1. A) STRATEGIC SUBSTITUTES, NEGATIVE SPILLOVERS; B) STRATEGIC COMPLEMENTS, NEGATIVE SPILLOVERS

southwest of the Nash point encompasses all points that are Pareto-superior to N. In Figure 1A, z_{A} and z_{B} are strategic substitutes, and the two reaction functions have negative slopes; in Figure 1B, z_{A} and z_{B} are strategic complements, and the two reaction functions have positive slope.

Examining the two graphs, one sees immediately that while all cooperative points may be Pareto-superior to the Nash equilibrium when the reaction functions have positive slope (depending on the specific functional form for V), this cannot be the case when the reaction functions have negative slope.

More formally, notice that a sufficient condition for Proposition 1 is that the payoff to player B in all Nash equilibria be higher than his payoff in the cooperative equilibrium when γ equals 0. In this case, (z_A^{**}, z_B^{**}) must lie on agent A's reaction function, and if V_A^B and V_B^A are negative z_B^{**} must equal 0: in Figure 1, the equilibrium is given by point A. However, if the reaction functions have negative slope, z_A^{**} must be larger than z_A^*, where the asterisk denotes any interior Nash equilibrium, and therefore

$$(5)\quad V_B(0, z_A^{**}, \sigma_B) < V_B(R_B(z_A^{**}), z_A^{**}, \sigma_B) < V_B(z_B^*, z_A^*, \sigma_B)$$

where $(R_B(z_A^{**}), z_A^{**})$ is point C in Figure 1A. The first inequality holds since $z_B = 0$ is not B's best response to z_A^{**}; the second inequality holds since, along R_B, B's payoff falls as z_A rises. Thus, agent B would abandon the agreement. If the reaction functions had no slope ($V_A^{AB} = 0, V_B^{BA} = 0$), the result would still follow, with the second inequality being replaced by an equal sign. Notice that what matters is the slope of the reaction functions, not the sign of the spillover: if V_A^B and V_B^A are positive, the argument is identical with $z_B^{**} = z_B^{\max}$, and $z_A^{**} < z_A^*$. Again, since the equilibrium must lie outside B's reaction function and since the change in B's payoff along R_B depends only on the sign of V_B^A, B must be worse off than in any Nash equilibrium. Proposition 1 is then established.

The intuition is straightforward: when one player controls the final outcome, the two variables must lie on his reaction curve, and the slope of this curve determines whether z_A and z_B move in the same or in the opposite direction, with respect to the Nash point. The dominant player will optimally choose the value of his partner's variable, given the sign of the externality, but if the slope of his reaction function is negative, this is accompanied by an opposite change in his own variable, and the shift from the Nash point must be harmful to the weaker player. If the slope is positive, the changes in the two variables have the same sign, and the weaker player may gain, even while the dominant player optimizes his own position (see Fig. 1B).

Therefore, the negative slope of the reaction functions is a sufficient condition for a breakdown of the cooperation between two agents when the division of power is very asymmetrical. This conclusion echoes more general discussions in industrial organization, where the slope of the reaction functions has been shown to be often crucial in determining firms' behavior (see Jeremy I. Bulow et al., 1985; Jean Tirole, 1988).

The remainder of the paper presents a simple general-equilibrium model in which two countries can form a currency union. Deviation from the cooperative agreement entails reverting to uncoordinated policies under national currencies. Since the two monetary regimes lead to different expressions for the indirect utility function, the comparison between the two equilibria will be slightly more complex than in the case analyzed above. However, the results of the model will confirm the intuition discussed here: if money supplies are strategic substitutes, then the influence that two partners exercise in the union cannot be too lopsided.

II. The Model

A. *Exposition*

To keep the analysis as simple as possible, it is necessary to have a framework in which differences in economic size can be easily represented. Standard models of imperfect competition when consumers "love variety" (Avinash Dixit and Joseph Stiglitz, 1977) are appropriate to this goal, since the size of a country translates immediately into the number of goods produced domestically, with no counterbalancing effect on the terms of trade.[1] Thus, I will follow closely

[1] If a change in the countries' relative endowments affects the terms of trade, national income depends on the overall solution of the general-equilibrium problem and is therefore much more difficult to control.

Krugman (1981), modifying his setup to include the optimal provision of a public good.

The world is composed of two countries, A and B. Total population is normalized to 2, with $2-\sigma$ consumers living in A 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

$$(6)\quad U_{\mathrm{A}}=(1-g)\ln\left(\sum_{i=1}^{n}c_{i\mathrm{A}}^{\theta}\right)^{1/\theta}+g\ln\Gamma_{\mathrm{A}}$$

$$U_{\mathrm{B}}=(1-g)\ln\left(\sum_{i=1}^{n}c_{i\mathrm{B}}^{\theta}\right)^{1/\theta}+g\ln\Gamma_{\mathrm{B}}$$

where n is the total number of varieties of the private good available, c_i is the consumption of variety i, and Γ is the public good. The parameter g (<1) represents the relative need for the public good; θ is less than 1, and $1/(1-\theta)$ is the elasticity of substitution between different varieties of the private good (and the elasticity of demand, if the number of varieties is large). 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, and the opportunity for international cooperation becomes irrelevant.

