TIME CONSISTENCY OF MONETARY POLICY IN THE OPEN ECONOMY

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Abstract

The paper is concerned with time-consistency problems caused by monetary policy in an open economy. The temptation to generate surprise inflation is shown to depend positively on the amounts of nominal debt issued by the government or issued by individuals. Private debt matters, because inflationary money growth causes redistribution between domestic residents and foreigners. A government that cares about the welfare of its residents will be tempted to inflate whenever it or its residents have issued nominal debt to foreigners. A net creditor position, however, may eliminate the time-consistency problem.

For the United States, these international considerations should become increasingly relevant as the country accumulates external deficits. My estimates indicate that the incentive to inflate more than doubled between 1982 and 1988. More than two-thirds of this increase was due to higher external debt, which was largely financed in nominal terms.

1. Introduction

It is well known that a government's ability to print money causes severe incentive problems that may have devastating welfare implications.[1] While early papers focussed on the government's ability to inflate away fiat money (Calvo (1978)), it is clear that the same problem affects all government liabilities denominated in the domestic currency.[2]

This paper shows that international lending modifies inflationary incentives in an important way. In addition to government debt, any external nominal government or private debt creates incentives for the government to inflate. For the United States, $1 of external debt has roughly the same effect on incentives as $3 of government debt.

The argument is set in a simple equilibrium model of an open economy with welfare maximizing government, in which welfare effects and incentives of monetary policy can be derived explicitly. Nominal government debt creates an incentive to inflate, because taxes are assumed to be distortionary, while money creation is, ex post, a lump-sum tax. External nominal debt creates similar incentives if the government cares about its own residents, because inflation devalues such debt. In an equilibrium with discretionary policy and rational expectations, the use of such nominal debt raises inflation and reduces welfare.[3] This effect of external debt has not been recognized in the literature on inflationary taxation.[4]

Quantitatively, inflationary redistribution of wealth from domestic residents to the government increases welfare by the marginal welfare cost of taxes while redistribution from foreigners to domestic agents increases welfare one-for-one. Since plausible estimates of the marginal welfare cost of taxes are about 1/3, changes in nominal external debt are about three times as important for monetary incentives as equally large changes in government debt. This is especially relevant for the United States, which has recently experienced large movements in external and government liabilities, most of which are denominated in dollars.

The paper is organized as follows. Section 2 presents the model. Optimal monetary policy is analyzed in Section 3. Section 4 discusses the U.S. data and Section 5 summarizes the conclusions.

2. The Model

Consider a two-country world populated by infinitely-lived identical individuals. The domestic setting--preferences, money, taxes, and several securities--will be described in detail. The foreign economy is similarly structured, except that government policy of the foreign country is considered exogenous. Foreign variables are indicated by an asterisk (*).

In period t, residents of the home country are endowed with Y_t units (sometimes called domestic output) of the single good and residents of the foreign country with Y_t^* units of the same good (foreign output).[5] Individuals have an intertemporal utility function

$$U_t = \sum_{j\geq 0} \rho^j \cdot c_{t+j} \tag{1}$$

with a constant rate of time preference r, $\rho = 1/(1+r)$.[6] There is no uncertainty, except about policy; but policy will be perfectly predictable along the equilibrium path.[7]

Money is introduced through a simple cash-in-advance constraint. Suppose an exogenous fraction ε of all payments can only be made with money in the seller's currency.[8] Then domestic residents hold

$$M_t = \varepsilon \cdot p_t \cdot Y_t \tag{2}$$

in fiat money at the end of the period, where p_t is the price level. Since Y_t is exogenous, inflation π_t can be considered a government choice variable. It is assumed that foreigners also receive a fraction ε of their sales of Y^* in their money M^*. But they have no reason to hold domestic money (assuming positive nominal interest rates) at the end of the period.[9]

To motivate the time-consistency problem of monetary policy, it is assumed that taxes are costly to collect (while inflation taxes are, of course, lump-sum).[10] Denoting tax rates by τ_t and tax revenues by $T_t = \tau_t \cdot Y_t$, collection costs are modelled as an additional loss of resources $h(\tau_t) \cdot Y_t$, where $h(\cdot)$ is a non-negative, increasing, and convex function.[11] Without further precautions, however, loss-minimizing money growth and inflation may easily be infinity, as in Calvo (1978). Realistically, high inflation disrupts allocative decisions, which reduces the productive capacity of an economy. These frictions are modeled by another non-negative and convex loss function $f(\pi_t)$, which is increasing for $\pi_t > 0$ and decreasing for $\pi_t < 0$. It indicates the loss of output relative to potential Y_t, if inflation π_t deviates from zero.[12] Overall, income net of taxes and frictional losses is $Y_t \cdot [1 - \tau_t - h(\tau_t)] - f(\pi_t)$.

