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Monetary Integration, Uncertainty and the Role of Monetary Policy

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Abstract

This research considers the positive theory of monetary integration in a general equilibrium monetary model of the world economy. The analysis demonstrates that, in the face of uncertainty and incomplete asset markets, participation in a monetary union may be welfare improving since it facilitates state-dependent resource transfers between regional economies. Such resource transfers are used to optimally reduce the variance of consumption for risk averse agents. This potential for improving welfare depends not only on the agents' risk aversion but on the interrelationship of the regional economies: contrary to Mundell (1961), economically diverse regions may be well suited to a common currency.

1. Introduction

Monetary integration is the process by which independent nations suppress national monies and national monetary authorities in favour of a single currency and a central monetary authority with designated control over monetary decisions. Since the creation of the European Economic Community by the Treaty of Rome in 1957, there have been a great many proponents of such an arrangement for Europe. Most recently, the members of the European Monetary System have accepted, in principle, the recommendations of the Delors Committee Report. This report provides a blueprint for the monetary unification of Europe and recommends, ultimately, a single currency for Europe under the authority of a European System of Central Banks (ESCB). Further, the report clearly commits the ESCB to pursue a policy stance of price stability. Despite this rapid movement towards a single currency for Europe, it is not clear why such an arrangement might in general be desirable nor why nations might voluntarily surrender monetary sovereignty and participate in a monetary union.[1]

The purpose of this paper is to consider the motives for monetary integration and the nature of the subsequent monetary union. To do so, a theoretical economy is developed that features monetary integration as the outcome of strategic policy decisions made by national policy makers and the supranational monetary authority. This approach, which is based on

[1]A large and growing literature considers both the positive and normative aspects of monetary integration for Europe. Examples of the former are Mundell (1961), Canzoneri and Rogers (1990), Casella and Feinstein (1989), and Casella (1990). Examples of papers that try to assess either the feasibility or the desirability of monetary integration for Europe are Cohen and Wyplosz (1989), Frenkel and Goldstein (1990), Eichengreen (1990a,b), Poloz (1990), and Weber (1990).

Casella's (1990) analysis of monetary integration, provides both a motivation for the monetary union, in that participation is an optimal policy response of national policy makers, and a characterization of the monetary union that is dependent upon this optimal behaviour.

Casella (1990) makes two important observations about monetary integration. The first concerns the incentives for participation: since participation in a monetary union is voluntary, all nations must be at least as well off within the union than without it for such a union to exist. The second observation concerns the difference between a regime of fixed exchange rates and a monetary union. The fixed exchange rate regime requires participating nations to pursue similar growth rates of national money supplies to avoid reevaluation of the parity rates. A monetary union, however, operates with exchange rates that are fixed by convention and does not require national monetary policy to maintain these rates. Consequently, a monetary union allows for regional disparities in the growth of money supplies. These regional disparities effectively transfer seigniorage revenue between participating regions. Casella uses these two observations to demonstrate that participation in a monetary union may be optimal for nations in the presence of a supranational public good externality.

The analysis developed below also relies on these two observations but considers more direct benefits and costs of monetary integration than those associated with the resolution of a public good externality. In particular, participation in a monetary union may be optimal for national policy makers seeking to diversify the risk of expected economic disturbances. Within an uncertain environment and with incomplete asset markets, the analysis demonstrates that regions united by a single currency possess a method of transferring resources that does not exist for regions with monetary autonomy. The transfer of resources is effected by regionally oriented, state-dependent monetary transfers; such transfers increase the wealth of the recipient region while simultaneously reducing the wealth of all regions through inflation. The set of transfers may be used as an insurance programme to smooth consumption over possible states of the economy and consequently improve the welfare of all regions.

One of the important features of this argument is how the conclusions contrast with Mundell's (1961) analysis of optimum currency areas. In a world characterized by nominal price rigidities and factor immobility, Mundell argues that countries or regions similarly affected by economic disturbances are well-suited to participation in a monetary union. This paper, which abstracts from the issues of nominal price rigidities and factor mobility, argues an opposing view. Economic regions that *expect* to experience dissimilar real economic disturbances may be better served by monetary integration since the monetary union allows a transfer of wealth from one participant to another depending upon the *realized* state of the world.[2] Naturally, the greater is the diversity between nations, the greater will be the ability for these nations to insure each other against future economic uncertainty. A further attractive feature of this insurance role for monetary policy is its consistency with the additional policy goal of price stability. Since the resource transfers are effected by relative and not absolute monetary transfers, the level of inflation can be

[2]This role for monetary policy is conceptually equivalent to the role of fiscal federalism as described by Eichengreen (1990a). Fiscal federalism is the practice of regionally oriented fiscal policy to reduce the impact of regional shocks. The cost burden of such fiscal policy is borne nationally and is optimal since it reduces the variance of consumption for all agents.

determined independently.

The following section of the paper develops the two country, general equilibrium model and then describes the competitive equilibria for both a multiple currency regime and a single currency regime. The analysis then proceeds to develop the policy makers' optimization problems under either regime. Because of the non-linear nature of the problem, analytical solutions to the multiple currency and the single currency competitive equilibria are not available. For the solution to the multiple currency equilibrium, numerical techniques must be used. However, for the single currency equilibrium, the analysis demonstrates and exploits the equivalence between the central authority's optimization problem over the feasible policy set and a central planner's optimization problem over all feasible allocations. This equivalence allows a complete characterization of the single currency regime and demonstrates the restrictions imposed on the central authority's behaviour if the monetary union is to exist.

2. The Model

The model is based on Svensson (1989) and is a two period, two country general equilibrium monetary model with a single perishable good. For each country, there is a single representative agent who receives an endowment of the good each period. Uncertainty enters the model via a stochastic second period endowment for both the domestic and foreign agent. In the first period, both agents choose an optimal consumption plan that may include the purchase of a variety of assets. The consumption plans are based on complete knowledge of both domestic and foreign first period endowments and common expectations of second period endowments. In the second period, the state of the world is revealed that, together with the returns from first period asset purchases, determines actual second period consumption.

The asset markets are very simple. Both the home and foreign agent may trade in a single riskless bond that pays one unit of the consumption good in all states and has a real price q. They may also trade in whatever number of currencies exist in the model. The important requirement of the asset markets is that they be incomplete; otherwise, the insurance provided by monetary policy is unnecessary. The assumption imposed here, that of a single indexed bond, meets this requirement but is also important for analytical purposes. Other more plausible asset market structures complicate the solution of the model. I indicate below where other structures would prevent the analysis from proceeding.

