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Currency Switch and the Choice of an
International Reserve Currency

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Abstract

This paper explains why sovereign issuers of reserve currencies do not use unexpected inflation to repudiate their foreign liabilities. Monetary restraint is exercised because of the fear that reserve users will switch to other currencies if an attempt is made to raise "excessive" revenue. By the same reasoning, capital flight can serve as a deterrent to excessive money creation. It is shown that even without policy precommitment or aversion to inflation, the availability of alternative currencies can support an equilibrium with a finite, time consistent inflation rate.

Contents Page

Summary

Changes in the inflation rate can influence the allocation of resources and the distribution of wealth. In an open economy, a movement in the inflation rate (or the exchange rate) may affect the real value of nominal international assets, especially when hedging opportunities are not available. A country whose currency is used as an international "vehicle" may be tempted to use inflation to decrease the value of its outstanding liabilities (reserve money).

This paper explains how reserve currencies are chosen and why sovereign issuers of these currencies in fact refrain from using inflation to repudiate their foreign liabilities. Inspiring this restraint by monetary authorities is a fear that foreigners holding the reserve currency will switch to other currencies if the monetary authorities attempt to raise excessive revenue through inflation (which will deprive them of valuable seigniorage in the future). The paper shows that even in the absence of other concerns about inflation (such as stabilization), the availability of competing currencies can impose monetary discipline that leads to a finite, time-consistent inflation rate.

An additional implication of this analysis is that capital flight essentially constitutes a currency switch and hence potentially serves as a deterrent to excessive money creation.

I. Introduction

It is well recognized that the use of a currency as an international reserve and currency of denomination of international assets can affect the conduct of monetary policy in the reserve issuing country because of inflation (capital) tax revenue considerations. In general, a country whose national currency is used as a "vehicle" in international transactions can extract resources from the rest of the world by inducing changes in the real value of her outstanding assets via nominal price changes. This incentive to redistribute world wealth has been analyzed, by, among others, Mundell (1971), Calvo (1978), Buiter and Eaton (1983), Dellas (1988a, 1988b, 1989). If policies for all periods are chosen at one point in time and no policy revisions are allowed (perfect pre-commitment), the optimal revenue maximizing inflation (deflation) rate is finite and uniquely determined by the net asset position of the reserve issuer. If, however, precommitment technology is unavailable, optimal policies may be time inconsistent and subsequently infeasible. What lies behind time inconsistency in this context is the fact that money (and in general nominal assets) is a durable good whose ex post return can be manipulated by monetary authorities. Notice that in an environment with rational expectations, reserve holders fully understand the nature of the reserve issuer's optimal strategies and attempt to avoid paying excessive inflation tax by changing the level of their international asset holdings. The time consistent solution to this noncooperative Nash game is the so-called "discretionary solution" and is suboptimal for all players.

In this paper we analyze the endogenous determination of a reserve ("vehicle") currency in an optimal seigniorage without policy precommitment setup. While it is true that official entities hold interest bearing foreign assets exclusively (whose value is not affected by anticipated inflation), our analysis is still applicable to the real world, as private citizens seem to hold substantial amounts of foreign currency. 1/ Our results shed light to the important issue of why sovereign issuers of international nominal assets do not use inflation to repudiate their foreign liabilities (or try to induce capital gains on their assets), and why the inflation rates on the major international currencies are low relative to the seigniorage/capital gains opportunities that are seemingly available. Unlike the Barro-Gordon (1983) model which relies on domestic policy considerations (like aversion to inflation) to set bounds on the choice of the inflation rate (see Dellas 1989), our model achieves inflationary restraint on international currencies by

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1/ A study published in the Federal Reserve Bulletin (March 1987, pp. 190-1) reported that more than 88 percent of the U.S. currency stock circulating outside banks was "missing"; that is, it could not be accounted for by purposes related to measured domestic activity. According to the same study, there exists anecdotal evidence suggesting that the amount of U.S. cash held abroad may be large, but no quantitative information is available.

allowing for <u>competition</u> among reserve issuers. The resulting equilibrium entails a finite, time consistent inflation rate and it features an implicit contract between reserve users and the reserve issuer that has the users pay the issuer a rent in the form of seigniorage. We also show that countries whose policymakers have a low rate of time discount are more likely to win such reserve issuing contracts.

