INTERNATIONAL BALANCE OF PAYMENTS
FINANCING AND ADJUSTMENT

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ABSTRACT

This paper explores some implications of the use of national currencies as international reserves. First, a closed economy overlapping-generations model is developed to derive time-consistent tax and inflation policies for a government that is financing a given stream of expenditures. Second, the effects of allowing a government to hold a foreign currency as a reserve asset and to have its currency held as a reserve asset abroad are considered. The use of national currencies as currencies of denomination for international lending creates an incentive for the governments whose currencies are used to alter their inflation rates to extract resources from the rest of the world. When reserves are constrained to be nonnegative the use of national currencies as international reserves raises the inflation rate in reserve issuing countries but does not effect the inflation rate in reserve holders. The opposite result arises when loans are denominated in the borrowers' currencies.

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With the decline in the role of gold in the international economy
the primary method that countries have used to finance payments imbalances
has been borrowing and lending denominated in terms of national currencies.
In the last century sterling was the primary reserve currency while in this
century it has been the U.S. dollar. Recently the currencies of a number
of additional countries have emerged as international stores of values.
These currencies have also served as the primary currencies of denomination
of international loans. The introduction of Special Drawing Rights (SDR's)
constitutes an attempt to replace national moneys with an international
money for use as an international reserve. Its adoption thus far has
been only partial, however, and its value remains tied to that of national
currencies. In the absence of a credible commitment to a commodity
exchange standard such as the gold exchange standard, the value of assets
and liabilities denominated in national currencies has been subject to the
political control of the governments and central banks issuing those
currencies. The use of these currencies to finance payments imbalances
will depend upon the expectations held by international transactors about
the strength of these institutions' commitment to maintain the real values
of their currencies.

Nevertheless, a currency's introduction into use as an international
store of value changes the context in which the issuers of currencies act.
First, the process whereby national currencies are distributed throughout
the world economy requires an adjustment via payments imbalances that may
have severe economic consequences for reserve issuers and holders alike.
Second, the presence of large currency balances held outside the country
of issue and of loans abroad denominated in local currency has serious

implications for the effect of central bank policy on national welfare. As a consequence, one might anticipate that being thrust into the role of a reserve issuer or international lender may significantly change the issuing country's monetary policy.

It is widely recognized that the use of a currency as an international reserve and currency of denomination of international assets and liabilities requires trust in the issuer's willingness and ability to maintain the real value of its currency. Triffin's (1961) discussion of the dollar problem emphasized that the U.S. dollar's widespread use as a reserve currency could, by itself, undermine belief in its long-run stability. The incentives facing a reserve issuer to undermine the value of its currency by inflation have been discussed by Mundell (1971) and Calvo (1978).

The use of national moneys as international reserves raises a number of questions: (i) What characteristics of a country make it likely to emerge as a reserve issuer? (ii) How does becoming a reserve issuer affect the inflation rate that is optimal from a national perspective? (iii) If, in fact, the rate of return on a currency is likely to fall if it is adopted as an international reserve, why are other countries' central banks willing to hold this currency as a reserve if they perceive this effect? and (iv) What are the costs and benefits of becoming a reserve issuer and a reserve holder?

Our purpose in this paper is to develop a model of the interaction of national monetary policy and international reserves to answer these questions. The issue is considered from the perspective of both

reserve issuers and reserve holders.

To understand how the use of national moneys as international reserves affects the conduct of monetary policy, one needs to specify the objectives of the government and the technology and preferences of the private sector. To generate a demand for currency at the national level, the exact consumption loan model of Samuelson (1958) is adopted. While this framework is very simple and highly stylized, it does generate a demand for money based directly on an underlying technology and individual preferences. Precise welfare comparisons across regimes are therefore possible.[1]

We assume that the government of each country must meet an exogenous level of government spending each period. This expenditure may be financed via a nondistortionary tax imposed on the current younger generation or by monetary issue. The government's objective is to maximize a weighted average of the lifetime utilities of all generations of its citizens.

Section I of the paper presents a closed-economy version of the model. The tax rate and inflation rate that obtain in each period reflect the government's weighting of the younger and older generations currently alive. The greater the weight placed on the older generation, the lower the inflation rate, and conversely. Only when equal weight is placed on the representative member of each generation alive does the steady-state rate of return on money balances equal the growth rate, achieving the golden rule. Otherwise, the lifetime utility of the representative citizen in the steady state is below the maximum possible level. When, in fact, this is

due to a rate of return on currency below the growth rate (when the government places greater weight on the utility of the younger generation), the outcome is not Pareto efficient. The problem arises because the government in any given period cannot credibly commit itself or its successor in the next period to avoid inflating the currency at a faster rate, thereby reducing the rate of return on savings to the current younger generation. It constitutes an example of the problem of the time inconsistency of optimal policy discussed by Kydland and Prescott (1977).

Section II introduces foreign reserves into the model. It incorporates both domestic holdings by the government of foreign currency and foreign holdings of domestic currency. We assume that reserve holders take current and future returns on foreign currencies as given, anticipating them correctly, and that reserve issuers take current and future holdings by foreigners of their currency as given, anticipating these correctly as well. We show that holding a foreign currency as a reserve does not affect the steady state inflation rate of the reserve holding country. The demand for reserves depends not only upon the government's weighting of the two generations currently alive but upon its weighting of future generations. When the government assigns future generations weights that decline geometrically into the future, then foreign reserves are demanded perfectly elastically at the rate of return on domestic currency. When the government acts only in the interests of generations currently alive, the demand for reserves is also infinitely elastic, but at a rate of return that is higher than that on domestic currency.