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

$$(7)\qquad l_i=\alpha+\beta x_i \qquad i=1,\dots,n$$

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.

In both countries, the government produces the public good with a simple constant-returns-to-scale technology:

$$(8)\qquad \Gamma_j=l_{\Gamma j} \qquad j=\mathrm{A},\mathrm{B}$$

where $l_{\Gamma j}$ is domestic labor employed in the production of the public good. The government's labor costs are financed by money-printing:

$$(9)\qquad w_j l_{\Gamma j}=M_j$$

where w is the nominal wage and M represents new issues of money. Notice that real money injections in terms of domestic wages, which I will call m, equal the supply of the public good:

$$(10)\qquad m_j=\Gamma_j.$$

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 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 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 money supplies to maximize the discounted welfare of present and future generations of their citizens.

B. *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 technologies are identical, I can focus on the symmetrical equilibrium in which all varieties produced in the same country will be sold at the same price. Because of the fixed cost α, each firm specializes in the production of one variety and sets its price so as to equate marginal revenue and marginal cost. Since $1/(1-\theta)$ is the elasticity of demand and $\beta(w)$ is the marginal cost, this implies

$$(11)\qquad p_j=(\beta/\theta)w_j \qquad j=\mathrm{A},\mathrm{B}.$$

The zero-profit condition determines the scale of production:

$$(12) \qquad p_j x_{ij} = w_j l_{ij} = w_j(\alpha + \beta x_{ij})$$

where x_{ij} is the production of variety i in country j, and l_{ij} is the labor input employed in such production. Substituting (11) in (12),

$$(13) \qquad x_{ij} = \frac{\alpha\theta}{\beta(1-\theta)} = x.$$

All varieties are produced in the same quantity, regardless of their country of origin.

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 A or B. If each variety is purchased with the currency of the country where it is produced, this implies

$$(14) \qquad e p_{\mathrm{B}} x_{i\mathrm{B}} = p_{\mathrm{A}} x_{i\mathrm{A}}$$

where e is the exchange rate (defined as units of A currency for one unit of B). Given (11) and (13), this yields

$$(15) \qquad e w_{\mathrm{B}} = w_{\mathrm{A}}$$
$$e p_{\mathrm{B}} = p_{\mathrm{A}}.$$

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:

$$(16) \qquad n_{\mathrm{A}} l_{\mathrm{A}} = n_{\mathrm{A}}(\alpha + \beta x) = (2-\sigma) - l_{\Gamma\mathrm{A}}$$
$$n_{\mathrm{B}} l_{\mathrm{B}} = n_{\mathrm{B}}(\alpha + \beta x) = \sigma - l_{\Gamma\mathrm{B}}$$

where n_{A} (n_{B}) is the number of varieties of the private good produced in country A (B). Substituting (8) and (13) in (16) and ignoring integer constraints, one derives

$$(17) \qquad n_{\mathrm{A}} = (2-\sigma-\Gamma_{\mathrm{A}})(1-\theta)/\alpha$$
$$n_{\mathrm{B}} = (\sigma-\Gamma_{\mathrm{B}})(1-\theta)/\alpha.$$

Since all varieties have the same price and consumers spend their disposable income equally on all, consumption levels are equal for all varieties. Thus, the utility function of the current generation simplifies to

$$(18) \qquad U_{\mathrm{A}} = (1-g)\ln\left[(n_{\mathrm{A}}+n_{\mathrm{B}})c_{\mathrm{A}}^{\theta}\right]^{1/\theta} + g\ln\Gamma_{\mathrm{A}}$$
$$U_{\mathrm{B}} = (1-g)\ln\left[(n_{\mathrm{A}}+n_{\mathrm{B}})c_{\mathrm{B}}^{\theta}\right]^{1/\theta} + g\ln\Gamma_{\mathrm{B}}$$

where c_j is per capita consumption of each variety by citizens of country j.

Consumption takes place in the second period of each consumer's life, while wages are received in the first. Therefore,

$$(19\text{a}) \qquad c_{\mathrm{A}} = \left(\frac{w_{\mathrm{A},-1}}{p_{\mathrm{A}}}\right)\Big/(n_{\mathrm{A}}+n_{\mathrm{B}})$$

for a consumer in country A, and

$$(19\text{b}) \qquad c_{\mathrm{B}} = \left(\frac{w_{\mathrm{B},-1}}{p_{\mathrm{B}}}\right)\Big/(n_{\mathrm{A}}+n_{\mathrm{B}})$$

for a consumer in country B, where w_{-1} is the nominal wage paid in period -1 (i.e., in the period preceding consumption).

