A NOTE ON RESERVE REQUIREMENTS AND PUBLIC FINANCE

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ABSTRACT

We use a simple general equilibrium model to show that any allocation (private consumption, real cash balances, and government spending) supported by a policy that involves reserve requirements (plus inflation and public debt) can also be supported by a policy that uses a direct tax on bank deposits (plus inflation and public debt), and vice-versa. In particular, a proportional reserve requirement is equivalent to a proportional tax on deposits plus an open market sale of bonds of an amount equal to banks' reserves.

I. INTRODUCTION

It has been long recognized that banks' reserve requirements are an implicit form of taxation.[1] Banks are forced to invest part of their resources in an asset with a return below the market level (reserves in the central bank) while the consolidated government can finance its budget deficits at more favorable rates.

A precise characterization of the taxation role of reserve requirements was offered by Romer (1985). In the context of an overlapping generations model, he showed that under certain conditions a reserve requirement has the same impact on the private sector as a

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proportional tax on deposits plus an open market sale of bonds of an amount equivalent to the resources kept inactive by the requirement.[2]

The intuition is straightforward. A proportional reserve requirement has the same effect on the rate of return received by depositors as a proportional tax on deposits. However, the substitution of a tax on deposits for a reserve requirement decreases the demand for monetary base and must be compensated for by an equivalent reduction in the supply of monetary base.[3]

An open question about the above characterization of reserve requirements is the impact of each form of taxation on government revenue. This is important. We know that if we substitute a proportional tax on deposits plus an open market sale of bonds for a reserve requirement (or vice-versa), the private sector remains indifferent. However, one of the instruments would be Pareto superior to the other if it implied higher government revenue in each period.

In this note, we show that Romer's characterization of reserve requirements can be extended to account for government revenue.[4] Consider the allocation (private consumption, real balances, and government spending) induced by a second-best optimal tax policy constrained to using reserve requirements, inflation, and public debt as the only instruments. The same allocation can be supported if we substitute a proportional tax on deposits and an open market sale of bonds for the reserve requirement. Similarly, any allocation induced by the use of a direct tax on deposits can be supported by substituting a reserve requirement plus an open market purchase of bonds for this tax.

Such equivalence is intuitive. Assume that a proportional tax on deposits substitutes for a reserve requirement and that the path of the monetary base is kept unchanged. As the demand for monetary base falls the inflation rate increases, which reduces the return on cash holdings. Alternatively, the supply of monetary base can be reduced to avoid any change in the inflation rate, but then government revenue will fall. However, in future periods, since all deposits can be invested in the productive asset, the base of the new tax broadens and government revenue is larger than in the previous steady state.

To avoid the temporary reduction in government revenue or the increase in inflation, the government must issue an amount of debt equivalent to the reduction in the supply of the monetary base. In future periods, the interest paid on this extra debt exactly offsets the extra revenue collected with the new tax. In other words, the open market operation designed to take care of the transition period has the same crowding-out effect on productive investment as the reserve requirement.[5]

Therefore, at least under certain conditions, a reserve requirement is equivalent to a proportional tax on deposits plus an open market operation of the magnitude of banks' reserves, even when we take into account government revenue. Clearly, this equivalence breaks down in complicated ways if government bonds are not perfect substitutes for other private assets, or if the banking industry is not characterized by perfect competition. Both issues are, however, beyond the scope of this note.

II. THE MODEL

The model is a simplified version of Romer (1985) and is similar to Freeman (1987). The simplifications are made for expositional purposes and are immaterial for the results. It is an overlapping generations model, with two-period-lived agents, and a constant rate of population growth. If we denote by N_t the size of the generation born in period t, then $N_t = (1 + n)N_{t-1}$. In each generation there is a representative consumer. In particular, the utility of the representative consumer born in period t is given by a function defined over consumption paths and cash balances:

