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Optimal seigniorage and financial liberalization

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This paper analyzes the effect of financial integration for countries relying on the taxation of their domestic financial system. A two-country model with overlapping generations and explicit financial intermediation is used. Governments derive revenues from seigniorage and set optimally, but non-cooperatively, the rate of inflation and the level of required reserves on bank deposits. A financial liberalization leads to lower reserve ratios, higher inflation rates, and larger stocks of government debt. When the liberalization is anticipated, governments may temporarily increase the reserve ratios before the liberalization occurs. (JEL F30, E60)

The current integration of international capital markets is creating an inescapable dilemma for governments relying on the taxation of their domestic financial sector. In the European Community (EC), in particular, competition from foreign financial markets is likely to lead to a substantial loss in public revenues for Southern European countries. An important source of government revenue for these countries has been seigniorage, *i.e.*, an implicit tax on monetary assets (mainly cash and bank deposits) yielding a return below market rates. The first column of Table 1 shows that seigniorage has traditionally been relevant for Italy, Spain, Greece, and Portugal.[1] This source of income has been almost negligible for other EC countries.

The literature usually represents seigniorage as an inflation tax on cash holdings and neglects the role of financial intermediation.[2] When banks are taken into account, however, another element of seigniorage is the ratio of required reserves on bank deposits held at the central bank. These reserves usually bear no interest or an interest well below the market rate. Thus, an increase in reserve requirements broadens the tax base on which the inflation tax is applied. Governments imposing seigniorage usually rely both on the level of inflation and on required reserves. Columns 2 and 3 of Table 1 reveal that Southern European countries have been using both instruments.

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TABLE 1. 1979–88.

	Seigniorage (% of tax revenues)	Reserves/ deposits (%)	Inflation rate
Spain	12.5[a]	17.1	11.0
Greece[b]	13.7	25.3	18.5
Italy	6.9	14.5	12.6
Portugal	10.7[c]	9.9	20.1[c]
Belgium	0.5	1.4	4.1
France	1.7	3.1	7.9
Germany	1.1	8.7	3.1
UK	0.6	2.7	8.3

Source: IMF—International Financial Statistics.
Seigniorage is computed from line 14.
Deposits are computed from lines 24 and 25.
Inflation is the increase in the GDP deflator.
[a] Excludes the year 1983.
[b] June 1988.
[c] Excludes 1988.

TABLE 2. Bank reserve ratios.

	Spain	Italy	Greece	Portugal
1979–84	13.7	13.4	23.5	12.1
1985–89	22.4	16.1	28.1[a]	8.7[b]

Source: See Table 1.
[a] 1985 to June 1988.
[b] 1985 to June 1989.

The recent European experience is also somewhat striking as far as the evolution of reserve requirements is concerned. In particular, it is interesting that in some countries required bank reserves increased in the late 1980s while most capital markets were being deregulated. Table 2 shows that bank reserve ratios have increased significantly in three out of four Southern European countries.

The role of required reserves in the collection of seigniorage is usually neglected as financial intermediation is not represented explicitly. A notable exception is Romer (1985), who models financial intermediation in a closed economy with overlapping generations and analyzes the role of reserve ratios and inflation in the steady state.[3] In the literature it is still an open question whether inflation and reserve requirements are optimal taxes in a second-best world, and it depends on how bank deposits and cash are modeled.[4]

In any case, the use of reserve ratios and inflation in an optimal taxation framework can be justified when tax collection costs are taken into account.[5] Reserve requirements, however, act in a way similar to a direct proportional tax

on deposits and have comparable administrative costs. It is thus relevant to compare the welfare properties of these two alternative instruments. In a recent analysis, Freeman (1987) claims that reserve requirements are dominated, from the steady-state point of view, by a tax on deposits. In Bacchetta and Caminal (1991), however, we argue that a steady-state comparison is not appropriate; and we show that a direct proportional tax on deposits and reserve requirements are equivalent taxes when dynamic trajectories are studied.[6]

While the optimal seigniorage through the use of both the inflation rate and reserve requirements has received some attention in a closed-economy context, to our knowledge it has never been investigated in open economies with integrated financial markets.[7] Drazen (1989) explicitly models financial intermediation in a Ramsey-type model of a small open economy. Motivated by the recent rise in reserves in Southern Europe (our Table 2), he examines the impact of such an increase before a financial liberalization. The level of required reserves, however, is given exogenously and is not chosen optimally by the authorities.

Finally, Miller and Wallace (1985)[8] studied the international spillover effects of seigniorage policies in an overlapping generations model with reserve requirements. In their model, financial intermediation is not explicitly considered, but domestic consumers are forced to hold a certain amount of currency in proportion of total savings. Such a required ratio is exogenously fixed and independent of the portfolio's composition.[9]

In this paper we extend the framework of Romer (1985) to a two-country world, where the authorities set the inflation rate and required reserve ratios optimally taking into account the actions of the foreign authorities. We derive the optimal response to a financial liberalization, both anticipated and non-anticipated, when governments act non-cooperatively. We deal with two different cases. First, we analyze the optimal choice of reserve requirements when the inflation rate is exogenous. This case corresponds to a fixed exchange rate system where countries take the inflation rate as given. And second, we let governments choose both the inflation rate and the reserve ratio. This case corresponds to a flexible exchange rate system.

When the inflation rate is exogenous, we show that financial integration always leads to a lower ratio of reserves and a higher stock of government debt. Moreover, in our framework the liberalization is welfare reducing, because, when capital movements are liberalized, governments have incentives to decrease the reserve ratio to attract foreign depositors and enlarge their tax base. Since both governments face the same incentives, in equilibrium all deposits are held in their domestic banking sector but reserve ratios are set inefficiently low.

When inflation is endogenous and can be set optimally by the authorities, it is shown that a liberalization leads to an increase in the inflation rates as well as a fall in the reserve ratios. The basic intuition is that inflation is a tax on both cash holdings and banks' reserves, while reserve requirements affect only reserves. As a consequence, a liberalization decreases the marginal revenue from inflation by less than the marginal revenue from reserve requirements. This explains why reserve ratios tend to fall more than inflation. On the other hand, lower reserve requirements imply lower revenues. This induces governments to raise additional revenue using the most efficient tax instrument more intensively, and therefore to increase inflation.

An issue of considerable interest for EC countries is the optimal response to

the anticipation of a financial liberalization. We show that it is optimal to increase temporarily the ratio of required reserves before the liberalization even when the inflation rate is constant. The intuition is simple. With integrated capital markets, tax revenues will be smaller. It is in the country's interest to impose higher taxes today to reduce government debt and incur smaller interest payments tomorrow. The level of government debt after the liberalization may therefore be higher or lower than before. Thus, the analysis provides an alternative explanation for the recent increase in reserves in Southern Europe shown in Table 2. Giavazzi (1989) argues that this increase is caused by a reduction in the inflation rate due to EMS membership. Our analysis shows that expected financial liberalization is another reason for such an increase.

The rest of the paper is organized as follows. Section I gives a description of the model. Section II analyzes the case of an exogenous inflation rate, first for an unanticipated liberalization and then for an anticipated liberalization. Section III deals with the equilibrium choice of both inflation and reserve requirements. The final section provides concluding comments. All the proofs can be found in the Appendix.