Finally, it is necessary to insure that markets are in equilibrium, or that the production of each variety equals its total demand:

$$(20) \qquad x = (2-\sigma)c_{\mathrm{A}} + \sigma c_{\mathrm{B}}.$$

Once the monetary regime is specified, inflation rates in the two countries will be determined as functions of government policies. It will then be possible to express c_{A} and c_{B} in terms of the money supplies and to derive the indirect utility functions

$U_{\mathrm{A}}(m_{\mathrm{A}}, m_{\mathrm{B}})$ and $U_{\mathrm{B}}(m_{\mathrm{A}}, m_{\mathrm{B}})$. The governments' problem will be:

$$(21) \quad \max_{\{m_{\mathrm{A},t}\}} \sum_{t=0}^{\infty} \delta^t U_{\mathrm{A},t}(m_{\mathrm{A},t}, m_{\mathrm{B},t})$$

$$\max_{\{m_{\mathrm{B},t}\}} \sum_{t=0}^{\infty} \delta^t U_{\mathrm{B},t}(m_{\mathrm{A},t}, m_{\mathrm{B},t})$$

where δ is the discount factor.

This is an infinite-horizon repeated game, and as usual, multiple equilibria might be sustainable with appropriate punishment schemes. I will concentrate on the simplest subgame-perfect equilibrium, in which the two governments repeat each period their optimal one-shot strategy, taking foreign policy decisions as given.

In all that follows, the policymakers' 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. All conclusions would be exactly identical were the analysis in aggregate rather than per capita terms.[2]

III. 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:

$$(22) \quad \sigma p_{\mathrm{A}} n_{\mathrm{A}} c_{\mathrm{B}} = (2-\sigma) e p_{\mathrm{B}} n_{\mathrm{B}} c_{\mathrm{A}}.$$

Total expenditure on A products by B consumers must equal total expenditure on B products by A consumers. Equation (22) determines the nominal exchange rate, if flexible, or the relationship between the two countries' monetary policies, if the exchange rate is fixed.

Inflation rates are determined by the equilibrium conditions in the two domestic money markets. By Walras's law, such conditions are implied by equilibrium in the goods market and in the foreign-exchange market, and inflations can indeed be derived by manipulating equations (20) and (22). Alternatively, they can be obtained directly by noticing that all monetary transactions inside each country take place in domestic currency. Therefore,

$$(23) \quad \sigma w_{\mathrm{B}} = \sigma w_{\mathrm{B},-1} + M_{\mathrm{B}}$$

$$(2-\sigma) w_{\mathrm{A}} = (2-\sigma) w_{\mathrm{A},-1} + M_{\mathrm{A}}$$

or

$$(24) \quad \frac{w_{\mathrm{B}}}{w_{\mathrm{B},-1}} = \frac{\sigma}{\sigma - m_{\mathrm{B}}}$$

$$\frac{w_{\mathrm{A}}}{w_{\mathrm{A},-1}} = \frac{2-\sigma}{2-\sigma-m_{\mathrm{A}}}.$$

In addition, recalling $e w_{\mathrm{B}} = w_{\mathrm{A}}$,

$$(25) \quad \frac{e}{e_{-1}} = \frac{w_{\mathrm{A}}/w_{\mathrm{A},-1}}{w_{\mathrm{B}}/w_{\mathrm{B},-1}}.$$

In each country, inflation depends on the percentage of the domestic labor force whose salary is paid with new issues of money, and the exchange rate moves to accommodate the difference in inflation rates.

Substituting (24) and (17) in (19), one can write per capita consumption of each variety of the private good by A and B consumers as

$$(26) \quad c_{\mathrm{A}} = \frac{\alpha\theta(2-\sigma-\Gamma_{\mathrm{A}})}{\beta(1-\theta)(2-\sigma)(2-\Gamma_{\mathrm{A}}-\Gamma_{\mathrm{B}})}$$

$$c_{\mathrm{B}} = \frac{\alpha\theta(\sigma-\Gamma_{\mathrm{B}})}{\beta(1-\theta)\sigma(2-\Gamma_{\mathrm{A}}-\Gamma_{\mathrm{B}})}.$$

[2]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, I 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. If the problem were set in aggregate terms, the right question would be whether the two weights could be equal. The two alternatives are identical.

Two points are worth noticing. First, the existence of national currencies insures that domestic purchasing power cannot be increased by issuing fiat money: total real consumption is determined only by each country's labor endowment and does not depend on policy variables. Define C_A and C_B as total private consumption in labor units in each country:

$$(27) \quad C_A = (2-\sigma)c_A[(p_A/w_A)n_A + (p_B/w_B)n_B]$$

$$C_B = \sigma c_B[(p_A/w_A)n_A + (p_B/w_B)n_B].$$

Then, equations (11), (17), and (26) yield:

$$(28) \quad C_A + \Gamma_A = 2-\sigma$$

$$C_B + \Gamma_B = \sigma.$$

Second, 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. Thus, as long as the exchange rate insulates each country from foreign inflation, money issues are exactly identical to lump-sum taxes collected in the second period of consumers' lives.