The policy analysis will focus on only two securities, namely a safe (real, indexed) bond and a nominal bond.[13] The real bond is sold at a real price of one in period t and must therefore (by equation (1)) have a payoff of $1 + r$ in period $t + 1$. The nominal bond promises a nominal interest rate i_t. It is also issued at a unit price and has a real payoff of $1 + i_t - \pi_{t+1}$ in period $t + 1$. Thus, nominal interest rates must satisfy

$$i_t = r + \pi^e_{t+1} \tag{3}$$

where π^e_{t+1} is expected inflation.

Now the budget constraints can be formulated. The quantity of debt issued by the government will be denoted by D^k_t, where $k = r$ or $k = n$ indicate real or nominal securities, respectively. Similarly, private debt will be denoted by B^k_t, and national liabilities by $L^k_t = D^k_t + B^k_t$. Security holdings are indicated by negative numbers. For individuals, the real cost of consumption must be covered by net income plus the excess of new borrowing over repayments of old debt. Taking into account money holdings, this is

$$\begin{aligned} c_t = {} & Y_t \cdot [1 - \tau_t - h(\tau_t)] - f(\pi_t) - \frac{M_t - M_{t-1}}{p_t} \\ & + B^r_t + B^n_t - (1+r) \cdot B^r_{t-1} - (1 + i_{t-1} - \pi_t) \cdot B^n_{t-1} . \end{aligned} \tag{4}$$

The government must finance old debt by taxes, money creation, or new borrowings,[14]

$$(1+r) \cdot D^r_{t-1} + (1 + i_{t-1} - \pi_t) \cdot D^n_{t-1} = T_t + \frac{M_t - M_{t-1}}{p_t} + D^r_t + D^n_t \tag{5}$$

Equations (4) and (5) can be combined for a national budget constraint,

$$c_t = Y_t \cdot [1 - h(\tau_t)] - f(\pi_t) + L_t^r + L_t^n - (1+r) \cdot L_{t-1}^r - (1 + i_{t-1} - \pi_t) \cdot L_{t-1}^n \ . \quad (6)$$

Government debt policy has real effects (through τ_t in (6)) because of the cost of tax collections, as in Barro (1979). Since domestic individuals do not hold foreign money at the end of the period and foreigners do not hold domestic money, money stocks cancel out in the national budget constraint. The government extracts seignorage only from domestic residents. Notice that individual optimization does not determine the optimal supply of assets, B_t^k. When analyzing monetary policy, private debt will be taken as given.[15]

3. Optimal Policy

The key assumption about policy decisions is that the government maximizes the welfare of the representative domestic individual, but that it is indifferent about the welfare of foreigners. In general, the government maximizes (1) subject to (6), given individual decisions.

To simplify the budget constraints, let $D_t = M_t/p_t + D_t^r + D_t^n$ be the total government debt and recall that nominal interest rates satisfy (3). Then (5) becomes

$$T_t = (1+r) \cdot D_{t-1} - D_t + \left(\pi_t^e - \pi_t\right) \cdot D_{t-1}^n - \left(1 + r - \frac{1}{1+\pi}\right) \cdot \varepsilon \cdot Y_{t-1} \ , \quad (7)$$

using the fact that $M_{t-1}/P_t = \varepsilon \cdot Y_{t-1}/(1+\pi_t)$. Thus, inflation increases seignorage and reduces the value of nominal debt. Quantitatively, the latter effect is by far the more important one for most developed economies; the focus will therefore be on nominal debt.[16]

Similarly, the national resource constraint (6) can be transformed to

$$c_t = Y_t \cdot [1 - h(\tau_t)] - f(\pi_t) + L_t - (1+r) \cdot L_{t-1} - \left(\pi_t^e - \pi_t\right) \cdot L_{t-1}^n \ , \quad (8)$$

where $L_t = L_t^r + L_t^n$ is total external debt (since foreigners do not hold domestic money). Finally, the expected utility of the representative domestic individual can then be written as a function of government choice variables (inserting (8) into (1)) as

$$E_t[U_t] = \sum_{j\geq 0} \rho^j \cdot E_t[Y_{t+j} \cdot (1 - h(\tau_{t+j})) - f(\pi_{t+j})] - (1+r) \cdot L_{t-1} - \left(\pi_t^e - \pi_t\right) \cdot L_{t-1}^n \,. \qquad (9)$$

To summarize, the government's problem is to maximize (9) subject to the budget constraint (7). In principle, both inflation and debt structure should be chosen optimally. But since optimal debt policy probably has additional determinants that are beyond the scope of this paper,[17] the focus will be on monetary policy. Taking the structure of private and government debt as given, it will be shown how debt structure affects monetary policy.