$$U\left(c_t^y, c_{t+1}^o, \frac{m_t}{1 + \pi_{t+1}}\right) \tag{1}$$

where c_t^y and c_{t+1}^o are the levels of real consumption during the first and second period of her life respectively, π_{t+1} is the inflation rate in period $t + 1$, and $m_t/1 + \pi_{t+1}$ is the level of real cash balances held at the beginning of period $t + 1$ (lower case letters are reserved for real variables, while capital letters for nominal variables). Consumers have access only to two assets: cash holdings and bank deposits.[6] Each agent is born with an endowment of the unique consumption good equal to y. Thus, the budget constraint for the first period is the following:

$$y \geq c_t^y + m_t + d_t \tag{2}$$

and for the second period:

$$c_{t+1}^o \leq \frac{m_t}{1 + \pi_{t+1}} + (1 + r_{t+1})d_t \tag{3}$$

where r is the real interest rate and d is the real supply of bank deposits. Hence, the intertemporal budget constraint is:

$$y \geq c_t^y + \frac{c_{t+1}^o}{1 + r_{t+1}} + \frac{i_{t+1}m_t}{1 + i_{t+1}} \tag{4}$$

where i is the nominal interest rate on bank deposits. We assume that U has the right properties to ensure well-defined bank deposit supply and money demand functions for any non-negative nominal interest rate.

There is a storage technology that exhibits constant returns to scale: for each unit of the good invested in period t it yields $1 + x$ units of the good in period $t + 1$, with $x > n$. Individual consumers do not have direct access to the storage technology but have to pool their savings through banks. One possible reason is that the use of this technology requires a minimum level of savings larger than that of any individual consumer.

Banks take deposits from consumers and, after satisfying the reserve requirement, invest the remaining funds. Bank investment takes two forms: the storage technology and government bonds. For banks to hold public debt, the government must pay the same real return on debt as the storage technology: x. Intermediation is assumed to be a costless activity and a perfectly competitive industry. Thus, in equilibrium banks' profits are zero.

The government purchases a certain amount of the good which in per capita terms will be denoted by g_t, and finances it through money creation or tax revenue, and by issuing bonds of one-period maturity.

III. RESERVE REQUIREMENTS

Let us first consider the case in which the government requires a positive fraction, ϕ_t, of all deposits at banks to be held as reserves of money. The demand for fiat money in period t is given by:

$$H_t^d = (\phi_t d_t + m_t) p_t N_t \tag{5}$$

where p is the price of the consumption good.

The balance sheet of the banking system is:

$$D_t = R_t + B_t + L_t \tag{6}$$

where D is the nominal amount of deposits, R is the level of banks' reserves, B the nominal amount of public debt and L the nominal amount of investment in the storage technology. All assets with subscript t are issued in period t and have one period maturity.

As long as the nominal interest rate is positive profit maximization implies that banks hold no excess reserves:

$$R_t = \phi_t D_t \tag{7}$$

Finally, the assumption of perfect competition in banking implies that the gross nominal interest rate paid to depositors in period t, $1 + i_t$, is given by

$$1 + i_t = \phi_{t-1} + (1 - \phi_{t-1})(1 + x)(1 + \pi_t). \tag{8}$$

We can define government policy as the vector of $\{\phi_t, H_t, B_t\}$ for t running from 0 to infinity, where H is the supply of fiat money (the monetary base). The amount of real government spending that can be financed in period t, will be given by the budget constraint:

$$p_t g_t N_t = H_t - H_{t-1} + B_t - (1 + x)(1 + \pi_t)B_{t-1} \tag{9}$$

This constraint can be rewritten in real per capita terms:

$$g_t = \frac{H_t - H_{t-1}}{p_t N_t} + b_t - \frac{1 + x}{1 + n} b_{t-1} \tag{10}$$

where b_t is the per capita stock of public debt in real terms in period t.

Next, we formally define a competitive allocation for a given policy.