We assume that assets are nominal and can be denominated in any currency; that no particular country or currency is unique in its characteristics so that the initial choice of the "vehicle" is random 1/ (since all national monies are perfect substitutes). However, we allow countries to <u>switch</u> reserve currency if the reserve issuer attempts to raise "excessive" inflation revenue. 2/ The value of the inflation revenue that triggers a switch may be exogenously determined as an implicit inflation tax payment (rent) the reserve user voluntarily makes to the reserve issuer (by holding that currency) to eliminate the incentive for monetary surprises. A currency, once dropped as a reserve, can never be chosen again; that is, there is a complete loss of credibility associated with inflation outbursts that can not be restored, (the punishment interval is of infinite length).

In an environment without policy precommitment we show the following: (a) If countries can freely and without cost switch between alternative "vehicle" currencies, there may exist a finite dynamically consistent solution which can be implemented as follows. The reserve user chooses a critical value of inflation revenue (inflation "tolerance" level) and (implicitly) "threatens" that he will switch reserve currency if the inflation revenue exceeds this non-zero threshold value. The proper selection of the inflation "tolerance" level deters the reserve issuer from choosing his optimal discretionary rate of inflation, so that the resulting (finite) inflation rate is time consistent. 3/ This scheme essentially amounts to having reserve users pay rent (royalties) for using

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1/ Dellas (1989) presents an explicit theoretical analysis of reserve choice in a Barro-Gordon type of economic environment where trade facilitation and portfolio considerations are the primary motives for holding reserves.

2/ The partial currency switch in favor of the German and Japanese currencies that started in the 1970s seems to have been a result of concerns about excessive seigniorage payments on the U.S. dollar.

3/ One can interpret this model as a principal-agent problem. The principal (the reserve user) can exert only indirect control over the actions of the agent (the reserve issuer) and he does so through the design of the payoff schedule. The payoff schedule is a self-enforcing implicit contract whose main characteristic is the threat of <u>terminating</u> the relationship (i.e., switching reserve currency).

a reserve currency, and it is welfare improving 1/ for both parties.
(b) If the cost of switching is non-zero but finite, again there may
exist a time consistent solution for the inflation rate which is either
identical to the solution in case (a) or corresponds to the cost of
switching.

The equilibrium inflation rate turns out to depend on the discount
rate of the reserve user. The lower the discount rate the lower the
inflation rate will be. Consequently, the optimal-seigniorage paradigm
without policy precommitment predicts that currencies of low rate of
discount countries will be sought as reserve currencies and currencies of
denomination of international assets. (This seems to be consistent with
the empirical evidence).

Our analysis has also implications for the choice of the monetary
environment in a closed economy. If the source of dynamic inconsistency
is the monopoly power of central banks in insuring money, then the
introduction of private monies or the circulation of foreign currencies,
by increasing competition among money suppliers, can serve as an
alternative to policy precommitment for restraining monetary authorities
and for removing time inconsistency. It may be the case that the threat
of capital flight (currency switch) has deterred governments from adopting
even more inflationary monetary policies in the Latin American countries.
If private monies are perfect substitutes, they should bear the same rate
of return. Our analysis shows how this common rate is determined.

II. The Model

Let us assume that all international transactions must be denominated
in a common "vehicle" currency; that no interest bearing assets exist, and
the only means of transferring resources over time is the reserve money;
that there is a large number of countries with a representative reserve
issuer and a representative reserve user.