Every period, the task of monetary policy is to choose the rate of inflation. Since inflation π_t is chosen after the nominal interest rate i_{t-1} has been set, the government takes π_t^e as given when it optimizes in period t. The first order condition for optimal inflation in maximizing (9) subject to (7) is therefore

$$U_\pi = h'(\tau_t) \cdot \left[\frac{\varepsilon \cdot Y_t}{(1+\pi_t)^2} + D_{t-1}^n \right] - f'(\pi_t) + L_{t-1}^n = 0 \,. \qquad (10)$$

In equilibrium, individuals form correct expectations about the resulting money growth and inflation. That is, the time-consistent perfect foresight path satisfies (10), evaluated at $\pi_t^e = \pi_t$.[18] Equilibrium nominal interest rates compensate bondholders for inflation. The net result is an equilibrium rate of inflation that depends on all variables in (10).

The equilibrium rate of inflation is best interpreted in comparison with the hypothetical solution that would be obtained if the government could precommit to an announced inflation rate. Precommitment means that the government optimizes in period t - 1 and that it can credibly announce optimal period-t inflation in period t - 1, before individuals set interest rates. In the government's optimization problem, expected inflation is then identically equal to actual inflation (and not taken as given). In other words, all terms involving $\left(\pi_t - \pi_t^e\right)$ vanish in (7) and (9). The first order condition for maximizing (9) subject to (7) and subject to $\pi_t^e \equiv \pi_t$ is

$$U_\pi^{FB} \equiv h'(\tau_t) \cdot \frac{\varepsilon \cdot Y_t}{(1+\pi_t)^2} - f'(\pi_t) = 0 \,. \qquad (11)$$

The solution to (11) will be referred to as the first-best inflation rate π_t^{FB}.[19] The first-best solution balances the marginal cost of inflation, $f'(\pi_t)$, against the gains from obtaining lump-sum revenues through seignorage.

The equilibrium inflation rate without precommitment differs from the first-best, because the policy-maker has an opportunity to devalue government debt and to redistribute wealth from foreigners to residents. This can be seen most easily by re-writing (10) as

$$U_\pi = U_\pi^{FB} + h'(\tau_t) \cdot D_{t-1}^n + L_{t-1}^n = 0 . \tag{12}$$

The equilibrium rate of inflation satisfying (10) and (12) will be referred to as the discretionary or second-best solution, π_t^{SB}.

The discretionary solution has two interesting features. First, any nominal external liability--private or governmental--has an inflationary effect. If national debt is outstanding in nominal terms $(L_{t-1}^n > 0)$, inflation redistributes wealth from foreigners to domestic individuals. Since such a redistribution would increase welfare, the government is tempted to inflate.

Second, nominal government debt and nominal external debt have qualitatively similar incentive effects, but enter into (12) with different weights, $h'(\tau)$ and 1, respectively. Whenever the weighted sum of debts $h'(\tau_t) \cdot D_{t-1}^n + L_{t-1}^n$ is positive, the second-best rate of inflation is higher than the first best. Intuitively, internal nominal government liabilities (money and bonds) tempt policymakers to inflate, because they can be used to extract a lump-sum tax from individuals. The welfare benefit of this tax is the reduced distortion, which is $h'(\tau)$ on the margin. External nominal debt has a unit weight, because a redistribution of wealth from foreigners to domestic individuals would increase welfare one-for-one.

Several other features of the solution are similar to those found in the literature. First, the tradeoff between seignorage on money and the cost of inflation has been studied by, e.g., Barro (1983), Mankiw (1987), and Roubini and Sachs (1988). Second, since the government cannot fool investors in equilibrium, the discretionary equilibrium yields lower welfare than the precommitment solution (strictly lower, unless $h'(\tau_t) \cdot D_t^n + L_t^n = 0$). This is a common feature of many time-consistency models, see, e.g., Barro and Gordon (1983a). Third, equation (10) shows that nominal government debt has similar incentive effects as fiat money. This has been noted by Bohn (1988a) and Persson et al. (1987). Finally nominal government debt affects the second-best but not the first-best solution, which is similar to the model of Poterba and Rotemberg (1990).

Thus, the distinctive feature of this model is that external debt matters for incentives in a similar way as fiat money and nominal government debt, but with a different weighting factor. The relative importance of internal and external nominal debt depends on the marginal welfare cost of taxes $h'(\tau)$. Estimates by Ballard, Shoven, and Whalley (1985) indicate that plausible values of parameter are far less than one. Their preferred value is 0.332 (p. 135, Table 4). Thus, changes in external debt have about a 3-times larger impact on incentives than changes in government debt. Nominal government debt sold to foreigners combines both incentive effects, i.e., has about 4-times the incentive effect of government debt held by domestic residents.

If other estimates of the marginal cost of taxes $h(\tau)$ were used, the values would change accordingly: The relative importance of external debt would be larger, if $h(\tau)$ were lower. With lump sum taxes, only external debt would matter. But note that lump-sum taxation would not remove the time-consistency problem. This is another feature that differs from the literature using closed economy models. Even with lump-sum taxes, government would have an incentive to devalue external debt through inflation.