The rate of inflation in the reserve issuer is, however, affected by changes in foreign holdings of domestic reserves. The effect of an increase in foreign holdings on impact is ambiguous, but in the new steady state, in which more reserves are held abroad, the rate of inflation in the issuing country is necessarily higher.

Section III considers global equilibrium in a world in which there are two types of countries, one characterized by a low inflation rate under financial autarky and another by a high inflation rate under financial autarky. We distinguish two cases, one in which gross international lending is always denominated in the currency of the lender, in which case reserves are constrained to be nonnegative, and the opposite case in which borrowing is always denominated in the currency of the borrower. The two cases generate quite different equilibria. Our model does not predict which type of equilibrium will emerge, or if it will be an intermediate one. This paper suggests, however, that a theory of default combined with an assumption of convertibility may be incorporated into the model to endogenize this decision.[2]

We show that when loans are denominated in the currency of the borrower countries with low rates of inflation under financial autarky become borrowers, while countries with high inflation rates become lenders. Becoming a borrower in its own currency raises a country's steady-state inflation rate but has no effect on the steady-state inflation rate of the lender. Moving from financial autarky to trade in reserves thus raises the average world inflation rate. The effect during the

transition from one steady state to the other may be quite different, however, with the reserve issuer experiencing a <u>lower</u> inflation rate along the way. The opposite results with respect to inflation arise when loans are denominated in the lender's currency. In this case, the high-inflation countries lend to low-inflation ones in the former group's currencies. These loans then provide an incentive for lenders to lower their inflation rates but have no effect on inflation in the second group. The average world inflation rate is consequently lower in the long run.

Our model allows one to compute the welfare effects of trade in reserves. We find that in the steady state, the utility of the representative generation is higher in lender countries but can be lower in borrower countries. The effects on generations alive during the transition may be quite different, however. The results thus suggest a justification for attempts by some governments to prevent their currencies from becoming reserve currencies.

Section IV discusses some possible extensions of our analysis that we believe would be especially worthwhile. Each of the issues raised here can potentially be analyzed in the framework we have developed, but they lie beyond the scope of a single paper. Section V provides a summary of the major results.

I. The Closed Economy Model

We illustrate our points in a very simple model. Our point of departure is the Samuelson (1958) exact consumption-loan model. Individuals live two periods, earning income only in the first period and saving a fraction of that income in order to consume in the second period. Individuals who enter the labor force in period t earn, before tax, an exogenously given amount y_t in the first period of their lives, a fraction τ_t of which is taxed by the government. Domestic government debt, which is assumed to be monetary, is the only asset available to individuals as a store of value. Output is nonstorable.

We assume that the utility function of a representative individual entering the labor force in period t is given by

$$U_t = \ln\ c_t^y + \beta \ln\ c_{t+1}^0 \qquad 0 \le \beta \qquad (1)$$

where c_t^y denotes consumption in the first period of life, t, when the individual is young, and c_{t+1}^0 consumption when the individual is old, period t + 1. While the Bernoulli assumption is special it provides a number of restrictions that simplify the analysis substantially. We will discuss the implication of relaxing some of these assumptions later on.

Let P_t denote the price level in period t and let m_t^d denote the real savings, and hence real money holdings at the end of period t of an individual born in period t. In period t, then, the individual chooses c_t^y and m_t^d to maximize U_t subject to the budget constraints

$$y(1-\tau_t) - c_t^y - m_t^d \geq 0 \tag{2}$$

$$c_{t+1}^0 \leq \pi_{t+1} m_t^d \tag{2'}$$

Here we define the inverse of one plus the inflation rate from period t to period t+1 as

$$\pi_{t+1} \equiv \frac{P_t}{P_{t+1}}$$

which equals one plus the rate of return on real money balances.

First-order conditions for a maximum imply

$$c_t^y = \frac{1}{1+\beta} (1-\tau_t)y_t \tag{3}$$

$$m_t^d = \frac{\beta}{1+\beta} (1-\tau_t)y_t \tag{3'}$$

$$c_t^0 = \pi_{t+1} \frac{\beta}{1+\beta} (1-\tau_t)y_t \tag{3''}$$

The government is required to meet a real expenditure path G_t. It collects, in period t, a real amount $\tau_t y_t L_t$ in tax revenue where L_t equals the number of young individuals in period t. The deficit is financed by monetary issue. The government budget constraint is therefore

$$G_t - \tau_t y_t L_t = \frac{M_t^d - M_{t-1}^d}{P_t} \tag{4}$$

where M_t^d denotes is the nominal money supply at the end of period t. Using the definition

$$m_t^d \equiv \frac{M_t^d}{P_t L_t}$$

and dividing equation (4) by L_t yields, in per worker terms,

$$g_t - \tau_t y_t = m_t^d - m_{t-1}^d \pi_t (1+n_t)^{-1} \tag{4'}$$

where n_t denotes the growth in the labor force from period t-1 to period t and g_t denotes government spending per worker. The government's objective in each period t is to choose a tax rate τ_t to maximize a weighted sum of the utilities of all generations subject to equation (4) or (4'). Thus, in each period t, the government's objective function W_t is given by

$$W_t \equiv \sum_{i = - \infty}^{\infty} w_{t+i} U_{t+i} \tag{5}$$

In choosing τ_t in period t, the government takes all past τ_i as given and assumes that it or its successor will behave equivalently in the future. Governments are therefore assumed to behave in a _time-consistent_ fashion and to anticipate this behavior correctly. Solving the government budget constraint (4') incorporating optimal private savings behavior characterized by equation (3') yields, as an expression for the rate of return on currency in period t,

$$\pi_t = \frac{\left[\left(\frac{\beta + \tau_t}{1 + \beta} \right) y_t - g_t \right] (1+n_t)}{M_{t-1}^d} \tag{6}$$