A country desiring to adopt a foreign reserve currency faces the
following maximization problem:

$$(1) \quad V\left(\frac{M_t}{P_t}, X_t\right) = \max_{C_t, M_{t+1}} \left[U(C_t) + W\left(\frac{M_{t+1}}{P_t}\right) + \beta E_t V\left(\frac{M_{t+1}}{P_{t+1}}, X_{t+1}\right) \right]$$

1/ There are reasons that make holding of positive real balances
desirable for the reserve user. First, real balances enter the utility
function and hence provide direct utility services. Second, money in this
paper is the only store of value, so it enables people to choose a
smoother consumption profile. For these reasons the reserve user will
have an incentive to implement this scheme. It is also beneficial to the
reserve issuer because, by construction, it guarantees the maximum
possible inflation revenue.

subject to

$$(2) \qquad X_t + \frac{M_t}{P_t} = C_t + \frac{M_{t+1}}{P_t}$$

where M_t is the beginning of period t amount of reserves, M_{t+1} is the end of period t reserves, P_t is the nominal price level, C_t is consumption, X_t is a nonstorable endowment good which is the same across countries and whose arrival follows a normal distribution with mean X. The shocks to the endowment are independently distributed over time and across countries. E_t is the expectations operator in period t, V is the value function, β is the discount factor, and U and W are the subutility functions. The first order conditions are

$$(3a) \qquad U'_t = \lambda_t$$

$$(3b) \qquad \frac{1}{P_t} W'_t + \beta E_t V' \frac{1}{P_{t+1}} = \frac{\lambda_t}{P_t}$$

where

$$U'_t = \frac{\partial U(C_t)}{\partial C_t} \quad, \quad V' = \frac{\partial V(\frac{M_{t+1}}{P_{t+1}})}{\partial (\frac{M_{t+1}}{P_{t+1}})} \quad, \quad W' = \frac{\partial W}{\partial (\frac{M_{t+1}}{P_t})}$$

and λ is the Lagrange multiplier.

Combining equations (3a) and (3b) and using the envelope theorem for V' we have

$$(4) \qquad W'_t + \beta E_t U'_{t+1} \frac{P_t}{P_{t+1}} = U'_t$$

Condition equation (4) states that along an optimal path, the utility cost of obtaining \$1.00 at time t must equal the utility gain from holding that dollar for a period and converting it back into expected consumption in period t+1.

The derived demand functions are

$$C_t = C(E_t \frac{P_t}{P_{t+1}}, X_t) \qquad \frac{M_{t+1}}{P_t} = f(E_t \frac{P_t}{P_{t+1}}, X_t)$$
$$\quad\;\;(-)\quad\;(+) \qquad\qquad\qquad\qquad (+)\quad\;(+)$$

where the signs in parentheses are the signs of the derivatives of the demand functions.

By imposing the standard Inada conditions on the utility function we have that

$$(5) \qquad \lim(\frac{M_{t+1}}{P_t}) > 0 \text{ as } E_t P_{t+1} \rightarrow \infty$$

Equation (5) says the people hold money even when the expected return to money (savings) becomes zero. This is due to the fact that money enters the utility function and hence provides a flow of utility services. The equilibrium real money stock in the period before the expected price level becomes infinite satisfies $U'_t = W'_t$.

In the following analysis we will make an informational assumption that precludes the immediate adjustment of real balances that would eliminate all opportunities for surprise seigniorage and hence the time consistency problem. We will assume that the price expectation in period t is conditioned on the previous period's price level, P_{t-1} (that is, P_t is not observable when EP_{t+1} is formed).

Let us now turn to the behavior of the country that issues M. The inflation tax revenue (seigniorage) in period t is $R_t = (M_{t+1} - M_t)/P_t$. Substituting from the demand for money we get (abstracting from output effects)

$$(6') \qquad R_t = f[E_t(P_t/P_{t+1}) - f[E_{t-1}(P_{t-1}/P_t)] (P_{t-1}/P_t)$$

The informational assumption we made earlier implies that the two expectations in equation (6') are equal so 1/