Definition 1. A *perfect foresight equilibrium with reserve requirements* for a given policy $\{\phi_t, H_t, B_t\}$, $t = 0, 1, 2, \ldots$, and initial conditions $\{B_{-1}, P_{-1}, R_{-1}, L_{-1}, M_{-1}$, and $D_{-1}\}$ is a sequence of prices $\{i_t, P_t\}$ and an allocation $\{c_t^y, c_t^o, g_t, m_t\}$, $t = 0, 1, 2, \ldots$, such that for all $t \geq 0$:

1. Given (i_{t+1}, P_t, P_{t+1}), (c_t^y, c_{t+1}^o, m_t) maximize equation (1) subject to equation (4) and the usual non-negativity constraints, and

$$c_0^o = \frac{m_{-1}}{1+\pi_0} + (1+r_0)d_{-1}. \tag{11}$$

2. Banks' assets and liabilities satisfy the balance sheet condition equation (6), no excess reserve condition equation (7) and the zero profit condition equation (8). Moreover, real investment must be non-negative:

$$L_t \geq 0, \text{ or equivalently } B_t \leq (1-\phi_t)D_t \tag{12}$$

where D_t satisfies equation (2) with equality.

3. Clearing in the money market:

$$H_t^d = H_t \tag{13}$$

where H_t^d is given by equation (5).

4. Government budget constraint equation (10).

Thus, we say that an allocation $\{c_t^y, c_t^o, g_t, m_t\}$ is *supported* by a policy of reserve requirements $\{\phi_t, H_t, B_t\}$, given some initial conditions, if there exist prices $\{i_t, P_t\}$ such that this allocation and prices satisfy Definition 1.

IV. A DIRECT TAX ON DEPOSITS

Suppose that instead of the reserve requirement the government directly tax deposits through a proportional tax on the return of deposits. That is, the tax revenue in period t in nominal terms is given by:

$$T_t = \tau_t[(1+x)(1+\pi_t) - 1]p_{t-1}d_{t-1}N_{t-1}. \tag{14}$$

where τ is the tax rate. Consequently, given the perfect competition assumption the after-tax gross nominal interest rate on deposits is:

$$1 + i_t = 1 + (1-\tau_t)[(1+x)(1+\pi_t) - 1]. \tag{15}$$

In the absence of the reserve requirement, the demand for the monetary base is simply:

$$H_t^d = m_t p_t N_t \tag{16}$$

and the government budget constraint becomes:

$$g_t = \frac{H_t - H_{t-1}}{p_t N_t} + \frac{T_t}{p_t N_t} + b_t - \frac{1+x}{1+n} b_{t-1}. \tag{17}$$

We can now define the equilibrium with such a tax scheme.

Definition 2. A *perfect foresight equilibrium with a tax on deposits* for a given policy $\{\tau_t, H_t, B_t\}$, $t = 0, 1, 2, ...,$ and initial conditions $\{B_{-1}, P_{-1}, L_{-1}, M_{-1}$, and $D_{-1}\}$ is a sequence of prices $\{i_t, P_t\}$ and an allocation $\{c_t^y, c_t^o, g_t, m_t\}$, $t = 0, 1, 2, ...,$ such that for all $t \geq 0$:

1. Given (i_{t+1}, P_t, P_{t+1}), (c_t^y, c_{t+1}^o, m_t) maximize equation (1) subject to equation (4) and the usual non-negativity constraints, and

$$c_0^o = \frac{m_{-1}}{1+\pi_0} + (1 + r_0)d_{-1}. \tag{11}$$

2. Banks' assets and liabilities satisfy the balance sheet condition

$$D_t = B_t + L_t \tag{18}$$

and the zero profit condition equation (15). Moreover, real investment must be non-negative:

$$L_t \geq 0, \text{ or equivalently } B_t \leq D_t \tag{19}$$

where D_t satisfies equation (2) with equality.

3. Clearing in the money market:

$$H_t^d = H_t \tag{13}$$

where H_t^d is given by equation (16).

4. Government budget constraint equation (17).

Again, we say that an allocation $\{c_t^y, c_t^o, g_t, m_t\}$ is *supported* by a policy of a tax on deposits $\{\tau_t, H_t, B_t\}$, given some initial conditions, if there exist prices $(i_t, P_t\}$ such that this allocation and prices satisfy Definition 2.

V. CHANGES IN THE TAX REGIME

We can now consider the allocative consequences of changes in the tax regime, that is a shift from a regime with reserve requirement to one with a direct tax on deposits and vice-versa. In fact, we show that both instruments are equivalent. More precisely:

Proposition: Any allocation supported by a reserve requirement can be supported by a direct tax on deposits and vice-versa.