Substituting equations (6) and (3) into equation (1) yields, as an expression for the utility of a representative member of the generation born in period t,

$$U_t = k + (1 + \beta) \ln y_t + (1+ \beta) \ln (1- \tau_t) + \beta \ln \pi_{t+1} \tag{1'}$$

$$k \equiv \beta \ln \beta - (1+\beta) \ln (1 + \beta)$$

where π_t is as defined in (6). Substituting equations (1') and (6) into the government's objective function (5) and maximizing with respect to τ_t yields, from the first-order condition for a maximum,

$$\tau_t = \frac{\beta(1 - \delta_t)y_t + \delta_t(1 + \beta) g_t}{(\beta + \delta_t) y_t}; \quad \delta_t \equiv \frac{w_t}{w_{t-1}}$$

which, from equation (6), implies

$$\pi_t = \frac{\beta(y_t - g_t) (1 + n_t)}{(\beta+\delta_t) m^d_{t-1}} \tag{8}$$

Note from expression (7) that when $\delta = 1$ (generations born at t and at t+1 enter the government's objective function with equal weight) then:

$$\tau_t = g_t/y_t \tag{7'}$$

--that is, all government spending is tax financed. When $\delta_t > 1$, so that greater weight is attached to the utility of the younger generation, then $\tau_t < g_t/y_t$, so that some government spending is financed by monetary issue. Conversely, when $\delta_t < 1$, so that greater weight is attached to the older generation, $\tau_t > g_t/y_t$--that is, taxes exceed expenditure--so that debt is retired. If the government objective function is a Benthamite one, so that the weight of each living generation is proportional to the number of its members, then $\delta_t = (1 + n_t)$, in which case, if population growth is positive, there is an ongoing deficit.

From expression (8), observe that the inflation rate in period t is higher: (i) the greater government spending is relative to income, (ii) the higher real money balances are at the end of the previous period, and (iii) the lower the population growth rate.

From equation (3),

$$m^d_{t-1} = \frac{\beta}{1+\beta} (1 - \tau_{t-1}) y_{t-1} \tag{9}$$

which, if optimal tax policy was pursued in period t-1

$$\pi_t = \frac{(1 + n_t)}{\delta} \quad \frac{y_t - g_t}{y_{t-1} - g_{t-1}} \tag{10}$$

When the two living generations receive equal weight ($\delta = 1$) and income less government spending is equal across periods, then the rate of return on money balances equals the population growth rate: the economy is following the golden rule. If $\delta > 1$ or if income less government spending is decreasing, then the rate of return on money balances is less than the population growth rate, and conversely. In the case of the Benthamite utility function and constant population growth, the rate of return on money is zero.

II. An Open Economy Model with Reserves

Consider now a situation in which the government of the country being considered (i) has available to it a foreign money which can be held as a reserve currency or (ii) finds that some of its money is held abroad as a reserve currency. Denote foreign holdings of domestic money denominated in domestic currency in period t as M_t^f and domestic holdings of foreign currency denominated in foreign currency in period t as M_t^{*d}. Let P_t^* denote the price level in terms of foreign currency in period t and E_t the domestic currency price of one unit of foreign currency. It is assumed that purchasing power parity obtains, so that

$$E_t = P_t / P_t^* \tag{11}$$

Allowing for these government holdings of assets modifies the government budget constraint, equation (4), so that it becomes

$$G_t - \tau_t Y_t L_t = \frac{M_t^d - M_{t-1}^d}{P_t} + \frac{M_t^f - M_{t-1}^f}{P_t} - \frac{E_t(M_t^{*d} - M_{t-1}^{*d})}{P_t} \tag{12}$$

It is assumed that no international transfers take place.

Defining real domestic currency holdings abroad per domestic worker as

$$m_t^f \equiv \frac{M_t^f}{P_t L_t}, \tag{13}$$

and real foreign currency holdings by the domestic government per foreign worker (where L_t^* denotes the number of foreign workers in period t) as

$$m_t^{*d} \equiv \frac{M_t^{*d}}{P_t^* L_t^*}, \tag{14}$$

the real rate of return on foreign currency as

$$\pi_t^* \equiv \frac{P_{t-1}^*}{P_t^*} \, ,$$

and the ratio of foreign workers to domestic workers in period t as

$$\lambda_t \equiv \frac{L_t^*}{L_t}$$

the government budget constraint may be written

$$g_t = \tau_t v_t = m_t^d - m_{t-1}^d \, \pi_t (1+n_t)^{-1} + m_t^f - m_{t-1}^f \, \pi_t \, (1+n_t)^{-1}$$

$$- \lambda_t \, [m_t^{*d} - m_{t-1}^{*d} \, \pi_t^* \, (1+n_t^*)^{-1}] \qquad\qquad (17)$$

where n_t^* denotes the growth in the number of foreign workers

between period t-1 and period t.