Substituting (17) and (26) in (18) and recalling that in each country the public good equals real money injections, the indirect utility function of the current generation can be expressed as

$$(29) \quad U_A = K_A + [(1-g)(1-\theta)/\theta]\ln(2-m_A-m_B) + (1-g)\ln(2-\sigma-m_A) + g\ln(m_A)$$

$$U_B = K_B + [(1-g)(1-\theta)/\theta]\ln(2-m_A-m_B) + (1-g)\ln(\sigma-m_B) + g\ln(m_B)$$

where

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

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

Each government maximizes the current utility of its residents with respect to its money supply, taking the foreign money supply as given. The first-order conditions for this problem are

$$(30) \quad \frac{(1-g)(1-\theta)}{\theta(2-m_A-m_B)} = \frac{g}{m_B} - \frac{1-g}{\sigma-m_B}$$

$$\frac{(1-g)(1-\theta)}{\theta(2-m_A-m_B)} = \frac{g}{m_A} - \frac{1-g}{2-\sigma-m_A}.$$

Even in its very simple form, the governments' game does not have a simple closed-form solution. However, it is possible to characterize three features of the equilibrium policies that will be important in what follows. First, uncoordinated policies yield inefficient allocations, as long as θ is less than 1. This 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.

Second, the indirect utility functions (29) are not homothetic. If μ is the share of resources that is devoted to the production of the public good in each country, (30) implies

$$(31) \quad \left[\frac{g}{\mu_B} - \frac{1-g}{1-\mu_B}\right](2-\sigma) = \sigma\left[\frac{g}{\mu_A} - \frac{1-g}{1-\mu_A}\right].$$

The term in square brackets is a decreasing function of μ. Thus when σ is smaller than $2-\sigma$, μ_B must be larger than μ_A: the smaller country always devotes a larger proportion of its endowment to the public good. The result is rather intuitive, since the number of varieties of the private good depends on the absolute amount of world resources employed in private production. Withdrawing from such production the same percentage of resources results in a more pronounced decline in the number of varieties if such action is taken by the large country.

Therefore, the government of the larger country is relatively more constrained in its provision of the public good. The implication is that in equilibrium the inflation rate will be higher in the smaller country, and its currency will be depreciating.[3]

Finally, notice that the total provision of the public good must be higher in the larger country. To see this, rewrite (31) as

$$(32)\qquad \frac{m_{\mathrm{A}}}{m_{\mathrm{B}}}=\left[\frac{g-\mu_{\mathrm{A}}}{g-\mu_{\mathrm{B}}}\right]\Big/\left[\frac{(1-\mu_{\mathrm{A}})}{(1-\mu_{\mathrm{B}})}\right].$$

If μ_{B} is larger than μ_{A}, and g is less than 1, the right-hand side of this equation is larger than 1.

IV. Common Currency

When the two countries share a common currency, e equals 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. Of course, all agents are still individually bound by their budget constraints, but there is no international monetary account that needs to be cleared. From a policy perspective, this is the fundamental difference between a common currency and fixed exchange rates.

The common inflation can be derived directly from the monetary equilibrium, taking into account that domestic and international transactions take place in the same currency:

$$(33)\qquad 2w=2w_{-1}+M_{\mathrm{A}}+M_{\mathrm{B}}$$

or

$$(34)\qquad \frac{w}{w_{-1}}=\frac{2}{2-m_{\mathrm{A}}-m_{\mathrm{B}}}.$$

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

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

$$(35)\qquad c_{\mathrm{A}}=c_{\mathrm{B}}=\frac{\alpha\theta}{2\beta(1-\theta)}=x/2.$$

Individual private consumption is exactly equal in the two countries, independently of the distribution of endowments. Each generation's utility is

$$(36)\qquad U_{\mathrm{A}}=K_{\mathrm{A}}+(1-g)\ln[(2-\sigma)/2]+[(1-g)/\theta]\ln(2-m_{\mathrm{A}}-m_{\mathrm{B}})+g\ln(m_{\mathrm{A}})$$

$$U_{\mathrm{B}}=K_{\mathrm{B}}+(1-g)\ln(\sigma/2)+[(1-g)/\theta]\ln(2-m_{\mathrm{A}}-m_{\mathrm{B}})+g\ln(m_{\mathrm{B}}).$$

Suppose now that an international central bank is created and that it is responsible for monetary decisions in the two countries.[4] The central bank decides money injections in A and B so as to maximize a weighted sum of utilities:

$$(37)\qquad \max_{m_{\mathrm{A}},m_{\mathrm{B}}}\ (2-\gamma)U_{\mathrm{A}}(m_{\mathrm{A}},m_{\mathrm{B}})+\gamma U_{\mathrm{B}}(m_{\mathrm{A}},m_{\mathrm{B}})$$

[3]This occurs because money is the only fiscal instrument. If lump-sum taxes were added to the model, governments would be indifferent between financing themselves with taxes or with money, and a fixed exchange rate (and equal inflations) could always be maintained.