I. The model

The world is composed of two identical countries, home and foreign. Variables corresponding to the foreign country are denoted by an asterisk. Each country is inhabited by overlapping generations of consumers living for two periods,[10] banks and an infinitely-lived government. Consumers in both countries have preferences defined over the same private good and a public good provided by their own government. They can invest their savings in bank deposits and in currency holdings. The banking sector is assumed to be perfectly competitive as in Romer (1985) or in Freeman (1987). The government finances a public good by issuing public debt and by using seigniorage, determined through the optimal choice of the inflation rate and of the banks' required reserve ratio. Throughout the paper, we will distinguish two alternative regimes: a world with no capital mobility between countries; and a liberalized world where households can hold deposits in foreign banks.

I.A. Consumers

At each period a new generation of N consumers is born and population grows at the constant rate n, *i.e.*,

$$\langle 1 \rangle \qquad N_t = (1+n)N_{t-1}.$$

Each consumer receives an endowment of one unit of the private consumption good in the first period, invests it in a portfolio of assets, and consumes the returns in the second period. The utility of a consumer born at time $t-1$ depends on real consumption, c_t, and on the real quantity of the public good, g_t, provided by the government in the second period of her life. All consumers have the same preferences so that there exists a representative consumer in each generation. The utility function $W(c,g)$ is assumed to be separable and the preferences of a consumer born at time $t-1$ can be written:

$$\langle 2 \rangle \qquad W_{t-1} = u(c_t) + v(g_t) \qquad u', v' > 0 \qquad u'', v'' < 0.$$

As consumption only takes place in the second period of life, the savings function is inelastic with respect to its return. This assumption makes computations much easier and seems to be a good approximation of the real world.[11]

If we denote by p_t the money price of the private consumption good in period t, at time $t-1$ the nominal wealth of a representative individual born in that period is simply p_{t-1}. In general, the wealth of an individual born at time $t-1$ can be invested in three assets: nominal cash holdings M_t, domestic bank deposits D_t, and foreign bank deposits F_t. (Notice that an investment made at time $t-1$ bears the subscript t.) Defining real asset holdings as

$$\langle 3 \rangle \qquad m_t = \frac{M_t}{p_t}, \qquad d_t = \frac{D_t}{p_t}, \qquad f_t = \frac{F_t}{p_t},$$

a consumer born in period $t-1$ faces the following portfolio constraint:

$$\langle 4 \rangle \qquad m_t + d_t + f_t \leqslant \frac{1}{1+\pi_t} \qquad \text{with } m_t, d_t, f_t \geqslant 0.$$

Domestic deposits yield a nominal interest rate i_t and foreign deposits yield i_t^*. Cash does not earn any interest but is needed for transactions purposes. We assume that consumers face the following cash-in-advance constraint:

$$\langle 5 \rangle \qquad c_t \leqslant \frac{1}{\alpha} m_t \qquad \text{with } 0 < \alpha < 1.$$

The interpretation of this constraint is that cash is needed to pay for a proportion of the consumption goods and the rest is paid for with deposits.[12]

When financial markets are protected, no foreign deposits are held ($f = 0$). When financial flows are liberalized, consumers are allowed to hold foreign deposits, but these deposits involve a cost (transactions and information costs) that does not exist for domestic deposits. Similarly, foreign residents are allowed to hold domestic deposits (f^*) bearing the same additional cost. This cost is assumed to be an increasing and convex function of the amount of foreign deposits, $\eta(f_t)$. More precisely, we assume that $\eta'(z) > 0$ for all $z > 0$, $\eta''(z)$ for all $z \geqslant 0$. Moreover, $\eta(0) = \eta'(0) = 0$.[13] This transaction cost function is a parsimonious way of producing a supply of deposits at foreign banks which is a smooth and increasing function of the interest rate differential. In its absence, an infinitesimally small interest rate differential would imply a huge capital flow and, consequently, reserve ratios would be driven to zero after a liberalization. However, it is important to emphasize that its existence does not affect the qualitative results. Moreover, in the case that governments can choose both the inflation rate and the reserves ratio (Section III) these costs are completely irrelevant, as equilibrium reserve ratios are equal to zero.[14]

Therefore, the individual's budget constraint for the second period is:

$$\langle 6 \rangle \qquad c_t \leqslant (1+i_t)d_t + (1+i_t^*)(1+\varepsilon_t)f_t + m_t - \eta(f_t),$$

where ε_t is the rate of depreciation of the domestic currency. By assuming that purchasing power parity holds (which implies that $1+\pi = (1+\varepsilon)(1+\pi^*)$) and by defining r to be the real interest rate (*i.e.*, $1+r = (1+i/1+\pi)$), the budget

constraint can be rewritten as:

$$\langle 7 \rangle \qquad c_t \leqslant (1 + \pi_t)[(1 + r_t)d_t + (1 + r_t^*)f_t] + m_t - \eta(f_t).$$

Combining the first- and second-period budget constraints we obtain:

$$\langle 8 \rangle \qquad c_t \leqslant 1 + r_t - i_t m_t + (1 + \pi_t)(r_t^* - r_t)f_t - \eta(f_t).$$

Utility maximization is equivalent to maximizing second-period consumption with respect to m and f, subject to the cash-in-advance constraint. As long as the nominal interest rate is non-negative, the resulting optimal portfolio is given by:

$$\langle 9 \rangle \qquad \begin{aligned} f_t &= \eta'^{-1}[(1 + \pi_t)(r_t^* - r_t)] && \text{if } r_t^* \geqslant r_t, \\ &= 0 && \text{otherwise,} \\ m_t &= \alpha c_t, \\ d_t &= \frac{1}{1 + \pi_t} - f_t - m_t, \end{aligned}$$

where consumption is given by:

$$\langle 10 \rangle \qquad c_t = \frac{1}{1 + \alpha i_t}[(1 + r_t) + (1 + \pi_t)(r_t^* - r_t)f_t - \eta(f_t)].$$

As they bear an additional cost, consumers hold foreign deposits only when the foreign interest rate is higher than the domestic one. As countries are identical, this means that either $f = 0$ or $f^* = 0$, *i.e.*, there cannot be deposits abroad for both countries simultaneously. Furthermore, in a symmetric equilibrium, $r = r^*$ and no deposits are held abroad ($f = f^* = 0$).

I.B. The banking sector

Banks receive domestic deposits d_t and foreign deposits f_t^*. A proportion ϕ_t is in turn deposited at the central bank without remuneration as a compulsory reserve.[15] The rest is invested in the production sector or in government bonds. The production sector is characterized by a constant returns to scale technology where an investment of one unit of the consumption good in period t produces $1 + x$ units of that good in period $t + 1$. We assume that the real return on production is superior to the population growth, *i.e.*, $x > n$. Consumers do not have direct access to this production technology as it requires a minimum level of investment. Thus, their savings have to be channeled through financial intermediaries. Finally, banks will hold government bonds if and only if their real return is equal or above x. Therefore, the government will issue debt with a return equal to x.