In a debtor country, the time-consistency problem of nominal government liabilities is reinforced by external nominal debt. On the other hand, if the country is a creditor in nominal terms, the time-consistency problem of monetary policy is reduced and may even vanish. Specifically, the first-best monetary policy is time-consistent, if individuals hold positive nominal claims, $\left(-B_t^n\right) > 0$, so that

$$\left(-L_{t-1}^n\right) = h'(\tau_t) \cdot D_{t-1}^n \tag{13a}$$

or

$$\left(-B_{t-1}^n\right) = (1 + h'(\tau_t)) \cdot D_{t-1}^n \tag{13b}$$

since (10) then reduces to (11). Domestic individuals must hold all government debt and they must hold additional nominal claims on foreigners. In effect, the government can credibly promise low inflation, if it is known that inflation hurts its own residents. Thus, even if the government has substantial nominal liabilities, an external creditor position may eliminate the time consistency problem entirely.

Unless (13) holds, welfare is lower in the discretionary equilibrium than in the first best solution. Therefore, one may ask whether the government can improve welfare by playing the game in a different way.[20] As usual in repeated game situations, the discretionary solution π_t^{SB} is only one of a multiplicity of subgame-perfect Nash equilibria in the game between government and investors.[21] However, π_t^{SB} is the only solution that does not depend on the history of the game. Its simplicity may make it the natural outcome. On the other hand, a government announcement of a different inflation rate may be credible, if the announced rate is supported by another subgame-perfect Nash equilibrium.

In particular, the first-best inflation rate can be sustained as a reputational equilibrium, provided the discount factor ρ is sufficiently close to one and provided π_{t+i}^{SB} and π_{t+i}^{FB} differ in all future periods $t + i$.[22] The latter qualification points to a potential weakness of reputational arguments in this game. If the government announces that inflation will be $\pi_t = \pi_t^{FB}$ (or some other value below π_t^{SB}) and if individuals believe it, the marginal one-period welfare gain from deviating is given by the expression in (10) evaluated at $\pi_t^e = \pi_t^{FB}$. It is increasing in current debt D_{t-1}^n and L_{t-1}^n. If a deviation triggers a subsequent movement to the discretionary solution so that $\pi_{t+i} = \pi_{t+i}^e = \pi_{t+i}^{SB}$, $i \geq 1$, the welfare losses in future periods depend on the differences between π_{t+i}^{SB} and π_{t+i}^{FB}, which depend on future debt, D_{t+i-1}^n and L_{t+i-1}^n. Inflation π_t^{FB} can be supported as equilibrium, if discounted future losses exceed the one-period gain from deviating. Thus, for a given discount factor $\rho < 1$ the first-best outcome will be difficult to support by trigger strategies, if nominal debt varies significantly over time. The higher the current levels of nominal government debt and external debt, the less "likely" it is that low inflation can be supported by reputation.[23]

Overall, the model illustrates the importance of external nominal debt for inflationary incentives. In the discretionary equilibrium characterized by (10) or (12), inflation exceeds the first best inflation rate by an amount monotonically related to the linear combination $h'(\tau) \cdot D^n_{t-1} + L^n_{t-1}$. In a reputational setting, a high value of the same linear combination increases the temptation to raise the inflation rate above the announced value. To assess the quantitative significance of government and external debt, the next section will compute the U.S. net external position in dollar-denominated investments.

4. Inflationary Incentives and U.S. External Debt

The model suggests that nominal government liabilities D^n and nominal external liabilities L^n are important for inflationary incentives. While data on nominal government debt are well known, data on the currency denomination of external debt is not readily available. For the United States (as example), I have computed these numbers for 1980-1988 and two earlier years to explore the relative significance of external debt. The net investment position of the United States and its U. S. dollar component are displayed in Table 1 (The "foreign" column is discussed below). The appendix describes the data sources and underlying assumptions.[24]

Since 1981, the U.S. total net external position has fallen drastically. A large fraction of the external deficit is apparently being financed by Treasury bonds and dollar-denominated bank liabilities, leading to a sharply deteriorating net dollar-position since 1982. Net external nominal debt (L^n) jumped from -15.3 billion in 1982 to 533.1 billion dollars in 1988. Interestingly, the United States had a negative net external position in dollar-denominated claims in all years except 1982, even in years when the total net asset position was positive. This may reflect the role of the dollar as international reserve and transactions currency.