Money is introduced with cash-in-advance constraints as in Helpman (1981). The structure of the economy and the timing of markets are standard. Each period is split into two sub-periods. In the first sub-period, asset and currency markets open. In this sub-period, agents purchase financial instruments and meet financial obligations; in addition, they trade currencies to hold the amount required for that time period's consumption plan. In the second sub-period, each agent pursues two separate duties. The first is to use cash holdings from the first sub-period to purchase the consumption good. The second is to sell their endowment, the earnings from which are held over until the following period. In the case of multiple currencies, the seller's currency is always used for transactions. Note that the state of the world is revealed at the start of each period so that currency holdings do not have any precautionary demand component.

The policy analysis requires solutions to the competitive equilibria of both the multiple currency economy and the single currency economy. These are stated in general terms below.

The Multiple Currency Economy

The home agent chooses

$$\{c_{H1}, c_{H2}(s), c_{F1}, c_{F2}(s), M_1, M_2(s), N_1, N_2(s), B:\ s \in S\}$$

to maximize lifetime expected utility

$$E_s\Big(u(c_{H1} + c_{F1}) + \beta u(c_{H2}(s) + c_{F2}(s)) \Big) \qquad \text{(P1)}$$

subject to,

$$p_1 c_{H1} \le M_1 \qquad (1.1)$$

$$p_1^* c_{F1} \le N_1 \qquad (1.2)$$

$$p_2(s) c_{H2}(s) \le M_2(s) \qquad s \in S \qquad (1.3)$$

$$p_2^*(s) c_{F2}(s) \le N_2(s) \qquad s \in S \qquad (1.4)$$

$$M_1 + e_1 N_1 \le X_1 - p_1 qB \qquad (1.5)$$

$$\begin{aligned} M_2(s) + e_2(s) N_2(s) \le X_2(s) &+ p_1 y_1 + p_2(s) B + \\ &(M_1 - p_1 c_{H1}) + \\ &e_2(s)(N_1 - p_1^* c_{F1}) \qquad s \in S \qquad (1.6) \end{aligned}$$

$$c_{H1}, c_{H2}(s), c_{F1}, c_{F2}(s), M_1, M_2(s), N_1, N_2(s) \ge 0 \qquad s \in S.$$

The notation is:

- y_t -endowment of consumption good in period t.
- c_{it} -consumption of country i good in period t.
- M_t -domestic currency demand in period t.
- N_t -foreign currency demand in period t.
- B -demand for the indexed bond (may be positive or negative).
- X_t -cash transfers in period t.
- p_t -price of the consumption good in period t.

e_t -the domestic currency price of foreign currency in period t.

q -the price of the indexed bond in terms of the first period consumption good.

u -the instantaneous utility function.

β -the discount rate of time preference.

E_s -the expectations operator on the state space S.

All second period variables are state-dependent. The set S is the discrete state space and the probability distribution over S is known to both the home and foreign agent. Equations (1.1) - (1.4) are the cash-in-advance constraints imposed on the representative agent while equations (1.5) and (1.6) are the wealth constraints in the first and second period respectively. The foreign agent's problem is identical (a * denotes foreign choice variables, endowments, and commodity prices).

Definition: A multiple currency equilibrium is a set of prices,

$$\{\tilde{p}_1, \tilde{p}_1^*, \tilde{p}_2(s), \tilde{p}_2^*(s), \tilde{e}_1, \tilde{e}_2(s), \tilde{q}: \ s \in S\},$$

and allocations

$$\{\tilde{c}_{H1}, \tilde{c}_{H2}(s), \tilde{c}_{F1}, \tilde{c}_{F2}(s), \tilde{M}_1, \tilde{M}_2(s), \tilde{N}_1, \tilde{N}_2(s), \tilde{B}: \ s \in S\},$$

$$\{\tilde{c}_{H1}^*, \tilde{c}_{H2}^*(s), \tilde{c}_{F1}^*, \tilde{c}_{F2}^*(s), \tilde{M}_1^*, \tilde{M}_2^*(s), \tilde{N}_1^*, \tilde{N}_2^*(s), \tilde{B}^*: \ s \in S\},$$

that satisfy the domestic and foreign agents' optimization problems and the market clearing conditions:

$$\tilde{c}_{H1} + \tilde{c}_{H1}^* = y_1$$

$$\tilde{c}_{F1} + \tilde{c}_{F1}^* = y_1^*$$

$$\tilde{c}_{H2}(s) + \tilde{c}_{H2}^*(s) = y_2(s) \qquad s \in S$$

$$\tilde{c}_{F2}(s) + \tilde{c}_{F2}^*(s) = y_2^*(s) \qquad s \in S$$

$$\tilde{B} + \tilde{B}^* = 0$$

$$\tilde{M}_1 + \tilde{M}_1^* = X_1$$

$$\tilde{N}_1 + \tilde{N}_1^* = X_1^*$$

$$\tilde{M}_2(s) + \tilde{M}_2^*(s) = X_1 + X_2(s) \qquad s \in S$$

$$\tilde{N}_2(s) + \tilde{N}_2^*(s) = X_1^* + X_2^*(s) \qquad s \in S.$$

In any equilibrium, the law of one price must hold by the usual arbitrage arguments. Since the state of the world is revealed before second period cash balances are determined, this holds for all states of the world. Thus,

$$p_1 = e_1 p_1^*, \tag{1.7}$$

$$p_2(s) = e_2(s) p_2^*(s), \qquad s \in S. \tag{1.8}$$

The asset market structure employed here permits an aggregation of the temporal budget constraints that reduces the nominal economy to an equivalent barter economy. This result, which is an adaptation of a similar result in Helpman (1981), depends critically upon the asset market structure. If there are bonds with state-dependent real returns then it is not possible to aggregate the temporal budget constraints in any useful way.

The equivalence here between the nominal economy and the barter economy is not unconditional as it is in Helpman (1981). In Helpman's analysis, which abstracts from uncertainty, either cash balances are dominated in return by the assets available, in which case they are not held, or they have a zero price, in which case they do not appear in the budget constraint. In the present model, if the return on cash balances is not dominated by the real asset then they do enter the budget constraint with a non-zero price and there is no equivalence between the nominal and barter economy. Initially then, I consider only economies in which the following condition holds:

$$E_s\left(\beta \frac{u'(c_2(s))}{u'(c_1)} \frac{p_1}{p_2(s)} \right) \le 1. \tag{1.9}$$

The condition in (1.9) states that the domestic agent's expected utility of holding one unit of the domestic currency for consumption in the second period is less than the expected utility of consuming the real value of the unit of currency in the first period. A similar condition holds for foreign currency and the foreign agent. Consequently, each agent will hold only sufficient currency for purchases of the consumption good and not use either currency as a savings instrument.