The banking sector is assumed to be perfectly competitive and banks have access to a costless intermediation technology. Thus, in equilibrium banks will make zero profits which in turn determines the real interest paid on deposits:

$$\langle 11 \rangle \qquad 1 + r_t = \frac{\phi_{t-1}}{1 + \pi_t} + (1 - \phi_{t-1})(1 + x).$$

In the present model, the demand for bank loans is perfectly elastic and the supply of deposits is rather inelastic (it does not depend directly on the interest rate, but only indirectly through the effect of the interest rate on consumption).[16]

I.C. The government

The government finances the public good through seigniorage or through borrowing from banks.[17] The government budget constraint is:

$$\langle 12 \rangle \qquad p_t g_t N_t = H_t - H_{t-1} + B_t - (1 + \pi_t)(1 + x)B_{t-1},$$

where H is the stock of monetary base in period t and B is the stock of one-period maturity public debt issued in period t (in nominal terms). In real per capita terms this constraint is:

$$\langle 13 \rangle \qquad g_t = h_t - \frac{1}{(1 + n)(1 + \pi_t)} h_{t-1} + b_t - \frac{1 + x}{1 + n} b_{t-1},$$

where h_t is the real monetary base in per capita terms, *i.e.*,

$$\langle 14 \rangle \qquad h_t = [m_{t+1} + \phi_t(d_{t+1} + f^*_{t+1})](1 + \pi_{t+1}).$$

The variable b_t represents real government bonds issued in period t in per capita terms, which are assumed to be held solely by private banks.[18] Finally, a standard solvency constraint is imposed on the government:

$$\langle 15 \rangle \qquad \lim b_t \left(\frac{1 + n}{1 + x} \right)^t = 0 \qquad \text{as } t \to \infty.$$

Using condition $\langle 11 \rangle$ in the optimal consumption function $\langle 10 \rangle$ and in the government budget constraint $\langle 13 \rangle$, c_t and g_t can be expressed in terms of inflation π_t, π_{t+1}, the reserve ratios ϕ_t, ϕ_{t-1}, and government borrowing b_t, b_{t-1}. It can be seen in particular that private consumption depends negatively on the reserve ratio and on inflation, as an increase in these variables implies a lower real return on deposits. On the other hand, government spending depends in general positively on these two instruments, as their increase implies a higher demand for money and thus a bigger seigniorage.

Therefore, there exists a trade-off between private consumption and government spending when setting the level of inflation and reserve requirements. To determine the optimal level of these variables, the government is assumed to maximize the discounted utility of all generations. More precisely, at time s, the government sets the optimal level of π_{t+1}, ϕ_t, and b_t, for t going from s to infinity,[19] by maximizing V_s:

$$\langle 16 \rangle \qquad V_s = \sum_{t=s}^{\infty} \delta^{t-s}[u(c_t) + v(g_t)].$$

To obtain stationary solutions we assume throughout that $\delta = (1 + n/1 + x)$, *i.e.*, that the social discount rate is equal to the real rate of interest on the amount of public debt in per capita terms.

II. Exogenous inflation rate

In this section we discuss the effects of a financial liberalization in the context of governments setting their money supply in each period in order to obtain a certain exogenously given inflation rate, which for convenience is set equal to zero. In other words, we assume that the inflation rate to which governments

are precommitted is not affected by a financial liberalization. This case could correspond to a fixed exchange rate system, where inflation is given. One can think of an asymmetric fixed exchange rate system where two countries (say Italy and Spain) liberalize their capital movements and take the inflation rate of the *n*th country (say Germany) as given. Alternatively, one can think of a pure gold standard. The assumption of exogenous inflation is relaxed in the next section.

II.A. Unanticipated liberalization

The first case we analyze is an unanticipated liberalization at time $t = 1$. Before that time, we assume that consumers are not allowed to hold foreign deposits. At time 1, there is a global financial liberalization, where consumers of both countries are allowed to hold deposits in the other country. This situation will dramatically modify the optimal strategy of the authorities: the possibility of holding deposits abroad will make consumers more sensitive to the domestic interest rate. A higher reserve ratio will decrease the interest rate on deposits and thus will lead to capital outflows, reducing the tax base. At the same time, a higher reserve ratio will still affect the consumption level of domestic consumers negatively, although they can protect themselves by using foreign deposits more intensively.

Thus, policy actions have spillover effects and consequently the authorities in each country have to take into account the level of the reserve requirement set abroad. This leads to a strategic interaction among policy makers. As countries are identical, it is natural to focus on symmetric Nash equilibria.

Before time 0, when financial markets are protected, we assume that the economy is at a steady state with government spending $\bar{g}$, government debt $\bar{b}$ and reserve ratio $\bar{\phi}$. At time 1, when the announcement of the disappearance of legal restrictions on financial services is made, the government chooses optimal values for these instruments.[20] The government maximizes V_s by choosing (ϕ_t, b_t) for t running from s to infinity. The first-order condition with respect to b_t gives:

$$\langle 17 \rangle \qquad v'(g_t) = v'(g_{t+1}).$$

Hence g_t is constant over time. The first-order condition with respect to ϕ_t gives:

$$\langle 18 \rangle \qquad -\frac{1+n}{1+x}u'(c_{t+1})\frac{\partial c_{t+1}}{\partial \phi_t} = \left(\frac{1+n}{1+x}\frac{\partial g_{t+1}}{\partial \phi_t} + \frac{\partial g_t}{\partial \phi_t}\right)v'(g_t).$$

The assumption of a stationary allocation before the liberalization means that $g = \bar{g}$, $b_t = \bar{b}$ and $\phi_t = \bar{\phi}$. The values of $\bar{g}$, $\bar{b}$, and $\bar{\phi}$ will satisfy the following condition:

$$\langle 19 \rangle \qquad (1+n)u'(\bar{c}) = v'(\bar{g}),$$

where

$$\langle 20 \rangle \qquad \bar{g} = \frac{n \cdot \bar{h}}{1+n} - \frac{x-n}{1+n}\bar{b},$$

$$\langle 21 \rangle \qquad \bar{c} = \frac{1+x-x\bar{\phi}}{1+\alpha(1-\bar{\phi})x},$$

$$\langle 22 \rangle \qquad \bar{h} = \bar{\phi} + (1-\bar{\phi})\alpha\bar{c}.$$

Equation ⟨19⟩ is obtained from ⟨18⟩ for $t < 1$ under the assumption of stationarity. Equation ⟨20⟩ is just ⟨13⟩ in the initial steady state with $\pi = 0$ and $f^* = 0$ as the economy is closed before $t = 1$. Equation ⟨21⟩ is the corresponding expression for ⟨10⟩ and ⟨22⟩ is the version of ⟨14⟩.