Implications for inflationary incentives are derived in Table 2. The table shows how much the net wealth of domestic residents would increase, if nominal liabilities were devalued by 10%, expressed as fraction of GNP (for details, see the Appendix). Conventional closed economy analysis would predict that welfare would increase by $h'(\tau)$ times the government debt/GNP ratio, as computed in the first line. Line 1 suggests that the rising government debt/GNP ratio has increased the temptation to inflate between 1981 and 1986. But in an open economy, the effect of nominal external debt (line 2) must be added to obtain the full gain from inflation (line 3). Then the increase is dramatic: The temptation to inflate has more than doubled (from 0.98% to 2.55%) between 1981 and 1988. While the government debt-GNP ratio has stabilized since 1986, the temptation to inflate due to rising external nominal debt continues to rise. A closed economy analysis of inflationary incentives would have missed most of this increase.

Intuitively, the United States had current account and budget deficits of comparable magnitude in recent years. Both have largely been financed with nominal debt. But because of the 3:1 weighting, the resulting concern about inflationary incentives should be attributed mainly to the deterioration in the external debt position rather than to the increase in government debt.

The literature on inflationary taxation (e.g., Mankiw (1987), Roubini and Sachs (1988), Trehan and Walsh (1989), Poterba and Rotemberg (1990)) has largely ignored the international dimension of the time-consistency problem, though several of the papers use international data. In the context of this paper, the omission of external debt is a misspecification; the mixed results on inflationary taxation are not surprising. As a conjecture, external debt may be even more important for other, smaller and more open economies than it is for the United States.[25]

In the model of Sections 2 and 3, foreign currency debt has no special role. This is somewhat surprising, since the 1978-79 "Carter-bonds" and more recent proposals to issue Yen-denominated Treasury bonds[26] were widely viewed as measures that should signal an effort to maintain the purchasing power of the dollar. In the model, the choice between foreign currency debt and indexed debt has no incentive effect. The temptation to inflate will indeed be reduced, if foreign currency debt replaces domestic currency (nominal) debt. But the same reduction could be achieved if indexed debt replaced nominal debt. The inflation reduction arises only because nominal debt is inflationary, not because foreign currency debt is particularly beneficial.

Foreign currency would likely have a more interesting role, if the government were able to influence the real exchange rate (e.g., because of monetary non-neutralities) or foreign inflation (e.g., through lobbying the foreign government). Foreign currency debt would then have incentive effects, namely encouraging a real appreciation of the domestic currency and high foreign inflation. Again, government as well as external debt in foreign currency debt would matter.[27] To assess the potential incentive effects, the third row in Table 1 shows the component of the U.S. net external positions that is presumably sensitive to real exchange rate movements. The fact that U.S. has a large net positive balance on this component means that there may be a temptation to devalue the real exchange rate. This merely illustrates the possible quantitative importance of real exchange changes for government incentives; it is beyond the scope of this paper to provide a full assessment of optimal exchange rate choices. But since some authors place considerable importance on monetary effects in explaining real exchange rates (e.g., Dornbusch (1976)), it should be noted that, if monetary non-neutralities were present, optimal monetary policy and optimal inflationary finance may have more determinants than those discussed in Section 3.[28]

5. Conclusions

In an open economy with capital mobility, the government's incentive to generate surprise inflation depend not only on government debt, but also significantly on external debt. If external debt is denominated in nominal terms, inflationary money growth causes redistribution between domestic residents and foreigners. A government that cares about the welfare of its residents will be tempted to inflate whenever the country is a net debtor in nominal terms. On the other hand, the usual closed-economy time-consistency problem (caused by the temptations to increase output and to reduce the internal government debt) can be offset by a sufficiently high net creditor position of the country.

For the United States, these international considerations should become increasingly relevant as the country accumulates external deficits. My estimates indicate that the incentive to inflate more than doubled between 1982 and 1988. More than two-thirds of this increase was due to higher external debt, which was largely financed in nominal terms.

FOOTNOTES

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[1]See, e.g., Kydland and Prescott (1977), Calvo (1978), and Barro and Gordon (1983a).

[2]See, e.g., Barro (1983), Lucas and Stokey (1983), Lucas (1986), Persson et al. (1987), Bohn (1988a, b) and Poterba and Rotemberg (1990).

[3]For simplicity, the model has no feature that would make nominal debt beneficial (cf. Bohn (1988a)). Reputational arguments are discussed below.

[4]See Mankiw (1987), Roubini and Sachs (1988), Poterba and Rotemberg (1990). An exception is Canzoneri (1989), who analyzes a cash-in-advance model in which seignorage revenue can be extracted from foreigners (see the discussion below).

[5]Equivalently, purchasing power parity is imposed. Endogenous exchange rates were discussed in an earlier version of the paper (available on request).

[6]Constant *r* keeps real factors invariant with respect to policy changes and simplifies the welfare analysis. For a model with endogenous real interest rates, see Bohn (1988a). Linear utility is not a necessary assumption, but it simplifies the exposition.

[7]Uncertainty in endowments or other exogenous variables could easily be added (with linear utility). Most importantly, the certainty model abstracts from differences in state-contingent payoffs of different securities.