$$(6) \qquad R_t = m_t \cdot (1 - P_{t-1}/P_t) = m_t \cdot \pi_t$$

where

$$m_t = (M_{t+1}/P_t) \quad \text{and} \quad \pi_t = (1 - P_{t-1}/P_t)$$

The reserve issuer maximizes the expected value of inflation tax revenue

$$(7) \qquad G(m_t) = \max_{\pi_t} [\pi_t m_t + \delta E_t G (m_{t+1})]$$

(8) subject to $M_{t+i} = 0$, $i = 1, 2, \ldots$ if $R_{t-1} = \pi_{t-1} \cdot m_{t-1} > n$

where G is the value function, δ is the discount factor, R is the inflation tax revenue and $n\epsilon[0, \infty]$ represents the cost of switching reserve currency for the reserve user. One can think of n as an initial investment in information collection about new "vehicle" currencies, the cost of changing the unit of account, or it may represent a fixed cost of entry for other potential reserve issuers, etc. It can be time dependent as these costs can vary over time.

According to equation (8), a reserve user will switch currency in period t (that is $M_{t+1} = 0$) when the current reserve issuer raised "excessive" inflation revenue in period t-1 by choosing a high P_{t-1}. When this is perceived (in period t), it triggers a complete collapse of the issuer's reputation that is unrestorable, and the reserve issuer loses all future inflation tax collections.

Let us first consider the determination of the inflation rate with policy precommitment. There are two possibilities depending on whether price competition among potential reserve sellers is allowed or not. Suppose that the potential reserve users randomly select a currency while

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1/ Note that this definition of inflation is positively correlated, but differs from the conventional definition $(P_{t+1} - P_t)/P_t$; and that it approaches an upper board of unity on the conventionally defined measures becomes infinite. Obstfeld (1988) has employed the same definition.

at the same time, reserve sellers do not attempt to induce a new selection by offering price (inflation rent) discounts. This equilibrium can be sustainable if the cost of contracting the reserve buyers after the initial selection is made exceeds the discounted sum of future inflation revenues (net of switching costs); or if potential reserve suppliers sign a binding agreement of no price wars before the lottery draw that determines the reserve currency takes place. Notice that in this situation switching takes place if and only if the inflation revenue in any period exceeds the cost of switching.

Suppose that the current reserve user can precommit his future actions in the sense that promises made in period t-1 about monetary policy to be followed in period t are always honored. Since the planning horizon of the representative reserve user is one period (because of the nature of the stochastic process which characterizes the arrival of the *nonstorable endowments*), *a one-period precommitment suffices to remove* dynamic inconsistency. Let $_{t-1}\pi_t$ be the optimal inflation rate for period t when the choice is made in period t-1. Under rational expectations, $_{t-1}\pi_t$ maximizes the inflation revenue function $_{t-1}\pi_t \cdot m(_{t-1}\pi_t) = {}_{t-1}\pi_t \cdot m(_{t-1}\pi_t)$. The precommitted inflation rate 1/ is $\pi_t = \min[_{t-1}\pi_t, \pi_t(n)]$ where $\pi_t(n)$ solves $\pi_t(n) \cdot m_{t-1}(n) = n$; that is the reserve issuer will choose $\pi_t = {}_{t-1}\pi_t$ to maximize expected inflation revenue, unless $_{t-1}\pi_t$ is not feasible because it violates that inflation revenue threshold value i.e., $_{t-1}\pi_t \cdot m(_{t-1}\pi_t) > n$.

If n = 0, the reserve issuer does not have any incentive to agree on a monetary policy rule as the reserve user switches currency with nonzero inflation rates. If however, real balances are--as we have assumed in equation (1)--valuable, the reserve user will agree to pay a positive inflation tax so he can lure the reserve issuer into adopting a precommitted monetary policy. The inflation rate will be bounded between zero (only the reserve user benefits) and $_{t-1}\pi_t$ (the reserve issuer maximizes expected revenue). Its exact value is indeterminate.