If the condition in equation (1.9) is met (this must be verified once the solution has been calculated), then using the law of one price conditions of equations (1.7) and (1.8), the constraints can be written as

$$p_1c_1 = X_1 - p_1qB \tag{1.10}$$

$$p_2(s)c_2(s) = X_2(s) + p_1y_1 + p_2(s)B \qquad s\in S, \tag{1.11}$$

where $c_t = c_{Ht} + c_{Ft}$, $t=1,2$.

Equations (1.10) and (1.11) can then be aggregated as follows:

$$c_1 + qc_2(s) = \frac{1}{p_1} X_1 + \frac{q}{p_2(s)} X_2(s) + \frac{qp_1}{p_2(s)} y_1 , \qquad s\in S. \tag{1.12}$$

The right hand side of the intertemporal budget constraint (1.12) is equivalent to $y_1 + qy_2(s)$, $s\in S$. To show this, note that the market clearing conditions imply the following velocity equations:

$$p_1y_1 = X_1$$

$$p_2(s)y_2(s) = X_1 + X_2(s) \qquad s\in S.$$

Using these velocity equations, the right hand side of (1.12) can be rewritten, for any $s\in S$, as

$$y_1 + qy_2(s) - y_1 - qy_2(s) + \frac{X_1}{p_1} + \frac{q}{p_2(s)} X_2(s) + \frac{qp_1}{p_2(s)} y_1$$

$$= y_1 + qy_2(s) - \frac{X_1}{p_1} - \frac{q}{p_2(s)} (X_1 + X_2(s)) + \frac{X_1}{p_1} + \frac{q}{p_2(s)} X_2(s) + \frac{q}{p_2(s)} X_1$$

$$= y_1 + qy_2(s).$$

This result allows one to consider the solution to the nominal economy by calculating the solution to the real economy:

$$\underset{\{c_1, c_2(s)\}_{s\in S}}{\text{maximize}} \quad E_s\Big(u(c_1) + \beta u(c_2(s)) \Big)$$

subject to,

$$c_1 + qc_2(s) = y_1 + qy_2(s), \qquad s\in S.$$

The important implication of the equivalence between the nominal and real economy is that monetary policy does not have a role to play in the competitive equilibria of the multiple currency economy. Consequently, the loss of monetary autonomy imposes no costs on the national policy makers. While this is extreme, it does simplify the policy analysis below.

The Single Currency Economy

This section develops the same economy with a central authority in control of a single currency. The ability to make national monetary transfers still exists and consequently, the central authority's budget constraint is simply a combination of the national monetary authoritys' constraints in the multiple currency regime. Contrary to the multiple currency economy, however, money will have a role in this model. The intuition for this is straightforward. In the above economy, cash transfers are wholly offset by price increases and the structure that ensures all second period earnings are taxed away. In the single currency economy, the cash transfers have a global inflation cost and a local benefit, thus there exists some role for monetary policy to redistribute resources amongst the agents.

The economy is identical to that above except there is now only one currency. The home agent chooses

$$\{c_{H1}, c_{H2}(s), c_{F1}, c_{F2}(s), M_1, M_2(s), B\colon\ s\in S\},$$

to maximize expected lifetime utility,

$$E_s\Big(u(c_{H1} + c_{F1}) + \beta u(c_{H2}(s) + c_{F2}(s)) \Big) \tag{P2}$$

subject to,

$$p_1(c_{H1} + c_{F1}) \le M_1 \tag{2.1}$$

$$p_2(s)\big(c_{H2}(s) + c_{F2}(s)\big) \le M_2(s) \qquad s\in S \tag{2.2}$$

$$M_1 \le X_1 - p_1 qB \tag{2.3}$$

$$M_2(s) \le X_2(s) + p_1 y_1 + p_2(s)B + M_1 - p_1(c_{H1} + c_{F1}) \qquad s\in S \tag{2.4}$$

$$c_{H1}, c_{H2}(s), c_{F1}, c_{F2}(s), M_1, M_2(s) \ge 0 \qquad s\in S$$

The foreign agent's problem is identical and the notation is as above. With only a single currency, the agent has only a single cash-in-advance constraint in each period, equations (2.1) and (2.2). Equations (2.3) and (2.4) are the wealth constraints for the first and second period respectively.

Definition: A single currency equilibrium is a set of prices $\{\hat{p}_1, \hat{p}_2(s), \hat{q}\colon\ s\in S\}$ and allocations

$$\{\hat{c}_{H1},\hat{c}_{H2}(s),\hat{c}_{F1},\hat{c}_{F2}(s),\hat{M}_1,\hat{M}_2(s),\hat{B}:\ s\in S\},$$
$$\{\hat{c}^*_{H1},\hat{c}^*_{H2}(s),\hat{c}^*_{F1},\hat{c}^*_{F2}(s),\hat{M}^*_1,\hat{M}^*_2(s),\hat{B}^*:\ s\in S\},$$

that satisfy the domestic and foreign agents' optimization problems and the market clearing conditions:

$$\begin{aligned}
&\hat{c}_{H1} + \hat{c}^*_{H1} = y_1 \\
&\hat{c}_{F1} + \hat{c}^*_{F1} = y^*_1 \\
&\hat{c}_{H2}(s) + \hat{c}^*_{H2}(s) = y_2(s) && s\in S \\
&\hat{c}_{F2}(s) + \hat{c}^*_{F2}(s) = y^*_2(s) && s\in S \\
&\hat{B} + \hat{B}^* = 0 \\
&\hat{M}_1 + \hat{M}^*_1 = X_1 \\
&\hat{M}_2(s) + \hat{M}^*_2(s) = X_1 + X_2(s) && s\in S.
\end{aligned}$$

As in the multiple currency equilibrium, condition (1.9) is assumed to be satisfied. Consequently, cash balances are not held as a savings instrument in equilibrium. Given this assumption, the budget constraints and the equilibrium conditions combine to give the unit velocity equations:

$$p_1(y_1 + y^*_1) = X_1 + X^*_1$$

$$p_2(s)\big(y_2(s) + y^*_2(s)\big) = X_1 + X^*_1 + X_2(s) + X^*_2(s) \qquad s\in S.$$

It is clear from these velocity equations that an aggregation similar to that used in the multiple currency problem will not reduce this problem to a barter economy. The agent's problem can, however, be simplified; again, this is because of the restricted asset market. The home agent's problem can be restated:

$$\underset{\{c_1, c_2(s)\}_{s\in S}}{\text{maximize}} \quad E_s\left(u(c_1) + \beta u(c_2(s)) \right)$$

subject to,

$$c_1 + qc_2(s) = \frac{1}{p_1} X_1 + \frac{q}{p_2(s)} X_2(s) + \frac{qp_1}{p_2(s)} y_1 , \qquad s\in S.$$

As in the multiple currency economy, the solution to the competitive equilibrium, for any given set of policy variables $\mathbf{X} = \{X_2(s), X_2^*(s)\colon s\in S\}$, would normally have to be obtained using numerical techniques. However, as the next section demonstrates, an analytical solution is available once the central authority's objectives are completely specified.