[8]One may naturally set $\varepsilon = 1$. But various stories about cash and credit goods or trading opportunities would be consistent with $0 < \varepsilon \leq 1$. Since velocity $1/\varepsilon$ differs from one in reality, the factor ε should not be constrained to one in the model. Otherwise, one might obtain a very misleading impression about the quantitative importance of seignorage.

[9]This differs from Canzoneri (1989), who sets up a cash-in-advance model in a way that foreigners are forced to hold some domestic fiat currency (See Helpman and Razin (1984) on currency choice in general.) It should be emphasized that seignorage will not play an important role in this paper, because holding of government-issued money are quantitatively small relative to the volume of other nominal claims (see below). Therefore, I feel that simple assumptions on

money are preferable to a more elaborate, rigorous model of why fiat money is held. Canzoneri has taken the complementary approach of modeling seignorage on fiat money in detail but leaving out nominal debt.

[10]Only taxes on endowments are considered. Taxes on interest income would create more time-consistency problems (which are well known and not the subject of this paper) and might cause additional distortions. But notice that, due to the fixed discount factor, taxes would not affect after-tax returns.

[11]The loss function $h(\cdot)$ can be interpreted as a function indicating the net cost of inefficiencies caused by distortionary taxes, which are not modeled explicitly. This way of modeling frictions follows Barro (1979). Under some conditions, such distortions could be derived from first principles. For example, if all taxes were income taxes, if output were produced from labor inputs, and if the utility function included an additive term for the disutility of labor, the key equations (10) and (11) would remain unchanged. The functional form of $h'(\tau)$ would involve the labor supply elasticity and other parameters of the model in a specific way. But a less restrictive interpretation will be more convenient for the calibration in Section 4.

[12]Many individuals apparently dislike inflation, but it is unclear why moderate, anticipated inflation (i.e., short of hyperinflation) should have significant real cost (see Fischer and Modigliani (1978)). One could assume that real money balances at the start of the period enter into the utility function, which would make $f(\cdot)$ a specific function of preference parameters. But since this would only complicate the model without providing additional insights, a flexible functional form is used.

[13]Few governments currently issue indexed securities (e.g. Britain, but not the US). But in this certainty model, any asset with a return that is unaffected by domestic inflation is equivalent to an indexed bond. Foreign currency debt is an example (See Section 4).

[14]For simplicity, government spending is set equal to zero. Any exogenous process of government spending could be added easily.

[15]That is, it is beyond the scope of this paper to model all determinants of private debt that may be relevant in practice (e.g., differences in time-preferences, risk aversion, transactions cost, motives of portfolio diversification and hedging).

[16]For the United States, the ratio of the money base (which is the relevant concept of money for seignorage) to GNP was 5.7% at the end of 1987 as compared to a government debt (privately held) to GNP ratio of 38.9%. With nominal interest rates below 10%, total seignorage is less than $25 billion, as compared to federal receipts of $854 billion FY1987 (for data, see 1988 Economic Report of the President).

[17]In particular, considerations of tax-smoothing over time or, in a stochastic model, over states of nature may be important; see, e.g., Barro (1979), Lucas and Stokey (1983), Bohn (1990). If minimizing incentive problems is the only goal of debt policy, the problem of excess inflation could clearly be eliminated by setting nominal debt as indicated by (13) below. See Persson et al. (1987) for a closed economy analog.

[18]If the mapping from π_t^e to π_t has a derivative less than one, a unique time-consistent solution (a fixed point) exists. This will be assumed and it seems to be satisfied in all interesting cases. For example, nonnegative nominal government debt is a sufficient condition.

[19]Second order conditions are always satisfied, guaranteeing a unique interior solution. Some readers might want to call this policy second-best (and other policies third best) because of the cost of tax collection $h(\tau)$. With lump sum taxes, zero inflation would be first-best. But costly tax collection is a maintained assumption in this paper, so that the distinction of first- and second-best will refer to monetary policy. Notice that the solution to (11) to close to zero, if ε is small.

[20]An alternative answer could be that the government should not issue nominal debt and that it should prevent foreigners from buying domestic nominal securities, i.e., restrict international portfolio diversification. Or, taking the structure of private debt as given, the government could issue or hold nominal claims as necessary to satisfy (13). But since the model is not set up to address factors that might determine the particular structure of government debt or make

international portfolio diversification desirable, I will take the time series of D_t^n and L_t^n as exogenous. See Bohn (1990) for an analysis of optimal debt management.

[21]See Friedman (1977), Barro and Gordon (1983b), Fudenberg and Maskin (1986), Rogoff (1987); more references are in Rogoff. I refer to the solution of (10) as the discretionary solution in order to have an identifying label for it; of course, all reputational solutions are discretionary in a sense.