The Behavior of a Reserve Holder

Consider first the situation of a country whose currency is

not held abroad, but which contemplates holding a foreign currency as a

reserve. We assume that this country treats the rate of return on the

reserve currency, π_i^*, as exogenous to its own behavior for all i.

One reason is that this country may be one of a large number of small countries that hold this reserve currency, and its contribution to total demand is negligible. We assume that this country anticipates perfectly the actual rate of return on foreign currency.

Setting $m_i^f = 0$ for all i in equation (17), this country chooses in each period t a tax rate τ_t and an amount of reserves $\lambda_t m_t^{*d}$ to maximize its objective function W_t, which, it is assumed, continues to be given by equation (5), with $\delta_t = w_t/w_{t-1} = \delta$

Defining

$$\hat{g}_t = g_t + \lambda_t \; [m_t^{*d} - \pi_t^* \; (1 + n_t)^{-1} \; m_{t-1}^{*d}] \tag{18}$$

the optimal tax rate τ_t is given by

$$\tau_t = \frac{\delta(1+\beta)\hat{g}_t + \beta(1-\delta)y_t}{(\delta+\beta)y_t} \tag{19}$$

The rate of inflation is consequently

$$\pi_t = \frac{(1 + n_t)}{\delta} \left(\frac{y_t - \hat{g}_t}{y_{t-1} - \hat{g}_{t-1}} \right) \tag{20}$$

Substituting these expressions into W_t yields

$$W_t = \sum_{i=-\infty}^{\infty} W \; k_i + \ell n \; (y_i - \hat{g}_i) + \beta \; \ell n \; (y_{i+1} - \hat{g}_{i+1})] \tag{21}$$

where

$$k_i \equiv -(1+\beta)\ell n \; (1+\beta) + \ell n \; \delta + \ell n\beta + \ell n(1+n_{i+1})$$

Differentiating this expression with respect to m_t^{*d} yields, as a first-order condition for a maximum,

$$\frac{-\lambda_t(w_t + \beta w_{t-1})}{\tilde{y}_t - \lambda_t(m_t^{*d} - m_{t-1}^{*d} x_t)} + \frac{\lambda_{t+1}(w_{t+1} + \beta w_t) x_{t+1}}{\tilde{y}_{t+1} - \lambda_{t+1}\left(m_{t+1}^{*d} - m_t^{*d} x_{t+1}\right)} \qquad (22)$$

$$+ \sum_{i=t+1}^{\infty} \frac{dW_t}{dm_i^{*d}} \frac{dm_i^{*d}}{dm_t^{*d}} = 0$$

where

$$x_t \equiv \pi_t^* (1 + n_t)^{-1}$$

$$\tilde{y}_t \equiv y_t - g_t$$

Note that since m_t^{*d} depends upon m_{t-1}^{*d}, in general _future_ values of m^{*d} will be affected by the _current_ reserve holding decision. The best choice from the current perspective must incorporate the effect of that choice on the country's own future policy response.

This paper will now focus on two special cases

Case 1. $w_i = w_{t-1} \rho^i; \quad i = t, \ldots, \infty \qquad \rho < 1$

In this case one may write

$$W_t\left(m_{t-1}^{*d}\right) = (w_{t-1} \beta k_{t-1} + w_t k_t) \, \ell n \, (y_t - g_t) + \rho W_{t+1} (m_t^{*d}) \qquad (23)$$

If optimal policy is pursued in each period $i > t$ then

$$\frac{dW_i}{dm_i^{*d}} = 0 \qquad\qquad i \geq t+1$$

and expression (23) reduces to

$$-\frac{(w_t + \beta w_{t-1})}{\tilde{y}_t - \lambda_t (m_t^{*d} - m_{t-1}^{*d} x_t)} + \frac{(w_{t+1} + \beta w_t) x_{t+1}}{\tilde{y}_{t+1} - \lambda_{t+1} (m_{t+1}^{*d} - m_t^{*d} x_{t+1})} = 0 \qquad (23')$$

In the steady state $\lambda_t = \lambda_{t+1} = \lambda$, $\tilde{y}_{t+1} = \tilde{y}_t = y$, $x_{t+1} = x$,

$m_{t-1}^{*d} = m_t^{*d} = m_{t+1}^{*d} = m^{*d}$ Therefore expression (23') can be obtained

only if

$$x = \rho^{-1}$$

When x exceeds ρ^{-1} the demand for foreign reserves is infinite in

steady state while if x_t is less than ρ^{-1}, demand equals negative

infinity. From Section I, the autarkic inflation rate is $(1 + n)/\delta$.

Consequently, since $\delta = \rho$ in this case, the demand for foreign reserves in the

steady state is bounded only when the rate of return on foreign reserves equals

the return on domestic money. In other words, the demand for reserves is

infinitely elastic at the domestic inflation rate.

Case 2. $w_i = 0$ $i \neq t-1, t$

In this case, the current government only takes into account the welfare of

generations currently alive. It assumes that future governments will

act equivalently. The current government and future governments thus pursue

different objectives. In particular, the current government must incorporate

the effect of its current policies on the future government's treatment

of the current younger generation.

To solve for optimal reserve demand, it is assumed that at each period t,

foreign reserves are held according to the formula

$$m_t^{*d} = a_t + b_t \, m_{t-1}^{*d} \tag{24}$$

where a_t and b_t denote parameters to be determined.