Now assume that reserve issuing countries can without cost engage in price competition, that is, they can offer "inflation revenue discounts" to attract reserve issuers, either before or after the initial selection has been made. Then the only feasible inflation rate is $\pi_t = {}_{t-1}\pi_t = 0$. This is due to the fact that if $\pi_t = b > 0$ the inflation revenue collection is positive, so there are profits to be made by entering the reserve issuance market and offering $0 < \pi_t < b$. Since the only criterion reserve buyers use in selecting the reserve currency is the return on money ($-\pi_t$) a currency with $\pi_t < b$ will always be chosen over one with $\pi_t = b$. This argument applies to any b > 0, subsequently the only inflation rate that discourages further price competition is $\pi_t = 0$.

1/ m_t depends also on income X_t, so n is a function of X_t. However, to focus on the game theoretic aspects of the model we have found useful for simplification purposes to assume that $X_t = X$, t = 0, 1, 2, ... for the remaining of the paper. See footnote 1 on page 14 for the more general case.

In the absence of policy precommitment, strategic price competition is no longer an issue because offers of inflation tax discounts are not credible. Switching will only take place when there is a violation of the inflation "tolerance" level.

Let me briefly describe some elements of the game. No collusion between money users is necessary. They can all switch currency simultaneously because they are identical, but this does not require strategic collusive behavior by individual users. It only requires that each atomistic holder of international reserves has a decision rule (derived from utility maximization) which states that he seeks an alternative currency when the currently observed inflation rate exceeds some critical value. The derivation of the critical value is based on knowledge of the objective function of the reserve issuer (the discount rate).

The inflation rate π is not a monotonic function of n in the interval $[0,\infty]$ so we need consider three special cases.

1. <u>Case A: n = 0</u>

If n = 0, countries can without cost switch currencies. Obviously $\pi_t = 0$ is time inconsistent because $R(\pi = 0) = 0$, while the revenue from choosing $\pi_t > 0$ is always positive. We will argue that a time consistent solution with $1 > \pi_t > 0$ exists if the reserve user properly chooses an inflation "tolerance" level $K = \pi_t(K) \cdot m_t(K)$ and announces that he will switch foreign reserve currency if the inflation revenue raised in any period exceeds K. This announcement deters the reserve issuer from reverting to discretionary policies.

<u>Proposition I</u>: The optimal choice of $K = \pi_t(K) \cdot m_t(K)$ satisfies $\pi(K) = 1 - \delta$.

To prove this we need compare the revenues of the reserve issuer when he chooses $\pi_t = \pi(K)$ versus $\pi_t \neq \pi(K)$. First note that $\pi_t = \pi < \pi(K)$ is time inconsistent because if people expect π and hold $m(\pi)$, the reserve issuer can raise his revenue by choosing $\pi(K)$ since $\pi(K) \cdot m(\pi) > \pi \cdot m(\pi)$ (and no currency switch takes place). Consequently, rational individuals will never expect the inflation rate to be less than $\pi(K)$ and it will never pay the reserve user to choose $\pi < \pi(K)$. On the other hand, the total inflation revenue from choosing $\pi > \pi(K)$ when people expect $\pi(K)$ is $R_1 = m(K)$, because given m(K), the revenue maximizing value of inflation is $\pi_t = 1$. Since countries switch currency after a violation takes place, the foregone inflation revenue is $R_2 = \Sigma \delta^t \pi(K) \cdot m(K) = [1/(1-\delta)]\pi(K) \cdot m(K)$.

If $\pi(K) > 1-\delta$, then $R_2 > R_1$ and it never pays to exceed the revenue "tolerance" level. 1/ This concludes the proof of Proposition I.

Notice that our solution for the optimal inflation rate depends only on the discount rate of the monetary authorities. The more they care about future seigniorage opportunities (the higher δ), the lower the equilibrium inflation rate, and hence the higher the probability that this particular currency will be chosen as a reserve.

One can interpret $\pi(K) \cdot m(K)$ as the rent (royalty) reserve users have to pay for the use of currency. However, we need consider whether such a rent payment scheme is feasible in the sense that its implementation does not reduce welfare in either country.