Proof: a) Consider an allocation supported by the reserve requirement. Suppose that in Period 1 a direct tax on the returns from deposits is substituted for the reserve requirement. To avoid double taxation of returns on deposits in Period 1 the reserve requirement is abolished in Period 0. In fact, we set:

$$\tau_t = 0 \qquad t = 0$$
$$\phi_{t-1} \qquad t \geq 1 \tag{20}$$

where ϕ_t is the required reserve ratio prevailing in the old regime.

The policy shift is completed by setting the monetary base and public debt according to:

$$\overline{H}_t = m_t p_t N_t \tag{21}$$

where $\overline{H}_t$ is the new sequence of the monetary base, for $t \geq 0$, while m_t and P_t are the sequence of real cash balances and the price level prevailing in the old regime, and

$$\overline{B}_t = B_t + \phi_t D_t \tag{22}$$

where $\overline{B}_t$ is the new sequence of the nominal stock of public debt, for $t \geq 0$, and B_t, ϕ_t, and D_t correspond to the old regime.

Suppose that the path of the price level is unaffected by the policy shift.

Equations (8) and (15) plus equation (20) indicate that the nominal interest rate on deposits will be the same, and so will be the real rate. As a result, the solution to the consumer's maximization problem will remain unchanged, i.e. (c_t^y, c_t^o, m_t) are identical under both policies. In particular, since m_t is unaffected, condition equation (13) makes policy equation (21) compatible with the assumption that the price level is the same under both policies.[7]

Notice that the new path for the public debt assumed in equation (22) implies that investment in the storage technology is unchanged. From the balance sheet condition equation (18):

$$L_t = P_t(d_t + \overline{b}_t) = P_t(d_t + b_t + \phi_t d_t) = D_t + B_t + R_t$$

which coincides with equation (6). Hence, the non-negativity of real investment equation (19) is guaranteed.

Let us next look at government spending. In Period 0 the elimination of reserve requirements reduces the demand for money. To avoid an increase in inflation the government reduces money supply equation (21). Other things equal this would reduce government spending, but this is avoided by the increase in public debt given by equation (22).

Thus, government spending in Period 0 will be given by:

$$g_0 = m_0 - \frac{H_{-1}}{p_0 N_0} + \overline{b}_0 - \frac{1+x}{1+n} b_{-1}. \tag{23}$$

Plugging equation (22) into equation (23):

$$g_0 = \phi_0 d_0 + m_0 - \frac{H_{-1}}{p_0 N_0} + b_0 - \frac{1+x}{1+n} b_{-1} = \frac{H_0 - H_{-1}}{p_0 N_0} + b_0 - \frac{1+x}{1+n} b_{-1} \tag{24}$$

which coincides with the level of public spending in the regime with the reserve requirement (equation (10) for $t = 0$). Similarly, for any $t \geq 1$:

$$g_t = m_t - \frac{m_{t-1}}{(1+n)(1+\pi_t)} + \frac{T_t}{p_t N_t} + \overline{b}_t - \frac{1+x}{1+n} \overline{b}_{t-1} \tag{25}$$

Plugging equations (22) and (14) into equation (25):

$$g_t = m_t - \frac{m_{t-1}}{(1+n)(1+\pi_t)} + \frac{\tau_t[(1+x)(1+\pi_t) - 1]d_{t-1}}{(1+n)(1+\pi_t)} + b_t + \phi_t d_t - \frac{1+x}{1+n} b_{t-1} + \phi_{t-1} d_{t-1} \tag{26}$$

Finally, by setting τ_t according to equation (20):

$$g_t = \phi_t d_t + m_t - \frac{\phi_{t-1} d_{t-1} + m_{t-1}}{(1+n)(1+\pi_t)} + b_t - \frac{1+x}{1+n} b_{t-1} \tag{27}$$

which is exactly the level of government spending attained with the reserve requirement (equation (10)).

b) Clearly, the same experiment can be carried out in the opposite direction. Consider an allocation induced by a certain proportional tax on deposits, inflation, and stock of public debt. At Time 0 we can introduce a proportional reserve requirement and abolish the direct tax from Time 1 on. Simultaneously, if the government performs an open market purchase of bonds of a magnitude equivalent to banks' reserves, then the levels of private consumption, real cash balances, and government spending remain unchanged.