Substituting expression (24) into the objective function for m_{t+1}^{*d} yields

$$W_t = (w_{t-1} \beta k_{t-1} + w_t k_t) + (\beta+\delta) \ln \left[\tilde{y}_t - \lambda_t \left(m_t^{*d} - m_{t-1}^{*d} x_t \right) \right]$$

$$+ \delta \beta \ln \left[\tilde{y}_{t+1} - \lambda_{t+1} \left(a_{t+1} + b_{t+1} \, m_t^{*d} - x_{t+1} m_t^{*d} \right) \right]$$

Differentiating this expression with respect to m_t^{*d} yields as a first-order

condition for a maximum:

$$\frac{dW_t}{dm_t^{*d}} = \frac{-\lambda_t(\beta+\delta)}{\tilde{y}_t - \lambda_t(m_t^{*d} - m_{t-1}^{*d} x_t)} + \frac{\delta \beta \lambda_{t+1} (x_{t+1} - b_{t+1})}{\tilde{y}_{t+1} - \lambda_{t+1}(a_{t+1} + b_{t+1} m_t^{*d} - x_{t+1} m_t^{*d})} = 0 \tag{25}$$

Solving equation (25) for m_t^{*d}, one obtains

$$m_t^{*d} = \frac{\lambda_{t+1} \, \delta\beta (x_{t+1} - b_{t+1}) \tilde{y}_t - \lambda_t (\beta+\delta) \, (\tilde{y}_{t+1} - \lambda_{t+1} a_{t+1})}{\lambda_{t+1} \lambda_t \, (b_{t+1} - x_{t+1}) \, (\beta+\delta + \delta\beta)}$$

$$+ \frac{\delta\beta \, x_t}{\beta + \delta + \delta\beta} \, m_{t-1}^{*d} \tag{26}$$

Since an equivalent problem will be solved in period $t + 1$ one may set

$$b_{t+1} = \frac{\delta\beta \ x_{t+1}}{\beta + \ \delta+\delta\beta} \tag{27}$$

Substituting this expression into equation (26), it is found that

$$a_t = \frac{\lambda_t \ (\beta + \delta + \delta\beta)\tilde{y}_{t+1} - \lambda_{t+1}\delta\beta x_{t+1}\tilde{y}_t}{\lambda_{t+1} \ \lambda_t \ (\beta + \delta+\delta\beta)} + a_{t+1} \tag{28}$$

The steady state requires that

$$\tilde{y}_{t+1} = \tilde{y}_t = \tilde{y}, \ x_{t+1} = x_t = x, \ \lambda{t+1} = \lambda_t = \lambda, \ \text{and} \ m_t^{*d} = m^*$$

Inspection of equation (26) shows that the steady state is only compatible with

a finite demand for reserves if

$$x = \frac{\beta + \delta + \delta\beta}{\delta\beta} \tag{29}$$

or

$$\pi^* = \frac{(1+n) \ (\beta +\delta +\delta\beta)}{\delta\beta} \tag{30}$$

If the rate of return on foreign reserves exceeds this level, demand will

grow to infinity and conversely. Thus, in the long run the demand for

foreign reserves is perfectly elastic at the rate of return $\frac{(1+n) \ (\beta+\delta+\beta\delta \ )}{\delta\beta}$.

This rate of return will exceed the return on domestic money, which remains

$\frac{(1+n)}{\delta}$. Therefore a country in which the government maximizes the welfare

of only generations currently alive will not hold reserves unless the

return strictly exceeds the rate of return on domestic currency. The reason

is that an unborn generation, the younger generation in period t+1, will

share the return from an investment in reserves in period t with the younger

generation in period t. The myopic government weights only the second gain in

making its decision. Consequently, a higher rate of return is required for an

investment in reserves to appear worthwhile.

The Behavior of a Reserve Issuer

Consider now the behavior of a country which holds no foreign currencies, but which finds that foreign countries hold its currency as a reserve. It is assumed that this country takes foreign holdings of its own currency, m_i^f, as given in each period i. That is, when the government makes its taxation decision, other countries have made their past and contemporaneous reserve holding decisions. Because it raises a complicated, but very interesting, set of issues that lie beyond its scope, this paper ignores the possibility of a reputation effect whereby reserve holders' expectations of future inflation are determined by past performance. Rather, reserve holders form expectation of future inflation by calculating the optimal behavior of the reserve issuer each period.

Setting $m_i^{*d} = 0$ for all i in equation (17), the expression for inflation, given τ_t, becomes

$$\pi_t = \frac{(1+n_t)\left[(\beta + \tau_t)y_t - (1 + \beta)g_t + (1+\beta)m_t^f\right]}{\beta(1 - \tau_{t-1})y_{t-1} + (1 \div \beta) m_{t-1}^f} \tag{31}$$