[4]With a common currency, if the two countries could print money independently, they would generate money supplies that are too large. Since inflation depends on world-wide money issues, each country has an incentive to print currency domestically and export part of the inflation tax. The final outcome has lower welfare than under national currencies. In this model, the prediction can be verified by computing the Nash equilibrium when the two governments separately maximize (36). This type of inflationary bias has been noticed often in the literature (see e.g., Willem H. Buiter and Jonathan Eaton, 1983; Joshua Aizenman, 1989; Casella and Feinstein, 1989). The important conclusion is that coordination is essential to the very existence of a monetary union.

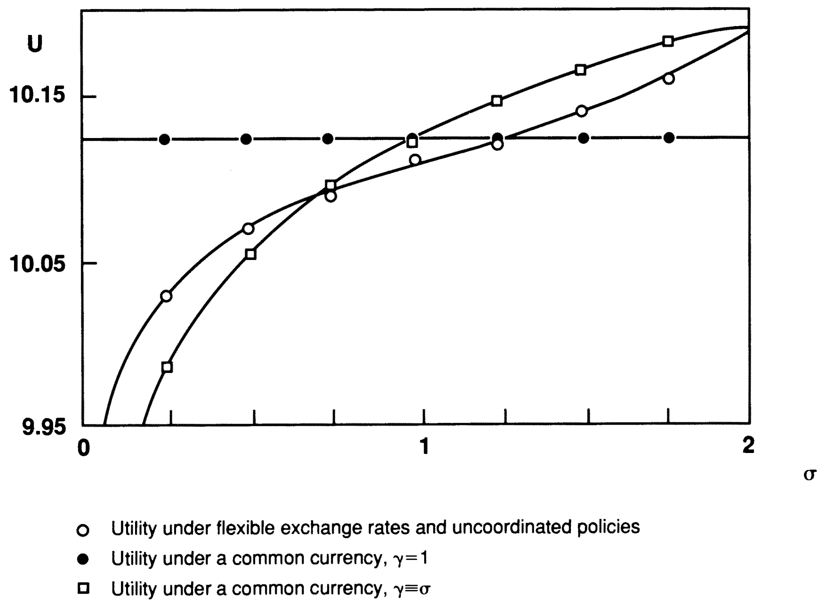

FIGURE 2. TWO COUNTRIES: WELFARE COMPARISONS
($\alpha = \beta = 0.1$, $\theta = 0.2$, $g = 0.1$)

subject to

$$m_A \leq (2-\sigma)$$

$$m_B \leq \sigma$$

where utilities are given by equations (36).

The first-order conditions for the bank's problem yield

$$(38) \quad m_A = \min\left(2-\sigma, \frac{(2-\gamma)g\theta}{1-(1-\theta)g}\right)$$

$$m_B = \min\left(\sigma, \frac{\gamma g\theta}{1-(1-\theta)g}\right).$$

Figure 2 compares a country's welfare under this regime (for the two cases $\gamma = 1$ and $\gamma = \sigma$) to utility under flexible exchange rates, for representative parameter values. Notice that if attention is limited to the case $\gamma = 1$, defining cooperation strictly as an agreement maximizing total utilities, the small country gains more than the large one; indeed the latter may well prefer to abandon the union.[5]

The parameter γ represents 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. If the weight is instead proportional to size ($\gamma = \sigma$), the public good amounts to the same share of total resources in the two countries.

Relative money injections equal the relative power of the two economies:

$$(39) \qquad \frac{m_B}{m_A} = \frac{\gamma}{2-\gamma}.$$

This is important, because one characteristic of this equilibrium is the potential for international wealth redistribution. Total consumption in each economy is now af-

[5]This result is similar to the conclusion in the international-trade literature that large countries may gain from tariff wars (Kennan and Reizman, 1988).

fected by money printing, and the country with higher per capita money injections is effectively increasing its share of world resources. Using equations (11), (17), and (35), and recalling that μ represents per capita money issues and C is total private consumption in labor terms, the sum of private and public consumption in the two countries is given by

$$(40)\quad C_A + \Gamma_A = (2-\sigma) + (2-\sigma)(\sigma/2)(\mu_A - \mu_B)$$
$$C_B + \Gamma_B = \sigma + (2-\sigma)(\sigma/2)(\mu_B - \mu_A).$$

With a common currency, issues of money generate inflation everywhere, independently of where they are spent. However, money spent domestically supplies the public good, compensating for the reduction in disposable income. If monetary injections are equal in per capita terms, the two effects exactly cancel each other; otherwise, higher per capita money injections increase the consumption of the public good more than they reduce domestic private disposable income. From a different point of view, when a country obtains higher per capita money supply, such a country consumes more than its own resources and runs a trade deficit financed by seigniorage revenues. Indeed equations (17) and (35) show that the term $(2-\sigma)(\sigma/2)(\mu_A - \mu_B)$ corresponds to the trade deficit of country A in labor terms (and equivalently for country B).