For $t \geqslant 1$, ϕ_t and b_t are also constant: from equation ⟨18⟩, $g_t = g$ implies that $\phi_t = \phi$ for $t \geqslant 1$. Furthermore, the solvency constraint plus equation ⟨13⟩ imply that $b_t = b$ for $t \geqslant 1$. For $t \geqslant 1$, the values of g, b, and ϕ are given by:

⟨23⟩ $$(1 + n)u'(c) = (1 - \mu z_a)v'(g),$$

⟨24⟩ $$g = \frac{nh}{1+n} - \frac{x-n}{1+n}b,$$

⟨25⟩ $$c = \frac{1 + (1-\phi)x}{1 + \alpha(1-\phi)x},$$

⟨26⟩ $$h = \phi + (1-\phi)\alpha c$$

⟨27⟩ $$g = h - \frac{\bar{h}}{1+n} + b - \frac{1+x}{1+n}\bar{b},$$

where $\mu = (\eta'^{-1})'(0)$ and where z_a is a positive variable defined in the Appendix. The variable μ represents the sensitivity of foreign deposits holdings to the interest rate differential in equilibrium. In a closed economy, we have $\mu = 0$ and if there are no information or transactions costs, we have $\mu = \infty$. The presence of this measure of substitutability between domestic and foreign deposits is the crucial difference between a liberalized economy and an economy with a protected financial sector.

All these functions are evaluated at the symmetric equilibrium, with $\phi_t = \phi_t^*$, where no foreign deposits are held. Equation ⟨23⟩ is the first-order condition ⟨18⟩ for the case $t \geqslant 1$. Equation ⟨24⟩ is obtained by rewriting ⟨13⟩ for $t > 1$, while ⟨27⟩ corresponds to ⟨13⟩ for $t = 1$.

Equations ⟨19⟩ to ⟨27⟩ characterize the values of public expenditure, government debt, and reserve ratios before and after the liberalization. The effect of the liberalization is apparent when we compare ⟨19⟩ and ⟨23⟩. When $\mu > 0$ the trade-off between private consumption and public spending changes, giving a larger relative weight to private consumption. This implies a lower value of ϕ, because deposits are more difficult to tax, given the possibility of holding deposits abroad. Thus, under capital mobility the monetary base is smaller.

Since z_a is an increasing function of ϕ, the larger the value of μ the lower ϕ, *i.e.*, the more substitutable domestic and foreign deposits are, the lower the value of the reserve ratios. In the limit, $\mu = \infty$ and $\phi = 0$, *i.e.*, it is impossible to tax domestic deposits when the foreign ones are perfect substitutes.

The effect of an unanticipated liberalization is given by the following proposition:

Proposition 1. After a financial liberalization, the reserve ratio as well as government spending is lower, while the stock of public debt and private consumption are larger.

When governments set the reserve ratios, they face a resource constraint between private and public consumption. In the absence of financial integration, the

optimal policy achieves the efficient allocation[21] as the marginal rate of substitution between private and public consumption is equal to the marginal rate of transformation (equations ⟨19⟩ to ⟨22⟩). With financial integration, these two marginal rates are no longer equal (equations ⟨23⟩ to ⟨27⟩) due to the fact that each government has an incentive to partially shift the tax burden from domestic to foreign consumers. In other words, after the liberalization, the initial situation is not an equilibrium since by cutting down the reserve ratio the loss in government revenue is now lower, given that the tax base increases. The reason is that the higher interest rates on deposits, caused by a lower reserve ratio, now attract foreign depositors. Since both governments face the same incentives, in the symmetric Nash equilibrium reserve ratios are lower, which leads to lower government spending and higher private consumption. Furthermore, the reduction in reserve ratios in the first period requires the issue of new public debt.

Cooperation among authorities would internalize the spillovers created by the liberalization.[22] In fact, the symmetric cooperative solution is equivalent to the equilibrium with protected financial markets. Therefore, we can notice the following:

Remark. When governments choose policies independently, reserve ratios are set at inefficiently low levels after the liberalization and there is room for international policy coordination. Moreover, a financial liberalization reduces welfare.

In this model, a liberalization is welfare decreasing for two reasons: first, countries are identical and there are no potential gains from trade; second, it distorts the optimal choice between private consumption and government spending. In a more sophisticated model we should have included some of the positive features of liberalizing banking services: to increase the degree of competition in the banking sector and to ease international transactions in the real sector. In this case, financial liberalization could be on the whole welfare improving, but still competition between governments would lead to inefficiently low reserve ratios.

II.B. Anticipated liberalization

A liberalization of financial markets is usually anticipated, as it has been in the European Community with Project 92. It is therefore of considerable interest to understand what the optimal behavior should be before a liberalization. In this section we consider the case where financial markets are liberalized at time 1, but the plans are known at time 0.

Before time 0, the optimal values for the public good, government borrowing, and reserve ratios are $\bar{g}$, $\bar{b}$, and $\bar{\phi}$. The authorities have to find the optimal values for these variables from time 1, when the markets are liberalized, but also at time 0 when the financial markets are still protected.

Similarly to Section II.A, the first-order condition of this optimization problem with respect to b_t implies that $g_t = g$ for all $t \geqslant 0$. Also, using ⟨18⟩ we can check that $\phi_t = \phi$ for $t \geqslant 1$, but ϕ_0 can potentially be different from $\bar{\phi}$ and ϕ. Finally, the solvency constraint plus the government budget constraint ⟨13⟩ imply that $b_t = b$ for all $t \geqslant 1$, but again b_0 can potentially be different from $\bar{b}$ and b. That is to say, the values of government spending, public debt, and reserve ratios will be characterized by equations ⟨19⟩ to ⟨26⟩, but now we have three new

conditions:

$$\langle 28 \rangle \qquad (1+n)u'(c_1) = v'(g),$$

$$\langle 29 \rangle \qquad g = h_0 - \frac{\bar{h}}{1+n} + b_0 - \frac{1+x}{1+n}\bar{b},$$

$$\langle 30 \rangle \qquad g = h - \frac{h_0}{1+n} + b - \frac{1+x}{1+n}b_0,$$

where

$$\langle 31 \rangle \qquad c_1 = \frac{1+(1-\phi_0)x}{1+\alpha(1-\phi_0)x}$$

and

$$\langle 32 \rangle \qquad h_0 = \phi_0 + (1-\phi_0)\alpha c_1.$$

Equation $\langle 28 \rangle$ comes from $\langle 18 \rangle$ for $t = 0$, and $\langle 29 \rangle$ and $\langle 30 \rangle$ are just equation $\langle 13 \rangle$ for $t = 0$ and $t = 1$, respectively. Finally, equations $\langle 31 \rangle$ and $\langle 32 \rangle$ correspond to $\langle 10 \rangle$ and $\langle 14 \rangle$, respectively.

The optimal response to an unanticipated liberalization can be derived from equations $\langle 19 \rangle$ to $\langle 26 \rangle$ and $\langle 28 \rangle$ to $\langle 32 \rangle$. Similarly to the case of an unanticipated liberalization, g turns out to be lower than $\bar{g}$. Comparing $\langle 28 \rangle$ to $\langle 19 \rangle$, it is easy to see that c_1 is lower than $\bar{c}$. Thus, the reserve ratios in period 0 are higher than before the anticipation of the liberalization while the stock of public debt in period 0 is lower. The following proposition summarizes the optimal response to an anticipated liberalization.

Proposition 2.

1. When a liberalization is anticipated, the reserve ratio temporarily increases to fall below its initial level after the liberalization.
2. Government spending falls when the liberalization is anticipated and is kept unchanged at this lower level after the liberalization.
3. Public debt temporarily decreases when the liberalization is anticipated. After the liberalization, the stock of debt is increased and can end up below or above its initial level.