VI. CONCLUDING REMARKS

A. Public Debt in Depositors' Portfolios

We have assumed that only banks purchase government debt. In this case, the return on debt had to be equal to the return on productive investment, x. It is trivial to allow depositors to hold public debt without altering the main result.

If depositors can hold public debt without paying any extra tax on its return, then its rate of return will be equal to the deposit interest rate. With depositors excluded from the public debt market, the government has to pay a higher interest rate, but it recovers part of it by taxing deposits.

Thus, it is easy to check that when depositors are allowed to purchase public debt the same characterization of reserve requirements holds, since the open market operation carried out to keep government revenue and inflation constant in the transition period, reduces the amount of bank deposits (and thus the base of the new tax) which exactly compensates the lower debt service.

B. Steady States Versus Transition Paths

Freeman (1987) showed in a very similar framework that a tax on deposits provides a higher steady state utility than a reserve requirement.[8] There is no formal contradiction between Freeman's result and ours. We are simply performing different experiments. Freeman is concerned only with steady states and neglects the changes along the transition path, namely the loss in utility to some generations caused by either the reduction in government revenue or by the temporary increase of inflation. On the contrary, our equivalence result emphasizes precisely those transitory adjustments.

We want to argue that if we are to talk about optimal taxation, when the government has the chance of intertemporally redistributing taxes through public debt, then a comparison between steady states is meaningless. If the objective function is to maximize the long-run level of utility of the representative consumer subject to a certain level of government revenue, then the optimal (short-run) policy consists of reducing the stock of public debt to the lowest possible level (minus infinity?). This policy obviously hurts the current old generation.

Assume instead that we take a more interesting approach to the optimal determination of the stock of public debt, for example by taking the present discounted value of the utility of all generations as the government objective function. Then (at least under the conditions of our model), reserve requirements and a direct proportional tax on deposits can both be part of the optimal tax system.

APPENDIX

On the Optimal Composition of Seigniorage

We show that the finiteness of optimal inflation rates does not depend on the consumers' demand for fiat money being sensitive to nominal interest rates. We assume, as in Freeman (1987), that cash balances are not in the utility function (that is $m = 0$).

Let us first reproduce Freeman's result. First, we define a stationary allocation with no public debt. Government spending is given by:

$$g = \left[1 - \frac{1}{(1+\pi)(1+n)}\right]\phi d$$

The representative consumer maximizes

$$u(c^y, c^o)$$

subject to $y \geq c^y + \dfrac{c^o}{1+r}$

Hence, indirect utility depends only on r.

$$v = v(r)$$

and $d \equiv y - c^y(r)$

Finally, the zero profit condition for the banking system implies

$$1 + r = \frac{\phi}{1+\pi} + (1-\phi)(1+x)$$

Notice that the real interest rate is kept constant if:

$$d\phi = \frac{\phi}{(1+\pi) - (1+x)(1+\pi)^2}d\pi$$

Hence

$$\frac{dg}{d\pi} = \left[1 - \frac{1}{(1+\pi)(1+n)}\right]\frac{d\phi}{d\pi} + \frac{\phi}{(1+\pi)^2(1+n)} = \frac{\phi(x-n)}{(1+\pi)(1+n)[(1+x)(1+\pi)-1]} > 0$$

Thus, the policy that maximizes the stationary utility subject to no public debt, must involve an infinite inflation rate.