Since money injections in the two economies are determined by their relative influence on the central bank, one reaches 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.

V. Participation in a Currency Union

Now suppose that each country is free to decide whether to join the common-currency agreement or maintain control of its economic policy. Implementing the currency union, therefore, requires that both countries gain from the agreement.

This section looks at two separate questions. First, will utility weights proportional to economic size be acceptable to the two countries? Second, will the demands of the two countries be compatible for any distribution of endowments?

Answering the first question requires comparing the utility that each country attains under a currency union when γ equals σ to the utility it attains in the Nash equilibrium with national currencies. The problem is complicated by the fact that the comparison is across two different regimes, with two different indirect utility functions. Nevertheless, since money supplies are strategic substitutes, the intuition discussed in Section I leads one to expect that a monetary union will be sustainable with $\gamma = \sigma$ only when σ (and therefore γ) is not too small. More precisely, it is possible to state the following proposition.

PROPOSITION 2: *In the model studied in this paper, there exists a minimum $\bar{\sigma}$ such that for all $\sigma < \bar{\sigma}$ the small country will require a larger relative weight in aggregate welfare than its relative size. That is, $\forall \sigma < \bar{\sigma}$, all cooperative equilibria, if they exist, will have $\gamma > \sigma$.*

A sufficient condition for Proposition 2 is

$$(42)\quad \lim_{\sigma \to 0} \left[U_B^*(\sigma, m_B^*, m_A^*) - U_B^{**}(\sigma, m_B^{**}, m_A^{**}) \right] > 0$$

where U_B^* is the realized utility under decentralized policies with national currencies (where choice variables are denoted by an asterisk), and U_B^{**} is the realized utility with a common currency and a common central bank setting $\gamma = \sigma$ (and where choice variables are denoted by two asterisks). As σ goes to 0, the first-order conditions (30) yield

$$(43)\quad m_B^* = g\sigma$$
$$m_A^* = g\theta(2-\sigma)/[1-g(1-\theta)].$$

Substituting this result in (29) and subtracting realized utility under a common currency [equations (36) and (38)], one obtains

$$(44)\quad \lim_{\sigma \to 0} (U_B^* - U_B^{**}) = [(1-g)\ln(1-g) + g\ln g] - [(1-g)\ln(1-\phi) - g\ln\phi]$$

where

$$\phi = \frac{g\theta}{1-g(1-\theta)}.$$

The expression $(1-g)\ln(1-z) + g\ln z$ reaches its maximum at $z = g$, and therefore the limit must be positive, as required, $\forall\theta \neq 1$.

When a country is very small, it must demand more than proportional weight in the cooperative agreement. If this were not the case, the control exercised by the larger economy would result in a very unbalanced solution of the externality problem: the small country would end up facing the costs of the coordination without reaping enough of the benefits. Notice that the result is very strong: since the small country prefers to revert to the Nash equilibrium, this cannot be used as a threat by the large country to enforce cooperation. Thus, the conclusion would still hold even if one considered punishment schemes in the repeated game.

The source of the result appears clearly if one looks at public-good provisions in the two equilibria. With decentralized decisions under national currencies, I have shown that per capita supply of the public good must be larger in the smaller country. In the common-currency regime with a central bank setting $\gamma = \sigma$, per capita supply of the public good is instead equal in the two economies [equation (38)]. Thus, with $\gamma = \sigma$ the restraint required by cooperation falls disproportionately on the small country.

Since I do not have a closed-form solution for the national-currencies equilibrium, I cannot derive an analytical expression for the minimum utility weight required by the two countries as a function of σ. However, numerical simulations were run for a variety of parameters values, and Figure 3A presents the result for a typical case. The minimum required weight (in percentage terms) is plotted against the country's economic size (again, as a percentage of world resources).[6]