Figure 1 represents the optimal behavior of the policy instruments and the other endogenous variables described by Proposition 2. The only ambiguous result is the comparison between the initial debt level $\bar{b}$ and the new steady-state level b. Government borrowing b_t decreases temporarily at time 0 and increases again at time one, but may be above or below its initial level. The most interesting result in Proposition 2, however, is the temporary increase in the ratio of reserves ϕ: even though the new steady-state ratio is below its initial value, it is optimal to raise the ratio in period 0.

These results are quite intuitive. In period 0 governments expect the liberalization of financial services to occur in the next period, and therefore know that international competition for bank deposits will lead to reduced reserve ratios and lower public expenditure. Thus, it is optimal to increase temporarily required bank reserves and reduce the stock of public debt to reduce the fall in public expenditure after the liberalization. As a consequence, the welfare losses

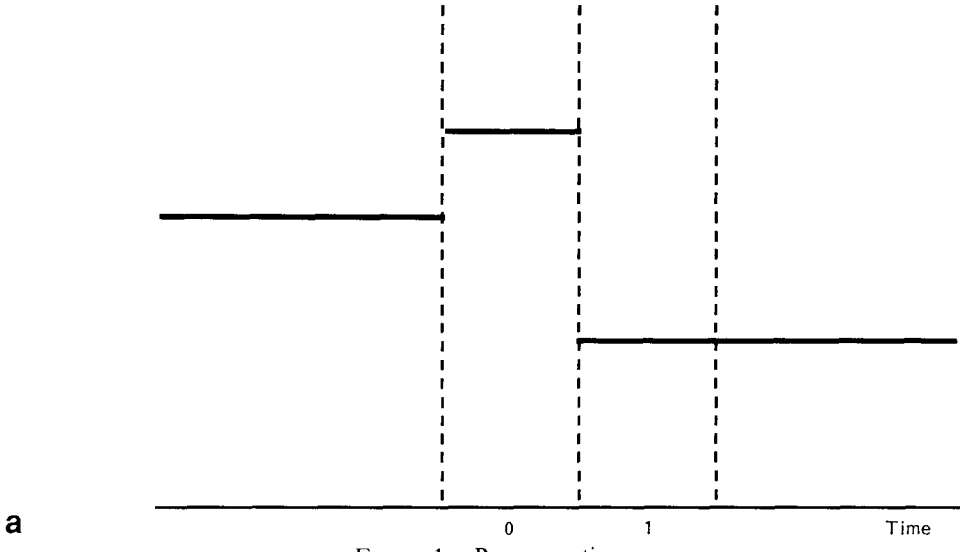

FIGURE 1a. Reserve ratios.

FIGURE 1b. Public debt.

FIGURE 1. Anticipated liberalization with exogenous inflation.

associated with the liberalization are heavier in the period before the liberalization and the one immediately after the liberalization.

III. Endogenous inflation

In this section we let governments choose both the reserve ratio and the inflation rate optimally, but non-cooperatively. This case may be thought of as a regime of flexible exchange rates. In this case, beside the first-order condition with respect to ϕ (equation $\langle 18 \rangle$ above) there is the first-order condition with respect to π_t:

$$\langle 33 \rangle \qquad -\frac{1+n}{1+x}u'(c_t)\frac{\partial c_t}{\partial \pi_t} = \left(\frac{1+n}{1+x}\frac{\partial g_t}{\partial \pi_t} + \frac{\partial g_{t-1}}{\partial \pi_t}\right)v'(g_t).$$

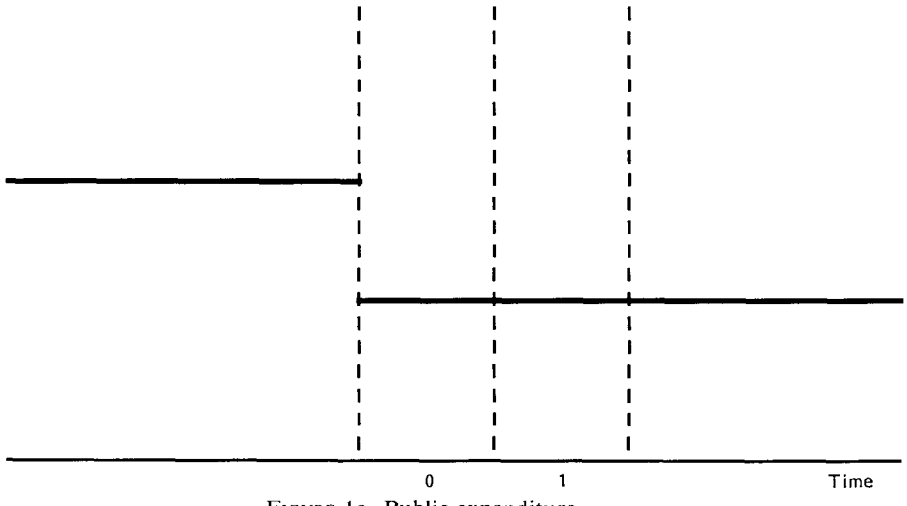

FIGURE 1c. Public expenditure.

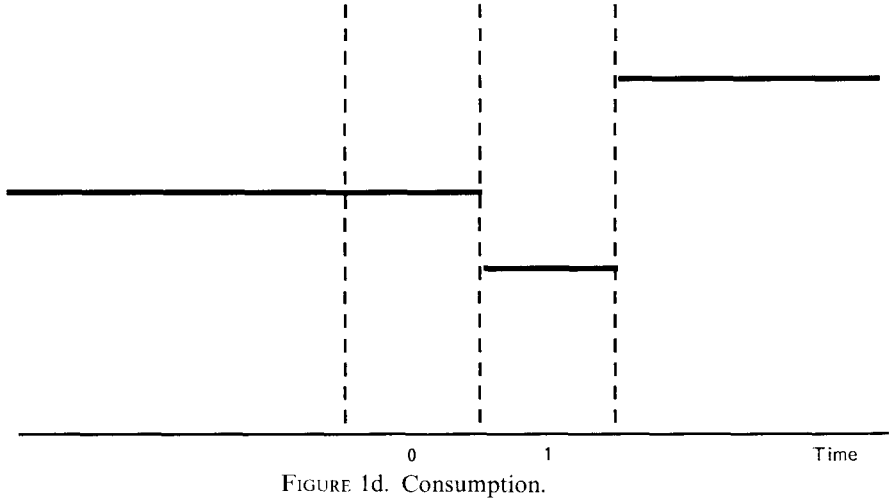

FIGURE 1d. Consumption.