The only two sustainable (time consistent) equilibria in this model are $\pi = 1$ and $\pi(K)$. While $\pi = 1$ remains an option the reserve issuer can exercise any time, we have shown that any $\pi > \pi(K)$ and consequently $1 = \max \pi$ is inferior to $\pi(K)$ for the reserve issuer. Hence to maximize his revenue subject to the currency switch threat he will always choose $\pi(K)$.

To determine whether the reserve user prefers $m(K)$ to $m(1)$ we need establish that his steady state level of utility is a decreasing function of the rate of inflation. Using the budget constraint (equation (2)) and denoting the constant levels of consumption and real balances as c and m respectively, we have

$$ c = X + \frac{M_t}{P_t} - \frac{M_{t+1}}{P_{t+1}} = X - p \cdot m \text{ where } p = \frac{P_{t+1} - P_t}{P_t}. $$

An interior solution is depicted in Figure I. It is obvious that an increase in the rate of inflation rotates the budget constraints at $c = X$ inward, leading to lower welfare (because, unlike the foreign residents, the domestic individuals do not receive any compensating monetary transfers). Since we have ruled out corner solutions (see equation (5)), $m(K)$ (point A) is preferred to $m(1)$ (point B).

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1/ If $X_t \sim N(X, \sigma^2)$ $t = 0,1,2,\ldots$ the time consistent solution is $\pi_t(n, X_t)$: $\pi(n_t, X_t) \cdot m(n_t, X_t) = n_t (X_t)$. Now suppose that in period t we have a high realization of X_t, say $X^h > X$ so that $m(n, X^h) > m(n, X^h)$. The gain from choosing $\pi_t = 1$ is $m(n_t, X^h) > m(n, X)$, while the expected loss due to the switch is $[1/(1-\delta)] E_t \pi (n, X) \cdot m(n, X)$. Then the condition for $\pi(n_t, X_t)$ to be finite is to choose n so that $\pi(n) > (1-\delta) \cdot e$ where $e = m(n, \max X_t)/m(n, X)$, $e > 1$ and $\max X_t$ is the highest possible realization of X_t.

2. Case B: $0 < n < \infty$

Proposition II: If $0 < n < \infty$ the time consistent solution for the inflation rate satisfies $\pi_t \cdot m_t = \max [n, K]$ where $\pi(K)$ was defined in Case A above.

Proof: As argued earlier (Case A), $\pi(n)$ may or may not be time consistent depending on whether $\pi(n) > 1-\delta$ or not. If $\pi(n) < 1-\delta$, then $n < K$ and the rent implied by the choice of $\pi(n)$ is not sufficient to remove the reserve issuer's incentive to engage in monetary surprises (because $R_1(n)$ $R_2(n)$). In this case, the reserve user has to raise the value of his inflation revenue threshold to $\pi(K) \cdot m(K) > \pi(n) \cdot m(n)$. By construction $\pi(K)$ is time consistent. On the other hand, if $n > K$, $\pi(K)$ is not time consistent because it generates less revenue than $\pi(n)$ and a departure from $\pi(K)$ does not cause a switch in reserve currency. However, $\pi(n)$ is time consistent because since $n > K$ it still pays enough rent to discourage the reserve issuer from exceeding $\pi(n)$.
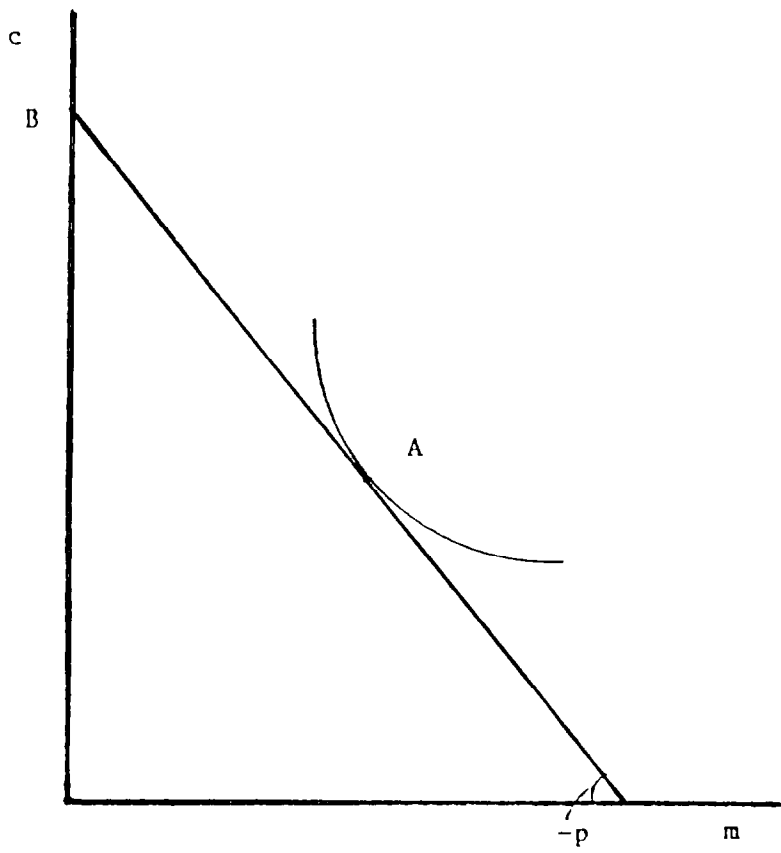
3. Case C: $n = \infty$