Since equations (3) and (3") continue to define consumption in each period, the utility of an individual entering the labor force in period t is

$$U_t = k_t' + (1 + \beta)\ln(1 - \tau_t) - \beta\ln\left[\beta(1-\tau_t)y_t + (1 + \beta)m_t^f\right]$$
$$+ \beta\ln\left[(\beta + \tau_{t+1})y_{t+1} - (1 + \beta)g_{t+1} + (1 + \beta)m_{t+1}^f\right] \tag{32}$$

$$k_t' \equiv \ln\beta - (1 + \beta)\ln(1 + \beta) + \ln(1 + n_t).$$

Continuing to assume a government objective function of the form of equation (5), the first-order condition for an optimal tax rate τ_t is given by

$$\frac{dW_t}{d\tau_t} = w_{t-1}\frac{\beta y_t}{\Delta_{1t}} - w_t\frac{(1+\beta)}{(1-\tau_t)} + w_t\frac{\beta^2 y_t}{\Delta_{2t}} = 0 \tag{33}$$

$$\Delta_{1t} \equiv (\beta + \tau_t)y_t - (1+\beta)g_t + (1+\beta)m_t^f$$

$$\Delta_{2t} \equiv \beta(1-\tau_t)y_t + (1+\beta)m_t^f$$

Note that the solution to equation (33) involves only contemporaneous variables. The effect of an increase in contemporaneous money holdings, m_t^f, is given by

$$\frac{d\tau_t}{dm_t^f} = -\frac{\dfrac{d^2W_t}{d\tau_t\,dm_t^f}}{\dfrac{d^2W}{d\tau_t^2}} = -\frac{\left(1+\beta\right)\beta y_t\left(w_{t-1}\Delta_{2t}^2 + \beta w_t\Delta_{1t}^2\right)}{\beta y_t\left(w_{t-1}\Delta_{2t}^2 - \beta^2 w_t\Delta_{1t}^2\right) + \dfrac{w_t(1+\beta)\Delta_{1t}^2\Delta_{2t}^2}{(1-\tau_t)^2}} \tag{34}$$

which is negative: the domestic tax rate falls as foreign holdings of the domestic currency rise.

Consider now the effect of an increase in foreign holdings of domestic currency on the rate of return on currency. Given current holdings, m_t^f, an increase in the previous period's holdings, m_{t-1}^f, lowers π_t. This result is evident from inspection of expression (31). The effect of an increase in m_t^f, given m_{t-1}^f, is

$$\frac{d\pi_t}{dm_t^f} = \frac{(1 + n_t)y_t \dfrac{d\tau_t}{dm_t^f} + (1 + \beta)}{\Delta_{2t-1}} \tag{35}$$

which, incorporating expression (34), has the same sign as

$$(\beta + 2)(\beta - 1)\,\beta(1 - \tau_t)^2 y_t^2 + 2(1 + \beta)^2 \beta(1 - \tau_t)y_t m_t^f + (1 + \beta)^3\, m_t^f \tag{36}$$

This expression is negative if m_t^f is small and β is less than one. For large values of m_t^f, it is positive. Therefore, an increase in foreign reserve holdings has an ambiguous effect on the inflation rate that period.

Consider an increase in foreign reserve holdings in period t from a level of zero to some positive permanent level, $\bar{m}^f$. The effect on π_t on impact is given by the sign of expression (36). The effect on π_i, $i > t$, assuming constant values of y_t and g_t, is given by

$$\frac{d\pi}{dm^f} = \frac{(1 + n_t)(1 + \beta)\left\{[\beta y + g + (1 + \beta)m^f]\dfrac{d\tau}{dm^f - \tau}\right\}}{\Delta_2^2} \tag{37}$$

which is necessarily negative. This result establishes the following proposition

Proposition 1: A permanent increase in foreign holdings of domestic currency lowers the rate of return on the currency (i.e., raises the inflation rate) in the steady state.

All new foreign holders of the domestic currency will earn the new steady state rate of return on that currency, since increased holdings in period t raise π_{t+1} to the new steady state level. During period t in which new reserves are acquired, however, the rate of return will never fall by as much as the steady-state change and may even rise. A permanent increase in reserves held abroad will consequently increase the permanent inflation rate, though it may initially lower the inflation rate.

III. Multi-country Equilibrium

Consider a world in which there are two types of countries, type I and type II. Each type of country can be characterized by a steady state inflation rate that would obtain under reserve autarky $\left(\pi_j^A, \quad j = I, II \right)$ and a rate $\bar{\pi}_j$ at which the long-run demand for foreign reserves is infinitely elastic. It is assumed that $\pi_I^A < \pi_{II}^A$; that is, type I countries have higher inflation under autarky, and that $\bar{\pi}_I < \pi_{II}^A$; that is, type I countries demand reserves at a rate of return below the autarky rate of return on type II currency.[3]

This section considers how the introduction of internationally held currencies will change the steady state of the world economy. It focuses first on two extreme cases, one in which reserves cannot be held in negative amounts and one in which reserves cannot be held in positive amounts. The first case corresponds to one in which loans are denominated in the borrower's currency and the second to one in which they are denominated in the lender's currency. While the model does not preclude a priori the possibility of two-way transfers of reserves, attention will focus only on steady states in which net and gross reserve positions are identical.

Nonnegative Reserves

The following proposition can now be established:

Proposition 2: In a steady state in which foreign reserves are held at a positive, finite level, (i) type II (low-inflation) currency will be held by type I (high-inflation) countries as a reserve, and (ii) the rate of return on type II currency will fall to $\bar{\pi}_I$.