3. Monetary Integration

National policy makers are considered to be completely altruistic and pursue policies which maximize the discounted expected utility of their own agents. They are assumed to have cash transfers as their only policy instrument and they have two options available to them: to engage in a flexible exchange rate system or to allow a central authority to have full control of a common money supply. If a national policy maker chooses the former, the agents receive the multiple currency allocations which cannot be affected by national monetary policy. Alternatively, if they choose to join the monetary union, the agents of both countries receive an allocation that is determined by the national monetary transfers enacted by the supranational central authority.

The central authority sets monetary policy to maximize a joint social welfare function that is a simple linear weighting of each nation's expected utility. The authority is constrained, however, to ensure that both nations are at least as well off *ex ante* by participating in the monetary union since participation is voluntary. The solution to the social welfare optimization is potentially quite difficult to characterize; however, the solution can be computed using a standard central planner's problem that seeks to find a feasible Pareto optimal allocation. Further, by correctly choosing the set of social welfare weights associated with the central planner's problem, the central authority can ensure that both nations are at least as well off *ex ante*.[3] The relationship between the central authority's problem and the central planner's solution technique is demonstrated below and is a simple adaptation of Negishi(1960).

Before the solution technique is presented, it is worth considering why an economy with incomplete markets has a computable competitive equilibrium via a central planner's solution. The reason is that the monetary transfers allow the central authority to make state-dependent resource transfers that do not distort the relative price of intertemporal consumption. In this manner, the central authority circumvents the incomplete asset markets and is able to support a Pareto optimal allocation. The ability to solve the central authority's problem using the central planning solution technique depends upon two assumptions. The first is the asset market structure that abstracts from assets with state-dependent real returns. The second is the requirement that cash balances are not held as a savings instrument in equilibrium. These assumptions ensure that cash transfers reallocate wealth between the domestic and foreign agents in a non-distortionary manner.

The central planner's problem for this economy is to choose $\{c_1, c_1^*, c_2(s), c_2^*(s): s \in S\}$ to maximize the weighted social welfare function $\mathcal{S}$:

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[3]Casella's analysis also focuses on this role for social welfare weights.

$$\mathcal{S} = \lambda\left(E_s U(c_1, c_2(s)) \right) + (1-\lambda)\left(E_s U(c_1^*, c_2^*(s)) \right), \tag{CP1}$$

subject to the feasibility constraints:

$$c_1 + c_1^* = y_1 + y_1^*$$
$$c_2(s) + c_2^*(s) = y_2(s) + y_2^*(s) \qquad s \in S.$$

The objective function of the central planner, given in CP1, is consistent with the assumed objectives of the supranational central authority; the only difference is the choice variables, which are consumption allocations rather than policy variables.

To pursue an analytical solution, the representative agents are specified to have identical logarithmic instantaneous von Neumann-Morgenstern utility functions. The expected utility functions are defined over the probability distribution $\{\pi(s): s \in S\}$.[4] The domestic and foreign agents' lifetime expected utility functions are then

$$E_s U(c_1, c_2(s)) = u(c_1) + \beta \sum_s \pi(s) u(c_2(s)) \tag{3.1}$$

$$E_s U(c_1^*, c_2^*(s)) = u(c_1^*) + \beta \sum_s \pi(s) u(c_2^*(s)) \tag{3.2}$$

where,

$$u(c) = \ln(c)$$

Given the specifications in (3.1) and (3.2), the optimal consumption levels are weighted functions of world income where the weights are equivalent to the social welfare weights.

$$\bar{c}_1 = \lambda(y_1 + y_1^*) \tag{3.3}$$

[4] Analytical solutions are available for all homothetic instantaneous utility functions. Logarithmic preferences are used because of the immediate relationship between the social welfare weight λ and the proportion of world income consumed by each agent.

$$\bar{c}_1^* = (1-\lambda)(y_1 + y_1^*) \tag{3.4}$$

$$\bar{c}_2(s) = \lambda\big(y_2(s) + y_2^*(s)\big) \qquad s\in S \tag{3.5}$$

$$\bar{c}_2^*(s) = (1-\lambda)\big(y_2(s) + y_2^*(s)\big) \qquad s\in S \tag{3.6}$$

The task now is to demonstrate that $\bar{c} = \{\bar{c}_1, \bar{c}_1^*, \bar{c}_2(s), \bar{c}_2^*(s):\ s\in S\}$ is supportable as a single currency competitive equilibrium by a set of transfers, $\bar{X} = \{\bar{X}_2(s), \bar{X}_2^*(s):\ s\in S\}$. To do so, the equilibrium conditions of the single currency economy are used to calculate the prices that support the consumption vector $\bar{c}$. The Euler equation associated with the domestic (or foreign) agent's intertemporal consumption choice is

$$q = \beta \frac{\sum_s \pi(s) u'(c_2(s))}{u'(c_1(s))}.$$

Using the solution given in equations (3.3)-(3.6), q can be written as a function of first and second period world income (denoted by superscript W) only:

$$\bar{q} = \beta \textstyle\sum_s \pi(s)\left(y_1^W / y_2^W(s) \right).$$

The other prices of the model, $\{p_1, p_2(s):\ s\in S\}$, are determined by the unit velocity equations given in the section above. These prices are functions not only of world income but of first and second period cash transfers. They are written below in terms of the exogenous first period cash transfers $\{X_1,\ X_1^*\}$ and the set $\bar{X}$ that supports the consumption vector $\bar{c}$.

$$\bar{p}_1 = \frac{(X_1 + X_1^*)}{(y_1 + y_1^*)}$$

$$\bar{p}_2(s) = \frac{X_1 + X_1^* + \bar{X}_2(s) + \bar{X}_2^*(s)}{\big(y_2(s) + y_2^*(s)\big)} \qquad s\in S.$$

The intertemporal budget constraint of either the domestic or foreign agent is sufficient to give a relationship between the social welfare weight λ and the policy set $\bar{X}$. The two constraints are rewritten here for convenience:

$$c_1 + qc_2(s) = \frac{1}{p_1} X_1 + \frac{q}{p_2(s)} X_2(s) + \frac{qp_1}{p_2(s)} y_1, \qquad s\in S.$$

$$c_1^* + qc_2^*(s) = \frac{1}{p_1} X_1^* + \frac{q}{p_2(s)} X_2^*(s) + \frac{qp_1}{p_2(s)} y_1^*, \qquad s\in S.$$