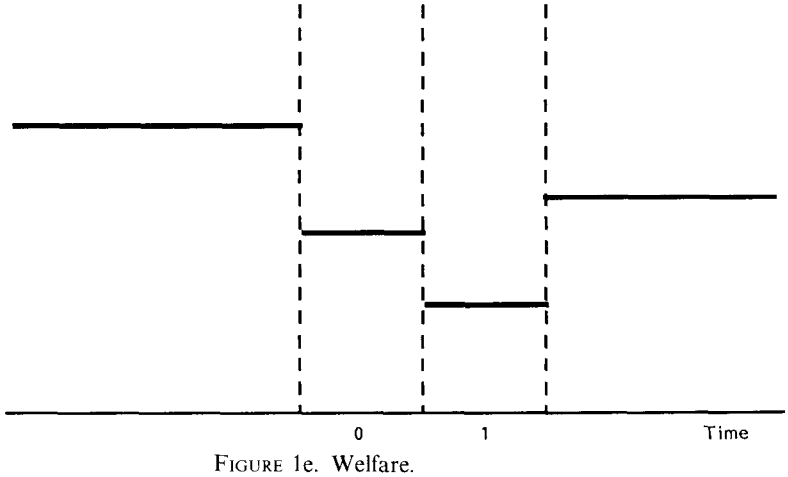

FIGURE 1e. Welfare.

Before the liberalization, this condition gives:

$$\langle 34 \rangle \qquad (1 + n)u'(\bar{c}) = v'(\bar{g}),$$

where $\bar{c}$ and $\bar{g}$ are the stationary levels of c and g in the closed economy. Thus, with no capital mobility, the first-order condition with respect to π_t (equation $\langle 34 \rangle$) is identical to the first-order condition with respect to ϕ_{t-1} (equation $\langle 19 \rangle$). Consequently, there are an infinite number of combinations of reserve ratios and inflation rates that maximize the utility of the representative consumer, in a stationary context. It is shown in the Appendix that the locus of optimal stationary values of ϕ and π has a negative slope. Moreover, at a certain point in time ϕ can be lowered and π increased (and the stock of public debt adjusted) without changing the levels of private consumption and government spending. In other words, the reserve ratio and inflation are perfect substitutes from the point of view of the optimal policy.

After the liberalization, we assume that the government sets new values for its instruments (π and ϕ).[23] The first-order condition with respect to ϕ is:

$$\langle 35 \rangle \qquad (1 + n)u'(c) = v'(g)(1 - \mu z_b),$$

while the one with respect to π is:

$$\langle 36 \rangle \qquad (1 + n)u'(c) = v'(g)(1 - \mu z_c),$$

where c and g are the stationary levels of consumption and government spending in an open economy and where z_b and z_c are positive functions given in the Appendix. It can be easily seen that $z_b > z_c$ when $\phi > 0$ and that $z_b = z_c = 0$ when $\phi = 0$. It is obvious that equations $\langle 35 \rangle$ and $\langle 36 \rangle$ cannot hold simultaneously when $\phi > 0$. Hence, the only solution to $\langle 35 \rangle$ and $\langle 36 \rangle$ is to have $\phi = 0$. The reason is that the perfect substitutability between the reserve ratio and the inflation rate prevailing in a closed economy breaks down as the effect of inflation on government spending $(1 - \mu z_c)$ decreases less than the effect of the reserve ratio $(1 - \mu z_b)$ when the economy is liberalized. Therefore, in this model, reserve requirements are dominated by an inflation tax when there is capital mobility.

When the reserve ratio is equal to zero, conditions $\langle 35 \rangle$ and $\langle 36 \rangle$ boil down to condition $\langle 34 \rangle$. That is to say the first-order conditions coincide with those of the closed economy, because, when the reserve ratio is zero, the inflation rate does not affect the return on deposits and thus the liberalization does not alter the optimal inflation rate. Since in a closed economy the reserve ratio and the inflation rate are perfect substitutes, a liberalization of capital movements does not affect the level of private consumption and of private spending. The only change brought by the liberalization is a change in the composition of seigniorage, with an elimination of the reserve requirements and an increase in inflation to maintain the same level of government revenue.

The effects of a liberalization when inflation is endogenous are summarized by the following proposition:

Proposition 3. A financial liberalization lowers the reserve ratio but increases the inflation rate and the stock of public debt. Government spending and private consumption remain constant.

Making inflation endogenous does not alter the result obtained in Section II.A

about reserve ratios. The reason for the increase in the rate of inflation after a liberalization is twofold. First, inflation is a tax on both cash holdings and banks' reserves, while reserve requirements affect only reserves. As cash holdings are not directly affected by a liberalization, the marginal revenue from inflation declines by less than the marginal revenue from reserve requirements. This explains why reserve ratios tend to fall more than inflation. Second, lower reserve requirements imply lower government revenues which induce the authorities to raise additional revenue using the most efficient tax instrument more intensively.

The other important element of Proposition 3 is that private consumption and government spending are not affected by the liberalization. This result has several implications that differ from the conclusions drawn in Section II, where the inflation rate was exogenous. First, the liberalization does not affect welfare. Thus, in this case, the reserve ratios are not set inefficiently low. The second implication is that the anticipation of a liberalization does not affect the authorities' behavior: as no decrease in total revenues is expected, it is not optimal to reduce the debt level with higher reserve ratios during the anticipation period. In other words, a financial liberalization has the same effects whether it is anticipated or not.

IV. Concluding remarks

In this paper, we have used a stylized model to analyze the effects of a liberalization of capital movements on the level and composition of seigniorage. In our model, a liberalization does not expand the feasible set for the world as a whole, as countries are assumed to be identical. A liberalization does, however, alter the optimal policy of each country by introducing incentives to attract foreign savings.

When each individual government can control both the inflation rate and the level of required reserves, it is shown that the optimal (non-cooperative) response to the liberalization consists of a decrease in the required reserves and an increase in the inflation rate. With integrated capital markets, a reserve ratio is a tax on bank deposits that affects the international allocation of bank deposits. Inflation, on the other hand, is a tax on both bank deposits and cash holdings of the domestic currency and, thus, is less influenced by international competition.

The change in the composition of seigniorage is shown to be capable of maintaining the levels of private consumption and government spending prevailing in the world without capital movements. Thus, a liberalization implies no welfare loss. In a previous version of this paper (Bacchetta and Caminal, 1990) we show that this result does not hold when inflation causes additional costs to consumers. In that case, the equilibrium response to a liberalization is qualitatively the same (lower reserve ratios and higher inflation rates), but the increase in inflation is not sufficient to maintain the previous level of public spending. Thus, welfare declines after a liberalization as the relative weight of public spending is inefficiently low.

The specification of the role of money as a cash-in-advance constraint may appear restrictive. Most of the results of this paper, however, hold as long as the demand for cash is not too sensitive to the nominal interest rate. In Bacchetta and Caminal (1990), we develop a model where cash is used to reduce the transaction costs of consumption. When these costs are increasing with the volume of transactions, the resulting demand for cash depends negatively on the nominal interest rate. In this framework we show that, when the interest elasticity of the

demand for cash is low, we obtain the same qualitative results as those in the case of the cash-in-advance constraint with respect to the direction of change of policy variables. However, when the demand for currency exhibits a positive interest elasticity, inflation creates an additional distortion. Consequently, liberalization reduces welfare.[24]

A crucial assumption underlying Proposition 3 is that deposits but not currency are free to cross borders after liberalization. If there is some degree of substitution between national currencies, the incentives to tax currency and deposits after the liberalization would be similar and, thus, inflation would probably also decrease in the Nash equilibrium. However, Canzoneri (1989) shows that when national currencies are complementary (different currencies are used for different transactions), additional incentives to set inefficiently high inflation rates appear.