[22]In general, this is the Folk-Theorem (see Fudenberg and Maskin (1986)). Strategies are such that any deviation from first-best triggers a reversion to the second-best outcome for a number of periods. Here, the one-period gain from inflating is the integral of U_π in (10) over the interval from the first-best inflation (where $U_\pi > 0$) to the value where $U_\pi = 0$; it is positive. The subsequent welfare loss from this deviation is the discounted difference between first-best and second-best welfare over the "punishment" interval. As long as the first- and second-best solutions differ, the loss can be made arbitrarily large for long punishment intervals by taking a value of ρ close to one.

[23]To be precise, the higher current nominal debt the smaller is the set of ρ-values for which trigger strategies support the first-best inflation rate, given future debt levels. One cannot make a general statement linking the permanent level of debt and ρ-values. This is because both gains from "cheating" and subsequent losses increase with the rising permanent nominal government and nominal external debt. A permanent increase in such debt may decrease or enlarge the set of ρ-values for which π_t^{FB} can be supported by a reputational equilibrium, depending on the functional forms of $f(\,)$ and $h(\,)$.

[24]There are 2 potential problems with the data. First, the market value of net foreign assets is difficult to measure; published statistics use book values to some extent. Second, the currency-denomination of some investment positions is not known.

[25]Long series on the currency composition of net investment positions for different countries would be needed to include external nominal debt in the regression framework of that literature. Their collection is beyond the scope of this paper, given the considerable amount of

raw data needed to compute just the selected numbers on nominal external debt shown in Table 1. A regression analysis with more complete data may be an interesting topic for future research.

[26]See "Baker Rejects Call for U.S. Treasury to Issue Yen Bonds," Wall Street Journal, April 27, 1987, and "Treasury Timing is Right for Reagan Bonds," Wall Street Journal, May 4, 1988.

[27]An earlier version of this paper (available on request) looks at this issue in more detail.

[28]Of course, if non-neutralities are important, monetary policy may have to consider additional real effects, e.g., on output as in Barro and Gordon (1983a, b). The point here is that non-neutralities may be affecting the incentive effect of financial assets.

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Appendix: Details on the Tables

Tables 1 and 2 are derived from Commerce Department and Federal Reserve data, as follows. To obtain Table 1, US foreign assets and liabilities were divided into items denominated in US-dollars, items valued within a foreign country, and a residual. The procedure will be described in detail for the year 1985. The same procedure was used for all other years, unless specifically noted.

Column 1 of Table A.1 reproduces the Commerce Department data for 1985, taken from the Survey of Current Business, June 1989. Columns 2-4 contain the decomposition. Of the US official reserves, line 7 clearly belongs in the foreign column and lines 4-6 are put in the residual category. Though Special Drawing Rights and the IMF position might be considered mixtures of dollar and foreign currency claims, their status as marketable assets is questionable. Therefore, I chose not to include them in either category. Concerning US loans and other long term government assets (lines 9-11), I assume line 11 is foreign, since line 10 identifies the dollar denominated component. Concerning line 12, it is unclear how much of it is foreign currency denominated. Lacking more detailed information, all of it is added into the foreign column.

Concerning US private assets, the assets in lines 14-17 are assumed to be sensitive to changes in the real exchange rate and are therefore copied into the foreign category. Lines 18 and 19 contain both dollar and foreign currency components. I compute the fraction denominated in foreign currency from data published in the Federal Reserve Bulletin (Tables 3.16, 3.19, and 3.23 in various issues up to February 1990) and allocate the entries in lines 18 and 19 accordingly. The Federal Reserve totals differ slightly from the Commerce Department's values in column 1, but the discrepancy is trivial for most years (under 1% for 1980-81 and 1982-87, 1.3% for 1982). Exceptions are 1970 and 1975, for which I do not have data on the foreign currency component of line 18. For these years, the fraction for 1980 (8.7%) is used. Since the foreign currency fractions are small for all years with complete data, the error is presumably not serious.

Foreign official assets in the US are all considered dollar denominated (see below for line 26). Foreign direct investment and investment in corporate stocks are clearly real assets (lines 29 and 33), while Treasury securities and bonds are nominal (lines 30 and 32). Lines 34 and 35 are divided into dollar and foreign currency components in the same way as lines 18 and 19, using Federal Reserve data (Tables 3.16, 3.17, and 3.22 of the Bulletin), except that the foreign currency fraction in line 35 was computed for all bank-reported liabilities (lines 26 and 35) for simplicity. If line 26 contains a foreign currency component, the amount should be entered in line 26 instead of line 35, but such a change would not affect the total foreign denominated debt.

I have also explored how an inclusion of foreign branches of US banks would affect the net investment position. It turns out that the consolidated numbers differ little (less than $20 billion for any year) from those in Table 1. Based on Federal Reserve statistics, foreign branches had net dollar liabilities and net foreign currency assets since 1984, which would increase both balances in Table 1 in absolute value.