This is the case analyzed by Calvo (1978) who showed that no finite time consistent solution for inflation exists.

Before proceeding to summarize our results, it is worthwhile making a few more points. First the assumption of the existence of a large number of potential reserve issuers is not necessary. We can still get the same results even with only two if we prohibit collusive behavior. Second, if the source of time inconsistency in a closed economy is the monopoly power of central banks, the introduction of currency competition will solve this problem. This can be accomplished by either allowing for private monies or permitting the use of foreign currencies in domestic transactions. Third, one can generalize our model to allow for the holding of more than one currency. While this can be accomplished by including more monies in the utility function (equation (1)), a more meaningful way would be to require a flexible cash in advance constraint that could capture both the facilitation of trade and portfolio aspects of holding international reserves. Such a set up could allow us to consider partial currency switches, to express the cost of switching in terms of liquidity and trade parameters, etc. However, we find it unlikely that substantially new results about the properties of the equilibrium inflation rates would emerge.

III. Conclusion

As is well known, a country whose currency is used in international transactions (valued by the rest of the world) has an incentive to engage in unanticipated monetary policies that decrease the real value of this country's liabilities. In a rational expectations environment such incentives are immediately recognized by everybody with the result that

Figure 1

time consistent policies associated with a finite price level may not exist. In this paper we have examined how this standard dynamic inconsistency issue is related to market structure in the context of the choice of international reserve currencies. We argued that dynamically consistent monetary policies with a finite price level exist if countries can freely switch between alternative reserve currencies when they find current inflation rates on reserves excessive. The key to this is that reserve users choose to remove any incentive for "surprises" by paying enough rent to the reserve issuer. This scheme is feasible because it is welfare improving for both parties and it is self enforced. Our model can then explain why international "vehicle" currency issuers do not use inflation to repudiate their debts even when neither precommitment technology nor aversion towards inflation on the part of policymakers are present. Time consistent policies may remain available even when switching is not completely without cost. When switching costs become infinitely large, a situation identified with the existence of a perfect monopoly in reserve currency issuance, time consistent policies with a finite price level do not exist. We show that the actual inflation rate depends on the rate of discount of the reserve issuing country. This implies that low discount-rate countries have a higher probability, ceteris paribus, to be selected as reserve issuers. Our analysis also implies that, in a closed economy, the introduction of private monies can serve as an alternative to policy precommitment for removing time inconsistent inflation rates.

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