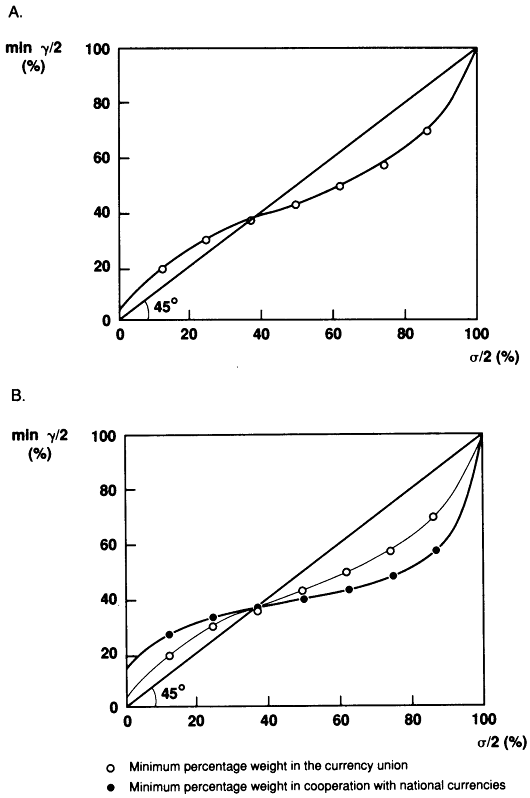

FIGURE 3. ECONOMIC SIZE AND MINIMUM PERCENTAGE WEIGHT
A) IN THE CENTRAL BANK AND
B) IN COOPERATIVE AGREEMENT
$(\alpha = \beta = 0.1,\ \theta = 0.2,\ g = 0.1)$

As expected, when the country is relatively small it demands more than proportional power to participate in the union. The interesting result of the figure is that

[6] The calculation is particularly simple since realized utilities in the monetary union simplify to $U_j(\gamma_j) = U_j(\gamma_j = 1) + g\ln(\gamma_j)$, where γ_j is the relative weight of country j in the welfare function of the union.

this need not apply only to countries of infinitesimal size: in this example, γ must exceed σ whenever a country is less than 37 percent of the world. If one thinks of σ as a random variable uniformly distributed between 0 and 2, this would concern more than two-thirds of all possible realizations.

The large country, on the other hand, is 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 more from the discipline imposed on its partner 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.

This conclusion holds for all values of θ and g less than 1, but the shape of the curve in Figure 3A is sensitive to the exact values of the parameters. The closer θ is to 1, the less important is the externality from the provision of public goods, and the closer is the central bank policy to the Nash equilibrium with national currencies: the small country's demands of influence on the union are mitigated, while the large country becomes less accommodating. Thus, the curve flattens at higher θ, approaching the 45° line as θ approaches 1. The effect of changes in g is less straightforward. The higher is g, the lower is the weight given to private trade, and the smaller is the importance of the externality: coordinated policies approach the decentralized choices under national currencies. However, the higher is g, the more weight is attached to achieving the desired amount of the public good, and the cost of the cooperation rises. Since the two forces counter each other, the final effect could theoretically be in either direction but should be very small. These intuitions were confirmed by numerical simulations.

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 3B. With a common currency, a larger than proportional γ implies, as an added bonus, a transfer of seigniorage revenues, and this acts to mitigate the demands of the small country. Not so with different national currencies. Here, monetary policies per 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. The minimum σ at which $\gamma = \sigma$ is acceptable must be the same in the two cases, since at that point no transfer takes place, and the two regimes are identical. However, in any acceptable distribution of power, the bias in favor of the small country (in relative terms) must be stronger with national currencies than in a monetary union.

The final question is whether a currency union can be supported (i.e., whether it is possible to satisfy simultaneously the requirements of the two countries). Since the utility functions are well-behaved, one knows that for all distributions of endowments utility weights exist such that a coordinated outcome is Pareto-superior to the Nash equilibrium. However, here one is confronting the Nash equilibrium under national currencies to the monetary union, with its inherent seigniorage transfer. One cannot be sure *ex ante* that the union will be always sustainable.

Figure 4 depicts the result of numerical simulations for representative parameter values. 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 for the countries to be willing to take part in the monetary union. If that curve went above 2, the agreement would not be sustainable. The curve has a minimum at $\sigma = 1$, because the gain from cooperation is maximal when the two economies have equal size. As is clear from the diagram, with two 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-

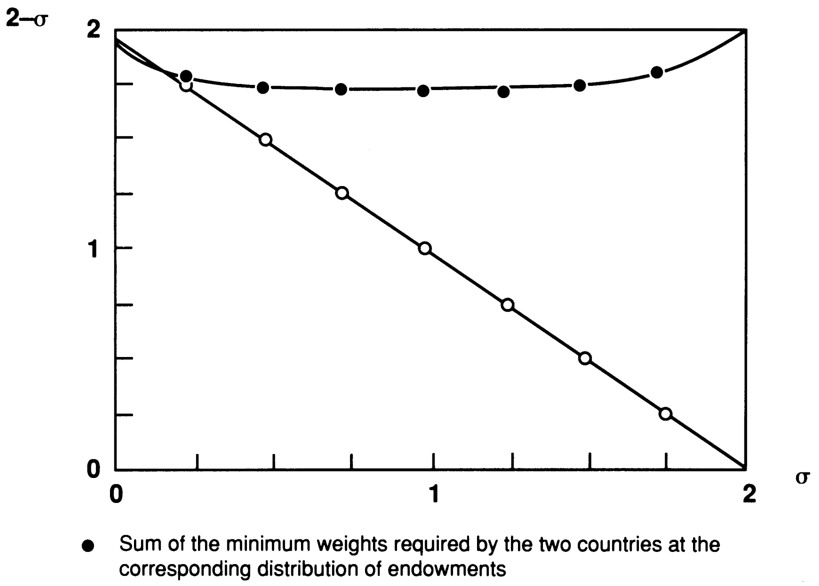

FIGURE 4. TWO COUNTRIES: SUSTAINABILITY OF THE CURRENCY UNION ($\alpha = \beta = 0.1$, $\theta = 0.2$, $g = 0.1$)