The two constraints are not linearly independent relationships and therefore only the domestic agent's constraint need be considered. Furthermore, only the relative levels of $X_2(s)$ and $X_2^*(s)$ are identifiable and not the levels themselves. Consequently, the set of transfers is normalized to sum to unity. This is an important feature of the solution since it permits the central authority to pursue a policy of price stability in addition to the state-dependent monetary transfers. Using this normalization and the price levels determined above, the intertemporal constraints uniquely determine the elements of the set $\bar{X}$:

$$\bar{X}_2(s) = \frac{(1+X_1^W)}{\bar{q}y_2^W(s)} \left(\lambda\left(y_1^W + \bar{q}y_2^W(s) \right) - \frac{X_1}{\bar{p}_1} - \left(\frac{\bar{q}\bar{p}_1 y_1}{1+X^W} \right) y_2^W(s) \right), \quad s\in S,$$

$$\bar{X}_2^*(s) = 1 - \bar{X}_2(s), \qquad s\in S.$$

The analysis above demonstrates that the central authority can support an *ex ante* Pareto optimal allocation as a single currency competitive equilibrium. To do so, the authority chooses the policy set $\bar{X}$ that supports the desired allocation. The authority is constrained in his choice of allocations, however, by the domestic and foreign agent's incentive compatibility constraints: the requirement that both agents are at least as well off by participating in the monetary union than otherwise. The following proposition addresses this issue.

Proposition 1

Given the structure above, it is always possible to choose a weighting scheme that makes both the domestic and foreign agent as well off in the single currency regime as in the multiple currency regime.

Proof:

The proof has two parts:

(i) A multiple currency competitive equilibrium with incomplete markets is equivalent to a barter economy with incomplete markets. This is demonstrated above. The allocations of this economy's competitive equilibrium are always Pareto-dominated by a competitive equilibrium with complete Arrow-Debreu securities. This must be the case since agents can always trade, given complete markets, to the allocations under incomplete markets.

(ii) With homothetic preferences, the competitive equilibrium with complete Arrow-Debreu securities has the following characterization:

$$c_1 = \gamma y_1^W$$

$$c_1^* = (1-\gamma) y_1^W$$

$$c_2(s) = \gamma y_2^W(s) \qquad s \in S$$

$$c_2^*(s) = (1-\gamma) y_2^W(s) \qquad s \in S$$

Comparison of these relationships and the solutions to the central planner's problem indicate that for the correct choice of λ, the central planner can always replicate a competitive equilibrium with complete markets and, by part (i) above, make all agents at least as well off. QED

The Characterization of the Feasible Policy Set

The remainder of the analysis will focus on the set of choices faced by the central authority and the exact nature of the insurance programme available within a monetary union. To do so, I will exploit the one to one relationship between choosing an element of the policy set **X**, suitably normalized, and the social welfare weight λ The discussion will be in terms of choosing λ but this is equivalent to choosing the relative levels of state-dependent monetary transfers.

To consider the structure of the central authority's problem, some additional notation is required. Denote the utility associated with consumption of the entire world endowment as $\mathcal{A}$:

$$\mathcal{A} = u(y_1^W) + \beta E_s u\big(y_2^W(s)\big).$$

The social welfare function given in (CP1), evaluated at the optimal consumption levels $\bar{c}$, can then be written as a convex function of λ:

$$\ell(\lambda) = (1+\beta)\Big(\lambda \ln\lambda + (1-\lambda)\ln(1-\lambda) \Big) + \mathcal{A}. \tag{3.7}$$

This function, for a given $\mathcal{A}$, is presented in Figure 1 over the possible range of λ: $\lambda \in [0,1]$. It has a minimum value of $u(\frac{1}{2}y_1^W) + \beta E_s u\Big(\frac{1}{2}y_2^W(s) \Big)$ at $\lambda = 1/2$ and $\lim_{\lambda \to 0} \ell(\lambda) = \lim_{\lambda \to 1} \ell(\lambda) = \mathcal{A}$.

The incentive compatibility constraints faced by the central authority are formally given as:

$$E_s U(\bar{c}_1, \bar{c}_2(s)) - E_s U(\tilde{c}_1, \tilde{c}_2(s)) \geq 0,$$

$$E_s U(\bar{c}_1^*, \bar{c}_2^*(s)) - E_s U(\tilde{c}_1^*, \tilde{c}_2^*(s)) \geq 0,$$

where $\tilde{c} = \{\tilde{c}_1, \tilde{c}_1^*, \tilde{c}_2(s), \tilde{c}_2^*(s)\colon s \in S\}$ is the multiple currency equilibrium allocation. These state that the expected utility within the monetary union for both the domestic and the foreign agent is at least as great as the expected utility associated with the multiple currency equilibrium. By evaluating these constraints at $\bar{c}$, they can be rewritten as concave functions of λ:

$$g(\lambda) = (1+\beta)\ln\lambda + \mathcal{A} - U_{MC} \geq 0 \tag{3.8}$$

$$g^*(\lambda) = (1+\beta)\ln(1-\lambda) + \mathcal{A} - U_{MC}^* \geq 0. \tag{3.9}$$