Alternatively, suppose that the government maximizes the present discounted value of the utility of all generations, and is allowed to use public debt to redistribute utility across generations. Thus, the government chooses $\{\phi_t, \pi_{t+1}, b_t\}_{t=0}^{\infty}$ in order to maximize:

$$\sum_{t=0}^{\infty} \beta^t v(r_{t+1})$$

subject to

$$\phi_t d_t - \frac{\phi_{t-1} d_{t-1}}{(1+\pi_t)(1+n)} + b_t - \frac{1+x}{1+n} b_{t-1} \geq \bar{g}_t \qquad \text{for all } t \geq 0$$

and where

$$d_t = d(r_{t+1})$$

$$1 + r_{t+1} = \frac{\phi_t}{1+\pi_{t+1}} + (1-\phi_t)(1+x)$$

The first order conditions of an interior solution are given by (λ_t is the Lagrange multiplier associated to the constraint corresponding to $\bar{g}_t$):

$$\phi^t: \quad \beta_t v'(r_{t+1}) \frac{(1+x)(1+\pi_{t+1})-1}{1+\pi_{t+1}} = \lambda_t \left[d_t - \phi_t d'(r_{t+1}) \frac{(1+x)(1+\pi_{t+1})-1}{1+\pi_{t+1}} \right]$$

$$- \frac{\lambda_{t+1}}{(1+\pi_{t+1})(1+n)} \left[d_t - \phi_t d'(r_{t+1}) \frac{(1+x)(1+\pi_{t+1})-1}{1+\pi_{t+1}} \right]$$

$$\pi_{t+1}: \quad \beta^t v'(r_{t+1}) \frac{\phi_t}{(1+\pi_{t+1})^2} = -\lambda_t \phi_t d'(r_{t+1}) \frac{\phi_t}{(1+\pi_{t+1})^2}$$

$$+ \frac{\lambda_{t+1}\phi_t}{1+n} \left[\frac{d_t}{(1+\pi_{t+1})^2} + \frac{d'(r_{t+1})}{(1+\pi_t)^3} \phi_t \right]$$

$$b_t: \quad \lambda_{t+1} = \frac{1+n}{1+x} \lambda_t$$

Using the third condition to eliminate the Lagrange multipliers, it can be seen that the first and the second conditions are identical and can be written as:

$$\beta^t v'(r_{t+1}) + \frac{\lambda_t}{1+x} \left[d_t - \phi_t d'(r_{t+1}) \frac{(1+x)(1+\pi_{t+1})-1}{1+\pi_{t+1}} \right]$$

Therefore, ϕ and π are perfect substitutes in the optimal policy.

Given that in Freeman's paper the planner maximizes steady-state utility, while in ours she maximizes the present discounted value of the utility of all generations, the reader might be tempted to conclude that the difference between Freeman's and our result is the weight the planner puts on different generations. But this interpretation is not correct; in fact our result holds for any β. The source of the difference is the possibility of using public debt to reallocate utility across generations. Obviously, this possibility makes no sense in the context of steady-state utility maximization. However, if we discuss the role of reserve requirements (which involves a government liability) in an optimal policy we must consider the composition of the government's portfolio.

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NOTES

1. Fama (1980) is one of the first references.

2. Revenues collected through banks' reserve requirements are part of the so-called "seigniorage". See, for instance, Brock (1989) on the optimal composition of seigniorage in a closed economy and Bacchetta and Caminal (1992) in a two-country world.

3. One of the necessary conditions of this characterization is that government bonds are perfect substitutes for either the bank asset or the bank liability, depending on who holds them: banks or depositors. Another important assumption is perfect competition and constant returns to scale in financial intermediation.

4. This result contrasts with Freeman (1987). In the last section we discuss the differences between the two papers.

5. A symmetric intuition can be given when reserve requirements substitute for a direct tax on deposits.

6. In the explicit analysis presented, public debt will be held exclusively by banks. This may be a property of the equilibrium if depositors must pay an extra tax on the return on public debt. The case of public debt in depositors' portfolio is discussed in the last section.

7. In principle, for a given policy there could be multiple equilibria. The only thing we claim is that with the new policy there exists an equilibrium with the same prices and allocation.

8. His paper contains a second result, which is that the optimal structure of seigniorage (again from the point of view of steady states) consists of an infinite inflation rate and the minimum reserve requirement compatible with the given level of public spending. However, it can be shown that if the planner maximizes the present value of the utility of all future generations (that is the case for which the optimal levels of public debt are well determined), the inflation rate and the reserve requirement are equivalent instruments. In particular, finite inflation rates are usually part of the optimal policy. This is shown in the Appendix.

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