Finally, a comment on the accuracy of the estimates is appropriate. Though some subjective judgement was unavoidable, the fact that all large dollar items are well-measured, leads me to believe that the net dollar position contains little error. For the quantitatively largest items in Table A.1, bank-reported assets and liabilities (lines 19, 26, and 35), the currency is known for all but an amount of less than $1 billion. If there are inaccuracies in my decomposition, they are likely in those smaller, "other" items that I did not inspect closely (e.g., lines 11, 12, 24, 25, 27). In addition, I do not have data on off balance sheet commitments like forward contracts or currency swaps. In the net foreign and in the total investment position, the valuation of US direct investment abroad is an important factor. If, as some observers suspect, this item is undervalued, the balances would be more positive than the numbers in Table 1 indicate.

Table 2 uses data on privately held government debt, monetary base, and GNP from the Economic Report of the President. Line 1 shows the rations of year-end privately held government debt plus monetary base to GNP, multiplied by $h'(\tau) \cdot 10\% = 1/30$. Exceptions are 1970 and 1975 where debt is only available for fiscal years. Line 2 shows 10% of the ratio of net dollar-denominated debt (from Table 1) to GNP, and line 3 is the sum of lines 1 and 2. Notice that lines 1 and 3 include the effect of devaluing the real value of money. If one wanted to isolate the part of the wealth effect that exceeds the first best, seignorage would have to be excluded (see equation (11) versus (12)). For the 1980's, excluding seignorage would reduce the numbers in lines 1 and 3 by 0.18%-0.19%.

Table 1: Net Investment Position of the United States

Year	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988
Total ($-L_t$)	58.6	74.2	106.3	141.9	136.7	89.0	3.3	-110.4	-267.8	-378.3	-532.5
Dollar ($-L_t^s$)	-20.8	-41.9	-49.8	-9.7	15.3	-8.8	-80.8	-193.5	-322.3	-432.3	-533.1
Foreign	103.2	163.3	287.0	303.4	298.6	303.7	314.9	360.1	410.4	466.5	497.4

Legend: Billions of US-dollars. See the Appendix for definitions and sources.

Table 2: Wealth Effects of a 10% Devaluation of Nominal Claims

	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988
Government Debt	1.16%	1.04%	0.95%	0.94%	1.08%	1.19%	1.25%	1.36%	1.46%	1.48%	1.46%
External Debt	0.21%	0.26%	0.18%	0.03%	-0.05%	0.03%	0.21%	0.48%	0.76%	0.96%	1.09%
Open Economy Total	1.37%	1.30%	1.13%	0.98%	1.04%	1.21%	1.47%	1.85%	2.22%	2.44%	2.55%

Legend: Own computations, see the Appendix for definitions and sources.

Table A.1: US Foreign Assets and Liabilities in 1985

Line	Type of Investment	Total	Dollar	Foreign	Other
1	Net Investment Position	-111.4	-192.6	359.1	-278.0
2	US assets abroad	949.7	541.3	378.0	30.3
3	US official reserve assets	43.2	0.0	12.9	30.3
4	Gold	11.1			11.1
5	SDR	7.3			7.3
6	Reserve position in the IMF	11.9			11.9
7	Foreign currencies	12.9		12.9	
8	Other US government assets	87.6	84.1	3.5	0.0
9	US loans and other long term assets	85.8	84.1	1.7	
10	Repayable in dollars	84.1	84.1		
11	Other	1.7		1.7	
12	US foreign currency holdings and US short term assets	1.8		1.8	
13	US private assets	818.9	457.2	361.7	0.0
14	Direct investment abroad	230.3		230.3	
15	Foreign securities	112.2		112.2	
16	Bonds	72.9		72.9	
17	Corporate stocks	39.3		39.3	
18	US claims on unaffiliated foreigners reported by US nonbanking concerns	29.0	26.7	2.3	
19	US claims reported by US banks, not included elsewhere	447.4	430.5	16.9	
20	Foreign Assets in the US	1061.1	733.9	18.9	308.3
21	Foreign official assets	202.7	202.7	0.0	0.0
22	US goverment securities	143.4	143.4		
23	US Treasury securities	135.7	135.7		
24	Other	7.7	7.7		
25	Other US government liabilities	15.9	15.9		
26	US liabilities reported by US banks, not included elsewhere	26.7	26.7		
27	Other foreign official assets	16.7	16.7		
28	Other Foreign Assets	858.4	531.1	18.9	308.3
29	Direct investment	184.6			184.6
30	US Treasury securities	83.6	83.6		
31	Other US securities	206.2	82.5		123.7
32	Corporate and other bonds	82.5	82.5		
33	Corporate stocks	123.7			123.7
34	US liabilities to unaffiliated foreigners reported by US nonbanking concerns	29.5	25.9	3.6	
35	US liabilities reported by US banks, not included elsewhere	354.5	339.2	15.3	