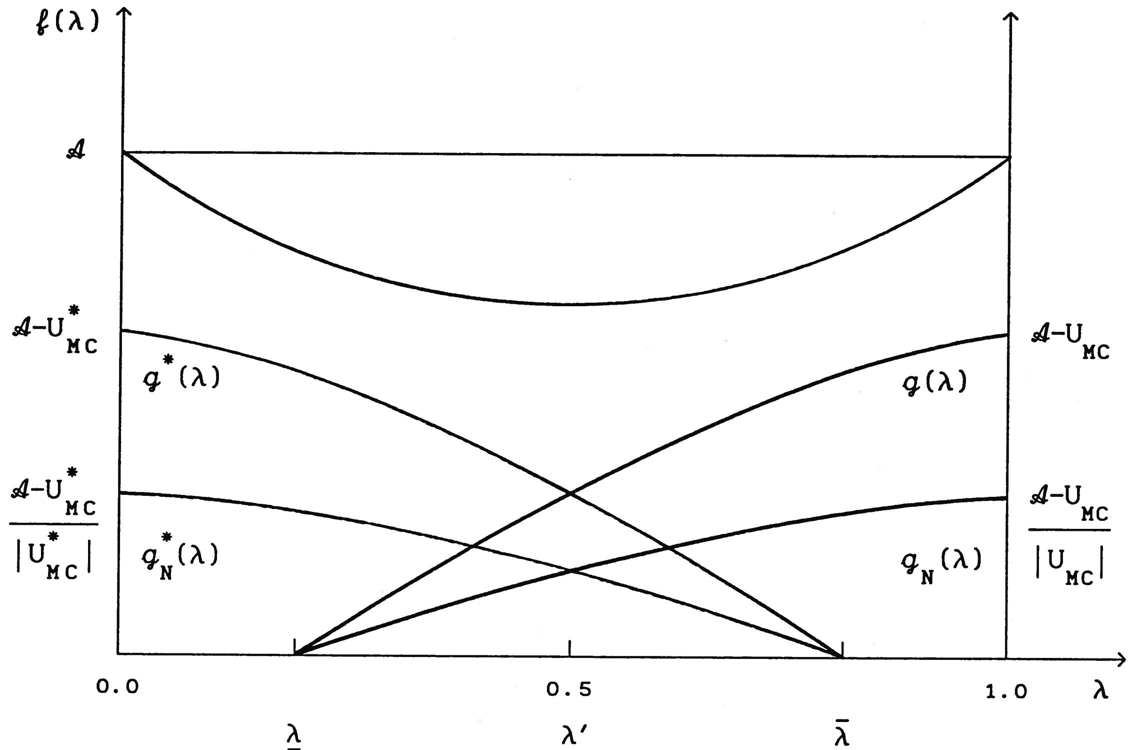

Figure 1

The level of utility for the multiple currency equilibrium is denoted now as simply U_{MC} and U^*_{MC} for the domestic and foreign agent respectively. Notice that $\mathcal{A}$, U_{MC} and U^*_{MC} are parametric to the central authority's choice problem, both being determined by the stochastic structure of endowments. The constraints in (3.8) and (3.9) restrict the choice of λ; only when both constraints are satisfied will a monetary union be supported by both agents. Constraints (3.8) and (3.9) are also portrayed in Figure 1 for a given $\mathcal{A}$. The value of λ for which $\mathcal{g}(\lambda) = 0$ is denoted $\underline{\lambda}$; similarly, $\mathcal{g}^*(\bar{\lambda}) = 0$.

For the domestic agent, a choice of λ such that $\lambda \geq \underline{\lambda}$ ensures that the domestic agent will be at least as well off under the single currency regime as under the multiple currency regime. For the foreign agent, the same criteria insists that $\lambda \leq \bar{\lambda}$. The set Λ, where $\Lambda = \{ \lambda : \underline{\lambda} \leq \lambda \leq \bar{\lambda} \}$, is thus the feasible set of λ and by Proposition 1 must always be non-empty. In Figure 1, the set Λ consists of $\underline{\lambda}$ and $\bar{\lambda}$ as well as the continuum of values between these two end points. A choice of λ between the two end points ensures that both agents are strictly better off within the monetary union.

An alternate situation is portrayed in Figure 2 where the set Λ consists of a single point, $\lambda = 1/2$. This situation arises if the two nations' endowment patterns are *ex ante* and *ex post* identical. With these endowment patterns, there does not exist any means to effect an insurance programme for the two agents. The only possibility is to replicate the multiple currency solution. Such an allocation causes both agents to be indifferent between monetary integration and the multiple currency regime. However, as long as some difference between the two nations exists - either mean, variance or endowment patterns - then Λ will consist of an infinite number of points and it is possible to make both agents strictly better off

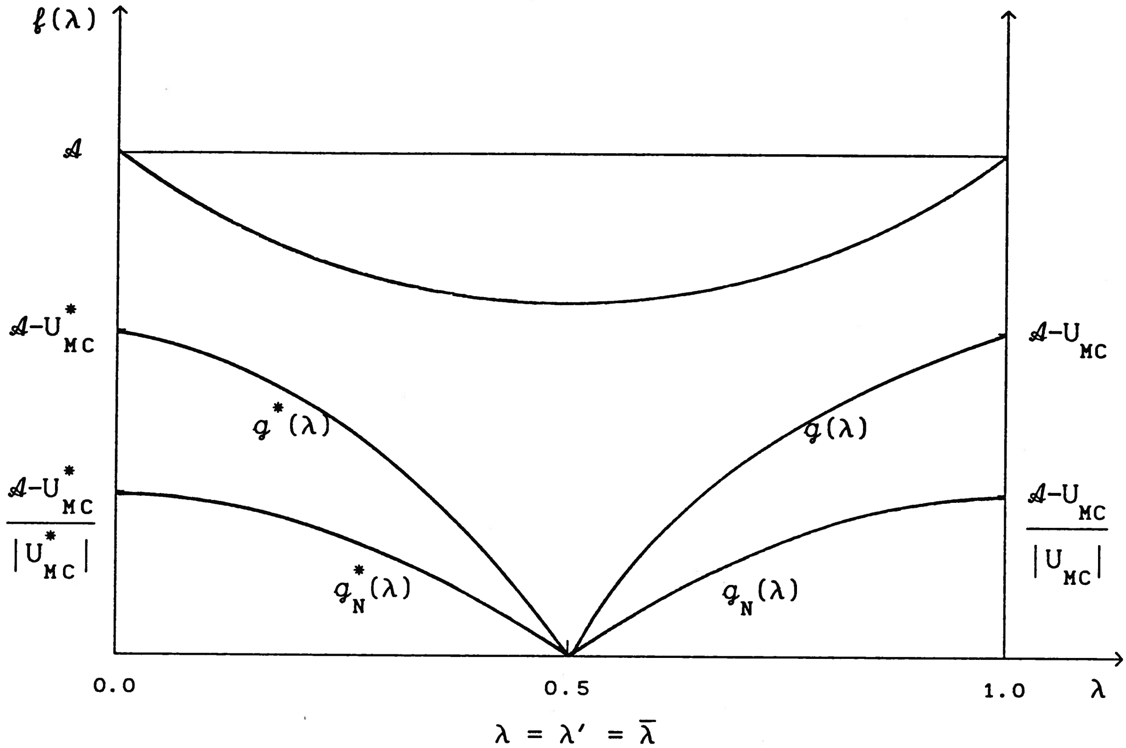

Figure 2

within the monetary union.

The Choice of λ:

The analysis above indicates that for a given pattern of endowments, a set Λ exists that supports a monetary union. However, what particular element of Λ is chosen is not clear. This is a feature of any monetary union and would seemingly be determined by the participants themselves as they seek to structure the supranational monetary institution.[5] One potential solution is for both nations to insist that they be weighted equally; however, if the two nations are sufficiently different, $\lambda = 1/2$ may not be an element of Λ. A more plausible solution, but one that is beyond the scope of this paper, is that the two nations participate in a bargaining game to determine a choice of lambda.