When the inflation rate is not a control variable for individual governments, we show that a liberalization is clearly welfare reducing, as the decline in the reserve ratio implies a fall in government revenues. This contrasts with the case of endogenous inflation where welfare is not affected. Hence, if this model is applicable to the EC, one can argue that Southern European countries will be interested in higher inflation rates after the liberalization of their capital movements. This may create additional pressures on the European Monetary System (and on the transition towards a European Monetary Union), either through demands for systematic realignments of central parities or by questioning the German leadership conducive to low inflation rates.

When the liberalization is anticipated, we show that it is optimal to temporarily increase the ratio of required reserves. This result can be applied to the particular situation of the EC. Countries relying on seigniorage anticipate a financial liberalization (in 1990 for Italy, 1993 for Spain, and possibly 1996 for Greece and Portugal) and the recent increase in reserve ratios can be justified as an optimal response. It can be argued, however, that a higher reserve ratio has negative effects that are not captured in the model. Drazen (1989), for example, introduces capital formation and shows that higher reserves lead to a lower capital stock when capital movements are liberalized. However, as the anticipation period is usually short, the negative effects of higher reserves would have to be very large to offset the revenue effect present in this paper.

The assumption maintained throughout the paper of identical countries is analytically convenient and has simplified the exposition considerably. However, the application of the model to the real world, in particular to the EC, requires some additional comments. When countries are very different, financial liberalization usually produces important gains in terms of allocative efficiency. Moreover, different countries can have different needs to raise seigniorage revenue. In this case, the Nash equilibrium will usually be asymmetric. With an exogenous inflation rate, for example, it is easy to see that the Nash equilibrium reserve ratios will still be inefficiently low. However, if international cooperation is feasible it is no longer clear which of the multiple efficient policy bundles will be chosen.

Appendix

Notation used in the text

$$z_a = \frac{\phi x(1 + \alpha r)^2}{1 - \alpha}. \qquad \langle A1 \rangle$$

⟨A2⟩ $$z_b = \frac{\phi}{1-\phi}\frac{1+\pi}{1-\alpha} i(1+\alpha i)^2.$$

⟨A3⟩ $$z_c = \frac{i\phi^2(1+\alpha i)^2(1+\pi)}{(1-\phi)[(1-\alpha)\phi + \alpha(1+i)^2]}.$$

Proof of Proposition 1

Proposition 1 means that $\bar{g} > g$, $\bar{\phi} > \phi$, and $b > \bar{b}$.

From equations ⟨19⟩ and ⟨23⟩ in the text:

⟨A4⟩ $$\bar{g} \leqslant g \text{ implies } \bar{\phi} > \phi.$$

From equations ⟨24⟩ and ⟨27⟩:

⟨A5⟩ $$h - \bar{h} = (1+x)(\bar{b} - b).$$

From equations ⟨20⟩ and ⟨24⟩

⟨A6⟩ $$\bar{g} - g = \frac{n}{1+n}(\bar{h} - h) - \frac{x-n}{1+n}(\bar{b} - b).$$

Using ⟨A5⟩ we set:

⟨A7⟩ $$\bar{g} - g = \frac{x}{1+x}(\bar{h} - h).$$

From equations ⟨25⟩ and ⟨26⟩ it follows that for interior solutions:

⟨A8⟩ $$\frac{\partial h}{\partial \phi} > 0.$$

From ⟨A7⟩ and ⟨A8⟩, $\bar{g} \leqslant g$ implies $\bar{\phi} \leqslant \phi$ which contradicts ⟨A4⟩. Therefore:

⟨A9⟩ $$\bar{g} > g,$$

⟨A10⟩ $$\bar{\phi} > \phi.$$

And using ⟨A5⟩

⟨A11⟩ $$b > \bar{b}.$$ Q.E.D.

Proof of Proposition 2

The proposition can be stated more formally:

⟨A12⟩ $$\phi_0 > \bar{\phi} > \phi,$$
$$\bar{g} > g,$$
$$b > b_0, \bar{b} > b_0.$$

Result 1

From equations ⟨23⟩ and ⟨28⟩

⟨A13⟩ $$\phi < \phi_0.$$

Result 2

From equations ⟨24⟩ and ⟨20⟩

⟨A14⟩ $$(h - h_0) = (1+x)(b_0 - b).$$

Given ⟨A8⟩ and Result 1:

⟨A15⟩ $$b > b_0.$$

Result 3
From equations ⟨19⟩ and ⟨23⟩

⟨A15⟩ $$\bar{\phi} \leqslant \phi \text{ implies } \bar{g} > g.$$

Solving for $\bar{b}$ in ⟨29⟩, plugging the result into ⟨20⟩ and rearranging, we get:

⟨A16⟩ $$(1 + x)\bar{g} = x\bar{h} - (x - n)(h_0 + b_0 - g).$$

Solving for h_0 in ⟨A14⟩ and plugging that into ⟨A16⟩, we get:

⟨A17⟩ $$(1 + x)\bar{g} = x\bar{h} - (x - n)[h + (1 + x)b - g - xb_0].$$

From ⟨24⟩:

⟨A18⟩ $$(1 + n)g = nh - (x - n)b.$$

Subtracting ⟨A18⟩ from ⟨A17⟩ and rearranging, we arrive at:

⟨A19⟩ $$(1 + x)(\bar{g} - g) = x(\bar{h} - h) + x(x - n)(b_0 - b).$$

From Result 2 we know that the last term is negative. Therefore if $\bar{\phi} \leqslant \phi$, $\bar{h} \leqslant h$ and then $\bar{g} < g$. Which contradicts ⟨A15⟩. Thus,

⟨A20⟩ $$\bar{\phi} > \phi.$$

Result 4
Subtracting ⟨19⟩ from ⟨20⟩ results in:

⟨A21⟩ $$\bar{g} - g = (\bar{h} - h_0) + (\bar{b} - b_0).$$

From ⟨19⟩, ⟨23⟩, and ⟨A8⟩:

⟨A22⟩ $$\operatorname{sign}(\bar{g} - g) = \operatorname{sign}(h_0 - \bar{h}).$$

Thus, ⟨A21⟩ and ⟨A22⟩ together imply:

⟨A23⟩ $$\operatorname{sign}(\bar{g} - g) = \operatorname{sign}(\bar{b} - b_0).$$

Subtracting ⟨24⟩ from ⟨20⟩ and rearranging, we get:

⟨A24⟩ $$\bar{g} - g = \frac{n}{1 + n}(\bar{h} - h) - \frac{x - n}{1 + n}(b_0 - b) - \frac{x - n}{1 + n}(\bar{b} - b_0).$$

The first term of the RHS of ⟨A24⟩ is positive (by Result 3 and ⟨A8⟩), and the second is also positive (Result 2). Thus,

⟨A25⟩ $$\bar{g} \leqslant g \text{ implies } \bar{b} > b_0,$$

which contradicts ⟨A23⟩. Therefore,

⟨A26⟩ $$\bar{g} > g.$$

Result 5
From ⟨A22⟩, ⟨A8⟩, and Result 4:

⟨A27⟩ $$\phi_0 > \bar{\phi}.$$

Result 6
From ⟨A23⟩ and Result 4:

⟨A28⟩ $$\bar{b} > b_0$$ Q.E.D.