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. I found that the union was sustainable for all parameter values tried in the simulations, unless g, the relative weight of the public good in utility, was allowed to differ between the two countries and be higher in the large one. In these cases, the large country valued the public good too much to be willing to accomodate the small country through the transfer the latter required.

The analysis conducted so far can be extended to investigate whether a currency union is sustainable in a world with more than two countries. Since policy decisions are centralized, in this model 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 rest of the world is interested in the total number of varieties of the private good produced by the countries belonging to the union, and therefore only the total volume of money-printing within the union is relevant outside, not the internal questions of distribution. Therefore, Figure 3A 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. In particular, it also describes the minimum power required by one country to take part in a union with *any* number of partners, as a function of its endowment relative to the total size of all countries in the agreement.[7]

When the number of countries is large, each single economy tends to be small with respect to the whole. Since belonging to the union without substantially influencing its policy is not desirable, each country will demand more than proportional power, thereby contributing to requests of control

[7]The same point, in a slightly different context, is made by Matthew B. Canzoneri and Dale B. Henderson (1991 Ch. 2). Note, however, that 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. Thus, Figure 3B does not extend immediately to $n > 2$.

that become unfeasible in the aggregate. As a simple example, consider the case of three countries of equal size. With the usual parameter values, Figure 3A indicates that, even though each of them has 33 percent of world endowment, each requires 35 percent of total power to participate in the union, an obviously impossible arrangement. In the static game, the union may be impossible to sustain.[8]

Two comments conclude the analysis. First, with several countries the focus on the static game may be misleading. If punishment strategies are credible, the union may be sustainable once the repeated nature of the game is taken into account explicitly. In particular, notice that while the temptation to deviate unilaterally is stronger, the inefficiency of the Nash equilibrium when all countries independently issue national currencies also rises with the number of countries.[9]

Second, the difficulty in sustaining a currency union in this model is reminiscent of the results in the literature on mergers in industrial organization. There, as here, mergers are not likely to take place when the choice variables are strategic substitutes (Stephen W. Salant et al., 1983). However, in a currency union, where inflation must be equal everywhere, thinking of money supplies as strategic substitutes seems most natural, and my negative results may depend on more fundamental factors than the specific model or game studied in this paper.

VI. Conclusions

Participation in a cooperative agreement may be worthless to an agent who cannot exercise substantial influence on the common decision-making. Indeed, when the choice variables are strategic substitutes, the weaker partner will prefer a noncooperative outcome, even if it is inefficient, to coordination dominated by his opponent. In the context of international policy agreements, this conclusion suggests that a small enough country may exact larger influence than is warranted by its size.

This paper has studied the idea within a simple model of a currency union, in which countries have the option of abandoning the union and reverting to independent monetary policies. In the model, money supplies are strategic substitutes, and the result above is confirmed: the small country requires and obtains more than proportional weight over the common policy.

Three observations should be added. First, small countries could be bribed or threatened into accepting less power than the paper predicts. If their participation must be bought through transfers, then these play a role identical to the more-than-proportional utility weight discussed here. On the other hand, if smaller countries are easier targets for punishments (e.g., through restrictions on trade), then it may be possible to enforce cooperation through threats. The monetary union would be a more complex, multidimensional agreement, but the effect studied in this paper would still be present, even if overrun by an opposite force.

Second, the paper has not derived endogeneously the need for a unique money. If the underlying motivation is more than transaction costs, it may affect the very problem being studied (i.e., the division of power in the determination of the common policy). For example, if the common currency is meant to solve a credibility problem affecting the monetary authorities of some of the member countries, then the very reason for existence of the union would demand that these countries renounce their influence; but then, of course, there could be no concern over the loss of national autonomy.

Finally, with more than two countries the analysis should address the link between the weight each country requires in the common welfare function and the voting game.

[8]In general, one should also consider that countries can form coalitions and gather in partial unions, in which the number of partners and their economic size are chosen optimally. In practice, this is not a concern in this model, since unilateral deviation always dominates deviating in a group: preventing every single country from abandoning the common-currency agreement is a sufficient condition for preventing coalitions.

[9]The same logic suggests that in the one-shot game it may be possible to support the monetary union through mixed strategies. See Casella (1990) for some examples confirming this intuition.

The rules of an agreement between two partners cannot be phrased in terms of voting shares, but voting becomes the natural framework in the case of associations with multiple members. This would be an important extension of the ideas discussed in the paper.

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