Without any formal justification, there is one element of Λ that seems an appropriate choice. This is the value, denoted λ', that equates the domestic and foreign agents' relative gains in welfare. Evaluating the solution at this point provides a clear indication of the potential welfare gains that exist for both agents. λ' is determined by the following relationship:[6]

$$\mathcal{G}_N(\lambda') = \frac{\mathcal{G}(\lambda')}{|U_{MC}|} = \frac{\mathcal{G}^*(\lambda')}{|U^*_{MC}|} = \mathcal{G}^*_N(\lambda') \tag{3.10}$$

The normalized functions represented in (3.10) are also presented in Figures

[5] In much the same way as the participating nations might constrain the central authority to pursue a non-inflationary monetary policy stance.

[6] The normalization is with respect to the absolute value of multiple currency equilibrium utility levels to account for possible negative values.

1 and 2. Although λ' is not a necessary outcome of the participants' structuring of the central monetary institution, this choice provides a reasonable benchmark to consider further the nature of a monetary union and the role of monetary policy.

Numerical Analysis

Clearly, the potential welfare gains from participating in a monetary union depend upon the nature of the two nations' endowment patterns since these determine the potential amount of co-insurance that exists. Ideally, the analysis should fully develop the relationship between the endowment patterns and the welfare gains; unfortunately, the non-linearity of the problem and the presence of incomplete asset markets restrict this development. Although the single currency competitive equilibrium can be specified with little trouble, the same is not true for the multiple currency competitive equilibrium and the latter is an important component in assessing the nature and the size of the potential welfare gains to monetary integration. Consequently, the analysis pursues these issues using simple numerical techniques.

In order to numerically investigate the welfare benefits of monetary integration and how these benefits are provided, the entire economy must be parameterized. This includes, among other things, choosing a particular element of Λ so that a single currency equilibrium may be compared with the multiple currency equilibrium. For the purposes of this paper, the allocation chosen for the single currency equilibrium is the one supported by λ' implicitly defined above in (3.10). Recall that this allocation equates the relative increase in utility between the domestic and foreign agent.[7]

What remains to be chosen are the preference parameters, in this case only β and β^*, and the endowment patterns, including the joint distribution of the second period endowments. The details of these are presented in the two numerical experiments in Tables 1 and 2. One other feature of the economy must also be chosen, and that is the monetary transfers that are not determined by the choice of λ. These include all the transfers in the multiple currency economy and the first period transfers in the single currency economy. For the multiple currency equilibrium, the monetary transfers do not affect the real allocations and are only constrained by the condition given in (1.9). For the single currency equilibrium, first period monetary transfers are constant at a value of 0.100 for both agents.

The difference between the numerical experiments presented in Table 1 and Table 2 are the endowment patterns. In Table 1, the domestic and foreign endowments are perfectly negatively correlated and there is no aggregate uncertainty. In this situation, the monetary union is able to provide perfect insurance and reduce the variance of expected consumption to zero for both agents. Alternatively, Table 2 presents an endowment pattern with perfect correlation. For the sake of interest, the agents are specified to have endowments of differing variability; otherwise, the monetary union would only be able to replicate the consumption patterns of the multiple currency equilibrium. In the experiment of Table 2,, the monetary union is unable to provide full insurance. Instead, the transfers

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[7]The multiple currency competitive equilibria and the value of λ' are both calculated using a Newton-Raphson non-linear equation solution technique adapted from Press, Flannery, Teukolsky, and Vetterling (1987). The programmes are available from the author upon request.

Table 1
Negatively Correlated Endowments

Parameters

$\beta = 0.975$
$\pi(s) = \{0.500,\ 0.500\}$

Endowments

$y_1 = 1.000 \qquad y_1^* = 1.000$

	μ	σ^2	ρ
$y_2(s) = \{1.000,\ 2.000\}$	1.500	0.250	-1.000
$y_2^*(s) = \{2.000,\ 1.000\}$	1.500	0.250	

Multiple Currency Equilibrium

$c_1 = 1.000 \qquad c_1^* = 1.000$

	μ	σ^2
$c_2(s) = \{1.000,\ 2.000\}$	1.500	0.250
$c_2^*(s) = \{2.000,\ 1.000\}$	1.500	0.250

$U_{MC} = 0.338 \qquad U_{MC}^* = 0.338$

Single Currency Equilibrium

$c_1 = 1.000 \qquad c_1^* = 1.000$

	μ	σ^2
$c_2(s) = \{1.500,\ 1.500\}$	1.500	0.000
$c_2^*(s) = \{1.500,\ 1.500\}$	1.500	0.000

$U_{SC} = 0.395 \qquad U_{SC}^* = 0.395$

Policy Variables

$\Lambda = [0.4856,\ 0.5143] \qquad \lambda' = 0.5000$

Table 2
Positively Correlated Endowments

<u>Parameters</u>

$\beta = 0.975$
$\pi(s) = \{0.500,\ 0.500\}$

<u>Endowments</u>

$y_1 = 1.000 \qquad y_1^* = 1.000$

	μ	σ^2	ρ
$y_2(s) = \{1.800,\ 1.200\}$	1.500	0.090	1.000
$y_2^*(s) = \{2.000,\ 1.000\}$	1.500	0.250	

<u>Multiple Currency Equilibrium</u>

$c_1 = 1.018 \qquad c_1^* = 0.982$

	μ	σ^2
$c_2(s) = \{1.774,\ 1.174\}$	1.474	0.090
$c_2^*(s) = \{2.026,\ 1.026\}$	1.526	0.250

$U_{MC} = 0.376 \qquad U_{MC}^* = 0.338$

<u>Single Currency Equilibrium</u>

$c_1 = 1.010 \qquad c_1^* = 0.990$

	μ	σ^2
$c_2(s) = \{1.918,\ 1.111\}$	1.514	0.163
$c_2^*(s) = \{1.882,\ 1.089\}$	1.486	0.157

$U_{SC} = 0.378 \qquad U_{SC}^* = 0.340$

<u>Policy Variables</u>

$\Lambda = [0.5042,\ 0.5053] \qquad \lambda' = 0.5048$

simply redistribute the burden of consumption variability between the two agents as best as possible given the pattern of endowments. This entails an increase in consumption variability for the more stable domestic agent and a decrease in variability for the foreign agent. For the domestic agent, this increase in variability is offset by an increase in mean consumption and, necessarily then, the foreign agent faces a reduction in mean consumption.