Proof of Proposition 3

Proposition 3 means that $\bar{g} = g$, $\bar{\phi} > \phi$, $b > \bar{b}$, and $\pi > \bar{\pi}$.

In the closed economy the stationary optimal values of $\bar{\pi}$ and $\bar{\phi}$ are given by equation ⟨34⟩ where

⟨A29⟩ $$\bar{c} = \frac{1 + \bar{\imath}}{(1 + \alpha\bar{\imath})(1 + \bar{\pi})}$$

⟨A30⟩ $$\bar{g} = \left(1 - \frac{1}{(1 + n)(1 + \bar{\pi})}\right)[\bar{\phi} + (1 - \bar{\phi})\alpha\bar{c}(1 + \bar{\pi})] - \frac{x - n}{1 + n}\bar{b}.$$

Thus, via the implicit function theorem

⟨A31⟩ $$\frac{d\bar{\pi}}{d\bar{\phi}} < 0.$$

If $\bar{\phi} = 0$, then there is no change when the liberalization occurs. If $\bar{\phi} > 0$, the fact that $\phi_t = 0$ for all $t \geqslant 1$ does not imply that c_t and g_t must change. In fact, we will show that governments can sustain $c_t = \bar{c}$, $g_t = \bar{g}$ for all $t \geqslant 1$, by rearranging the paths of $\{b_t, \pi_{t+1}\}$.

In period 1, $g_1 = \bar{g}$:

⟨A32⟩ $$\bar{g} = \alpha c - \frac{1}{(1 + n)(1 + \bar{\pi})}\left\{\bar{\phi} + (1 - \bar{\phi})\alpha\frac{1 + \bar{\imath}}{(1 + \alpha\bar{\imath})}\right\} + b - \frac{1 + x}{1 + n}\bar{b}.$$

For $t > 1$, $g_t = \bar{g}$:

⟨A33⟩ $$\bar{g} = \left[1 - \frac{1}{(1 + n)(1 + \pi)}\right]\alpha c(1 + \pi) - \frac{x - n}{1 + n}b,$$

where

⟨A34⟩ $$c = 1 - \frac{1 + x}{1 + \alpha[x + \pi(1 + x)]}.$$

From equations ⟨A29⟩ to ⟨A34⟩ it is easy to check that $\exists\pi$, $\pi > \bar{\pi}$, such that $c = \bar{c}$, $b > \bar{b}$.

Notes

1. The numbers presented in Table 1 represent an approximation of actual seigniorage revenues. For example, they do not take into account interests paid on bank reserves.
2. See Spaventa (1989) for a survey of the literature. Fischer (1982) was among the first authors to revive the interest in seigniorage in the 1980s.
3. Freeman (1987) uses a similar framework.
4. For a negative answer see, for example, Kimbrough (1989) who studies the optimal taxation problem in a model in which bank deposits and cash decrease transaction costs, and concludes that both instruments are dominated by alternative taxes.
5. See Slemrod (1990) for the role of tax collection costs in optimal taxation. If seigniorage is not dominated by alternative taxes, then another interesting question is its optimal composition (see Brock, 1989).
6. The basic reason is that the substitution of a tax on deposits for reserve requirements should be accompanied by an open market operation to have equivalent instruments. This change in the initial level of public debt held by the private sector is not taken into account when steady states are considered.
7. For a recent analysis of the optimal inflation rate only, see, for example, Canzoneri (1989).
8. We are grateful to one of the referees of this Journal for providing this reference. This model and ours share some common features but their goals are quite different.

9. Also, when analyzing the strategic aspects of policy making Miller and Wallace focus exclusively on monetary policy while keeping government spending exogenously fixed.
10. The model is similar to Buiter (1981), but includes financial intermediation and optimizing governments and has a simplified production sector.
11. See Hall (1988).
12. This assumption can be interpreted in the following way: the consumption bundle is composed of two goods that come in fixed proportions in the utility function. The first good is a cash good, in the sense that cash is needed to purchase it, and the second is a credit good. Then alpha is just the proportion of the first good in the consumption bundle. Notice that with this formulation the money demand function does not directly depend on the interest rate on deposits. Most of the results obtained in this paper can be extended to the case of an elastic money demand function. See Section IV for a discussion of this issue.
13. As it occurs with most *ad hoc* transaction costs or adjustment costs functions in the literature, it is difficult to argue whether the real world is better characterized by strictly convex, linear, or strictly concave costs. Obviously, departures from strict convexity would raise uninteresting technical problems.
14. Alternatively, we could have assumed that holding deposits in foreign banks do not entail any extra costs, but holding deposits in both domestic and foreign banks provide useful transaction services. If those services provided by deposits exhibit decreasing returns to scale then results would be very similar.
15. If reserves are remunerated below the market rate, the same results would obtain.
16. See Repullo (1990) for a richer specification of the banking sector in a similar framework.
17. We implicitly assume that the ability of raising revenue through alternative taxes is exhausted. Therefore, g can be interpreted as the level of public spending not financed by standard taxes. Moreover, the revenue from these alternative taxes remains constant after the liberalization.
18. Alternatively, government bonds could be held by domestic consumers and pay the interest rate i_t. Both approaches give identical results. Similarly, allowing foreign banks or consumers to hold domestic government debt does not alter the results in any significant way. We also assume that the total amount of bonds is smaller than total savings in the economy.
19. To avoid problems of time inconsistency, it is assumed that the government cannot affect the inflation rate of the current period: in each period, money supply should be consistent with the inflation rate to which the government precommitted at the beginning of the period. Moreover, the government is not allowed to reoptimize unless a once and for all institutional change occurs.
20. We assume that governments reoptimize only when the liberalization occurs: at this point in time governments can precommit to a certain policy. This assumption has at least two implications. On the one hand, the dynamics created by the liberalization are not mixed with those associated with the time inconsistency problem of the optimal policy. On the other hand, it avoids the multiplicity of equilibria generically associated with dynamic games played by large players.
21. The fact that in our model reserve ratios create no distortion is not important at all. What is essential is that with financial integration governments compete for the world savings.
22. It is usually the case in this literature that international coordination of economic policies can potentially increase the welfare of all countries. See for instance Miller and Wallace (1985). However, when domestic policies are subject to time inconsistency problems or political distortions then *ad hoc* coordination can be counterproductive. See, for example, Rogoff (1985) and Tabellini (1990).
23. As in the previous section, the first-order condition with respect to b_t guarantees that $g_t = g$ for all $t \geqslant 1$. However, some additional conditions may be required to guarantee that $\phi_t = \phi$ for all $t \geqslant 1$. Here we keep this technical issue aside and assume that such conditions hold.
24. When the demand for currency is highly sensitive to the nominal interest rate, however, the optimal response to a liberalization may be to lower inflation (the other results are unchanged). Nevertheless, this theoretical case may not be empirically relevant as the interest elasticity of the demand for currency is usually found to be small or insignificant.

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