If the weights attached to future generations by each government

decline geometrically--so that $\pi_j^A = \bar{\pi}_j$, $j = I$, II--then the inflation rate

in type I countries does not change, while the inflation rate in type II

countries will rise to $-\pi_I^A$. Thus, while under autarky $\pi_I^A = \frac{(1+n)}{\delta^I}$, $\pi_{II}^A = \frac{(1+n)}{\delta^{II}}$

(from equation (10)), when reserve holdings are allowed, $\pi_I^R = \pi_{II}^R = \frac{1+n}{\delta^I}$;

introducing reserves has raised inflation everywhere to the level in the

high-inflation countries. The superscript R denotes steady-state rates

of return when international lending takes place. The reason is that type I

countries find type II currencies attractive at their autarky inflation

rates. An excess demand for these currencies will exist until the inflation

rate is driven up to the level in type II countries. As type I countries

accumulate reserves, the increased reserves provide an incentive for

type II countries to inflate at a higher rate, imposing an inflation

tax on type I countries. Since the welfare of foreign holders of its

currency, as opposed to domestic holders, does not enter the reserve

issuers' objective functions, they are less constrained to maintain

low inflation rates.

The case in which $\pi_j > \pi_j^A$ for $j = I$ or $j = II$ is slightly more

complicated. If, say, $\pi_I^A < \pi_I < \pi_{II}^A$, then, again, type II countries

will issue reserves to type I countries. In the new steady state, $\pi_{II}^R = \bar{\pi}_I$.

Again, becoming reserve currency issuers has raised inflation rates in

.type II countries, but not as high as the autarky inflation rate in type I

countries. Type II countries will again experience strictly higher

inflation rates in the new steady state.

These results suggest how introducing liabilities denominated in the

borrower's currency can create more inflation in the world economy. The welfare

implications of introducing international reserves can be analyzed in terms
of our model. This paper will not attempt a thorough discussion but will
make the following points:

(1) In a steady state with finite reserves, type I (high-inflation,
reserve-holding) countries have as an additional source of government
revenue an amount $\lambda \hat{m}^{*d} [\bar{\pi}_I (1+n)^{-1} - 1]$ per worker where $\hat{m}^{*d}$ denotes
steady-state reserve holdings. When $w_i = \rho^{t+1} w_t$ $i > 0$, this amount
equals $\lambda m^* (\frac{1-\delta^I}{\delta^I})$ and when $w_i = 0$ $(i \neq t-1, t)$, it equals $\lambda m^* (\frac{\beta + \delta^I}{\beta \delta^I})$.
Taxes are lower and the rate of return on currency has not changed:
The representative individual in type I countries is better off in
the <u>steady</u> <u>state</u>. (Here δ^I denotes type I countries' value of δ.)

(2) In a steady state with finite reserves, type II (low-inflation,
reserve-issuing) countries transfer an amount $m^f [1 - \pi^* (1+n)^{-1}]$ to type
I countries each period. The representative individual in type II
countries can be worse off in the steady state because the rate of
return on his savings has declined.

(3) The older generation in the period in which reserves are
<u>acquired</u> in the reserve holding countries suffers from the transition.
The rate of return on their money holdings is lower than under autarky.
(This result may be seen by setting $m^{*d}_{t-1} = 0$ in equation (18) and
observing the effect of increasing m^{*d}_t on π_t in equation (20).)

(4) The younger generation in the period in which reserves are
<u>issued</u> by the reserve currency country benefits from lower taxes in that
period but experiences a lower return on savings in the subsequent period.
The net effect on welfare is therefore ambiguous.

(5) The effect of the transition on the older generation in the
reserve-issuing country is ambiguous, depending whether π_t rises or falls
as a consequence of issuing reserves.

Thus, the long-run effect of a move from reserve autarky to trade in currencies raises steady-state welfare in the reserve-holding countries but can lower steady-state welfare in the issuing countries. The effects during the transition, however, may go in the opposite direction.

One remaining question is how much currency of a typical type II country will be held abroad at the point where the rate of return on that country's currency equals $\bar{\pi}_I$. If all type II countries are identical in all respects except relative population size each type II country will have the same <u>per worker</u> money stock held abroad as a reserve currency in the reserve equilibrium. The contribution of each type II country to total international reserves will therefore be proportional to that country's population.

Nonpositive Reserves

The following proposition can also be established:

<u>Proposition</u> 3: In any steady state in which international borrowing takes the form of issuing <u>foreign</u>-currency-denominated liabilities at a finite, positive level, (i) type II (low-inflation) countries will borrow from type I (high-inflation) countries, and (ii) the rate of return type I currency will rise to $\bar{\pi}_{II}$.

Consider first the case in which $\bar{\pi}_j = \pi_j^A$, j = I, II. If type II countries can issue liabilities denominated in type I currency, they will do so until π_I rises to π_{II}^A. Thus, when positive, rather than negative, reserve holdings are precluded, international financial integration reduces, rather than increases, inflation. The reason is that when countries <u>lend</u> in their own currency, rather than borrow by issuing reserves denominated in their own currency, their

governments have an incentive to reduce, rather than to increase, their inflation rates.

The welfare effects of international financial integration when borrowing is foreign-currency denominated, both on impact and in the steady state, can be analyzed as well. The effects are substantially similar, so that issue will not be discussed here.

Relaxing the Nonegativity Constraints

If no constraint is imposed on the sign of reserve issue our model admits an infinite number of solutions. While borrowing in both domestic and foreign currency denominated assets occurs in international financial markets, the possibility of outright default may place an upper bound on the extent to which foreign currency denominated borrowing occurs. Default on such liabilities can occur without affecting the value of domestic agents' savings. As long as currency is internationally mobile, default on domestic currency held abroad could only occur if domestic households were defaulted upon as well. This ramification is likely to limit the incentive of a national government to default on its domestic currency or to destroy its value through inflation.