An interesting feature of the solutions presented in Tables 1 and 2 are the patterns of monetary transfers that support these allocations. For example, the pattern of transfers associated with Table 1 is simply $X_2(s) = X_2^*(s) = 0.5$ for all $s \in S$. A seemingly more plausible policy set would have the transfers to be counter-cyclical in order to transfer wealth to the nation with the lower realized endowment. Such intuition fails in this case because of the cash-in-advance constraint structure and the two period horizon. This structure essentially taxes away second period earnings since there is a one period delay in the receipt of these earnings and the agent only enjoys a lifetime of two periods. As a consequence, the second period endowments only enter the agent's optimization problem through second period prices, and they do so in aggregate. The central authority's problem then is not to offset economic disturbances directly with cash transfers, since these disturbances are not felt directly, but rather to manipulate prices to ensure that the variability of consumption for both agents is reduced.

The two numerical experiments in Tables 1 and 2 demonstrate the means by which the monetary union has positive welfare benefits. These tables also demonstrate the dependence of these welfare benefits on the nature of the endowment patterns, and in particular the relationship between the domestic and foreign endowments. The numerical experiment represented by the graph in Figure 3 further investigates the relationship between the pattern of endowments and the potential welfare gains to participation in a monetary union. A series of joint distributions is chosen that varies the correlation of endowments over the range [-1, 1]. The potential welfare gains are measured by the value of either the domestic or foreign agents relative increase in utility when the allocations are determined by λ' as defined above. These gains are measured on the vertical axis, while the correlation values are measured on the horizontal axis. Not surprisingly, the welfare gains are greatest when the endowment patterns are perfectly negatively correlated and a system of complete insurance can be effected.[8] The gains then decrease monotonically as the correlation increases until, at $\rho = 1$, there are no positive welfare gains to participating in a monetary union. (Note that the linearity of the relationship is a feature of the symmetry that characterizes this particular experiment and not a general result.)

[8]The experiment is structured so that at $\rho = -1$ there is no aggregate uncertainty. If there is aggregate uncertainty, then it may not be possible to provide complete insurance against all consumption risk. For full details of the experiment, see Appendix.

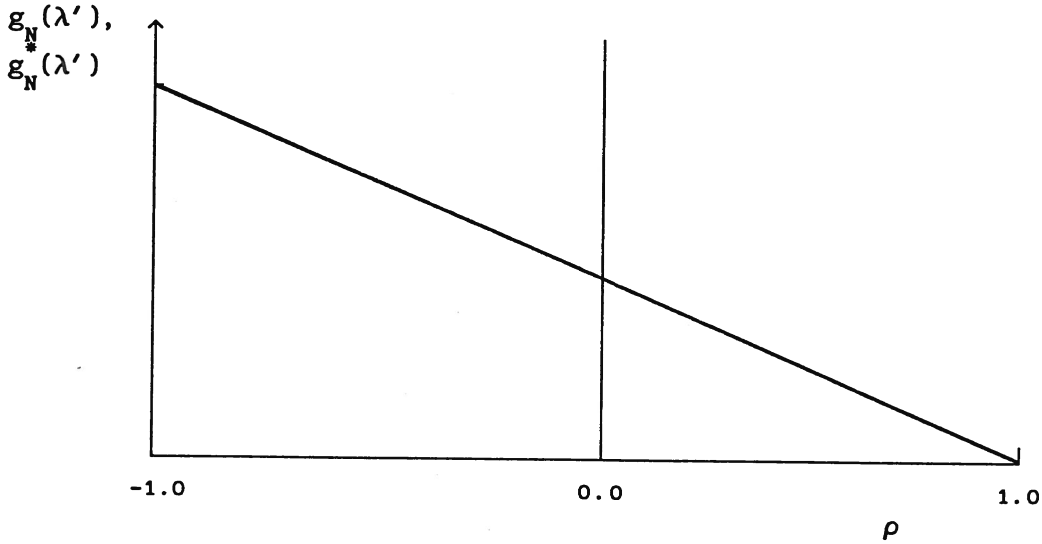

Figure 3

The important implication of Figure 3 is its contradiction of Mundell's (1961) conclusions on optimum currency areas. Recall Mundell's arguments that only regions similar in patterns of economic behaviour would be able to benefit from forming a currency union. This analysis concludes that dissimilar regions, those regions that have negatively correlated endowment patterns, face greater potential welfare gains from participating in a monetary union than economic regions similar in economic patterns.

4. Conclusion

The principles of optimum currency areas, as originally put forth by Mundell (1961), have gone largely unchallenged and indeed, many modern authors have adopted these principles in their analyses of European monetary integration. The analysis above, however, demonstrates that there exists alternative conclusions to those set forth by Mundell once the monetary theory of the 1960s is abandoned.

Rather than focus on the role of monetary policy to stabilize employment and inflation, this paper considers the importance of economic uncertainty and the welfare improving role of monetary policy designed to reduce the uncertainty of future consumption. The most important conclusion of this analysis is that there does not exist any *ex ante* welfare loss from participation in a monetary union. Furthermore, the paper demonstrates that monetary integration is more likely to be pursued by economically diverse regions and not economically homogeneous regions as argued by Mundell's (1961) analysis.

The framework of the analysis, which relies heavily on the general equilibrium exchange rate analysis pioneered by Helpman (1981), is not intended as an exhaustive portrayal of all issues of European monetary integration. However, by presenting alternative features of the integration problem it does contribute to the growing literature of monetary integration. Further, the idea that an inflation tax can be used to dissipate economic uncertainty amongst diverse economic regions is intuitively valid for many models of the the international monetary economy.

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Appendix

This appendix describes the numerical experiment reported in Figure 3. The purpose of the experiment is to demonstrate the method by which the insurance programme is able to improve welfare and how the method depends upon the pattern of endowments. It is important to realize that this is just one of many possible experiments that could be presented and does not, therefore, provide completely general results. Nevertheless, the experiment does clearly demonstrate the greater potential for co-insurance, and hence welfare gains, that exists for negatively correlated endowment patterns.

Table 3
Correlation Experiment

Parameters

$\beta = 0.975$

Endowments

$y_1 = 1.000 \qquad y_1^* = 1.000$

$y_2(s) = \{1.000,\ 2.000,\ 1.000,\ 2.000\}$

$y_2^*(s) = \{2.000,\ 1.000,\ 1.000,\ 2.000\}$

Probability Distribution

Number of experiments: 51

$r \in [0,\ 50],\ r \in I$

$\delta = 0.010$

$\pi_r(s) = \{0.500 - r\cdot\delta,\ 0.500 - r\cdot\delta,\ 0.00 + r\cdot\delta,\ 0.000 + r\cdot\delta\}$

The graph in Figure 3 is comprised of 51 experiments that vary the correlation from 1.0 to -1.0. The experiments are described in Table 3. As always, the multiple currency equilibrium allocations are independent of monetary policy. For the single currency equilibrium, first period monetary transfers are constant at 0.100 while second period monetary transfers are implicitly determined by the choice of λ, in this case λ' as determined in relationship (3.10).