Introducing a Nominal Interest Rate on Borrowing

It has been assumed that money pays a zero nominal rate of return. Introducing a nonzero nominal interest rate would not affect the results, except that the inflation rate would equal the nominal rate minus the real rate of return derived here. Whatever nominal return a reserve issuer offers its creditors ex ante, it determines the real rate of return ex post through its inflation policy.

IV. Possible Extensions

This paper has developed a model for analyzing the effects of introducing reserve currencies on inflation and welfare in the world economy. In order to obtain concrete results the analysis has been kept very simple. We conclude with a discussion of some issues that we believe are of considerable interest that could be analyzed in terms of the framework we develop here.

Non-Bernoulli Preferences

The assumption of the model that utility is logarithmic in consumption levels leads to savings behavior and private currency demand that is independent of the rate of return on the currency. The analysis is enormously simplified by this assumption. Alternative specifications would lead to much more complicated responses to alternative policies. In particular, the effect of expectations of future policy on the current private demand for currency would have to be incorporated into the model. Introducing non-Bernoulli preferences would consequently introduce a much richer set of dynamics as well as an additional source of potential time inconsistency of optimal policy.

Distortionary Taxation

Our model assumes that the government has access to proportional income taxes as a means of raising government revenue. Since income is exogenous in our model, such taxes are nondistortionary. If taxes do, in fact, impose an excess burden, then an additional role for seigniorage arises, as an alternative distortionary source of revenue. Differences in autarky inflation rates may then reflect differenct financing needs among countries as well as different valuations of generations by governments. The role of seigniorage as a form of optimal taxation in an open

economy has been analyzed in a small, open economy context by Calvo (1978) and Eaton (1982), but the role of reserves in redistributing tax burdens internationally has yet to be studied.

Default Risk

Our model does not introduce formally the possibility of outright default on foreign debt. The issue of default has by now been investigated extensively. See, for example Eaton and Gersovitz (1981a, 1981b), Sachs and Cohen (1982), or Kletzer (1982). One topic of potential interest would be to integrate analytic models of default into our paper's framework here. As suggested earlier, one important issue that such research might shed light upon is the currency of denomination of international debt.

Productive Capital

No role for productive capital exists in the model. The effects of international capital market integration on the allocation of capital has been analyzed in a nonmonetary overlapping generations model by Buiter (1981). It would be of considerable interest to investigate how the monetary phenomena considered here would interact with the international allocation of capital in the steady state. In particular, it would be interesting to determine to what extent the trading of monetary assets can substitute for trade in physical capital.

Uncertainty

Our model assumes perfect certainty. Introducing uncertainty about future values of exogenous variables would provide insight into a

number of issues. For example, the effects on uncertainty on the rates
of return of alternative currencies could be examined. Optimal reserve
portfolios could then be characterized, which could presumably include
more than one reserve held simultaneously. The role of government policy
in redistributing risk between generations domestically and the role of
reserves in reallocating risk internationally could be examined. Lapan
and Enders (1980), Aizenman (1981), and Eaton (1982) have considered the
implications of alternative exchange rate regimes for the international
allocation of risk. The implications of their analysis for reserve
positions in a multicountry context have yet to be drawn out.

Strategic Behavior

In our model governments make decisions taking other countries'
inflation rates and reserve positions as given. While this assumption
can be justified in a competitive context in which the numbers of countries
of different types are large, it is less appropriate in a world where some
countries are unique in their relevant characteristics. One possibility
is that strategic competition among potential reserve issuers will arise. The
country which is most successful at establishing a reputation as providing
a high and stable return on currency might then emerge as the sole reserve
issuer.

V. Conclusion

The major conclusions of our analysis can be summarized in the following points:

(1) Under financial autarky, inflation rates in different countries can be explained by their monetary authorities' attitudes toward the welfare of the younger and older generations. The problem of time consistency may yield an inflation rate that is not optimal.

(2) A government's demand for a foreign currency as a reserve in the long run may be infinitely elastic at a rate of return that is equal to or higher than the rate of return on that country's currency. Holding a foreign currency as a reserve does not affect the steady-state inflation rate of the reserve holder.

(3) The steady-state inflation rate of a country increases when foreign demand for that country's currency as a reserve rises to a higher permanent level.

(4) Trade in borrower-currency-denominated assets raises the average steady-state world inflation rate, while trade in lender-currency-denominated assets has the opposite effect.

(5) Trade in assets raises steady-state lifetime welfare in reserve-holding countries but can lower it in reserve-issuing countries, although the effect on the welfare of generations alive during the transition from autarky to the new steady state may be reversed. Governments may therefore be justified in acting to prevent their currencies' use as international reserves.

FOOTNOTES

[1]/ Recently, Townsend (1980) has shown that the exact consumption loan specification can be generated by a much larger class of transactions technologies than that suggested by the Samuelson model and subsequent literature.

[2]/ More generally, as Kareken and Wallace (1981) have pointed out, the multicountry model of the type we are dealing with is characterized by multiple equilibria. The paper restricts its attention to equilibria in which gross and net reserve positions are equal, and in which there is either a nonnegativity constraint or nonpositivity constrain on reserve positions. These restrictions identify a unique steady-state equilibrium.

[3]/ Recall from the first subsection of Section I that when weights on the utilities of each generation in the government's objective function in period t are of the form $w_{t+i} = \rho^i w_t$ for all t and i then $\bar{\pi}_j = \pi_j^A$; while if $w_i = 0$, $i \neq t$, t-1, then $\bar{\pi}_j > \pi_j^A$.

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