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Optimal Management of Indexed and Nominal Debt

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A tax-smoothing objective is used to assess the optimal composition of public debt with respect to maturity and contingencies. This objective motivates the government to make its debt payouts contingent on the levels of public outlay and the tax base. If these contingencies are present, but asset prices of non-contingent indexed debt are stochastic, then full tax smoothing dictates an optimal maturity structure of the non-contingent debt. If the certainty-equivalent outlays are the same for each period, then the government should guarantee equal real payouts in each period, that is, the debt takes the form of indexed consols. This structure insulates the government's budget constraint from unpredictable variations in the market prices of indexed bonds of various maturities. If contingent debt is precluded, then the government may want to depart from a consol maturity structure to exploit covariances among public outlay, the tax base, and the term structure of real interest rates. However, if moral hazard is the reason for the preclusion of contingent debt, then this consideration also deters exploitation of these covariances and tends to return the optimal solution to the consol maturity structure. The issue of nominal bonds may allow the government to exploit the covariances among public outlay, the tax base, and the rate of inflation. But if moral-hazard explains the absence of contingent debt, then the same reasoning tends to make nominal debt issue undesirable. The bottom line is that an optimal-tax approach to public debt favors bonds that are indexed and long term.

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1. INTRODUCTION

In standard macroeconomics, fiscal policy involves choices about expenditures, taxes, and debt issue. The kinds of public spending may be distinguished with respect to their interactions with private decisions, for example, some public activities would influence private production and some would interact with households' choices of consumption and leisure. The

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taxes may also be differentiated by types; levies may fall on labor income, capital income, consumption, bodies, and so on.

The fiscal authority also chooses its type of debt obligations. These choices include the maturity structure of the debt, whether to issue nominal bonds or bonds indexed to the price level or a foreign currency, whether debt payments should be contingent on other variables, such as government expenditures and the state of the business cycle, and so on. These kinds of decisions are less familiar as a part of macroeconomics, although some aspects have been studied by Lucas and Stokey (1983); Persson and Svensson (1984); Bohn(1988, 1990); Calvo and Guidotti (1990); Alesina, Prati, and Tabellini (1990); Giavazzi and Pagano (1990); Chari, Christiano, and Kehoe (1994); Missale and Blanchard (1994); and Marcet, Sargent, and Seppala (1996).

Optimal debt management can be thought of in three stages. First, if taxes are lump sum and the other conditions for Ricardian equivalence hold, as in Barro (1974), then the division of government financing between debt and taxes is irrelevant. Thus, the whole level of public debt will be indeterminate from an optimal-tax standpoint.

Second, if taxes are distorting-for example, because the amount paid depends on an individual's labor income or consumption-then the timing of taxes will generally matter, as in Barro (1979). This consideration tends to motivate smoothing of tax rates over time and thereby can make determinate the levels of debt at various dates. However, this element does not pin down the composition of debt, say by maturity.

Finally, if there is uncertainty about levels of public outlay, the tax base (say aggregate consumption or GDP), and asset prices, then the kinds of debt that the government issues will matter. In particular, the government may want to smooth tax rates over states of nature, and this consideration may dictate an optimal structure of the public debt. As one example, it maybe desirable for debt payouts to be conditioned on the level of government spending. As another example, it may be possible to design the maturity structure of the indexed debt so as to insulate the government's financing costs from shifts in riskless real interest rates.

The strategy in this paper is to assume that the government desires to smooth the path of taxes when confronted by a path of exogenous, but stochastic, outlays. Other analyses, such as Zhu (1992) and Barro (1995), show that this objective can be derived, under some conditions, from the more fundamental objective of expected utility maximization for the representative household. The analysis assumes that policymakers can make effective commitments about the form of future fiscal actions. Hence, unlike Lucas and Stokey (1983) and Persson and Svensson (1984), the debt composition is not set to ensure that policies are time consistent.

2. PUBLIC FINANCE WITH TAX SMOOTHING

The real public outlay for period t is G_t. This outlay is exogenous and stochastic. The government sets its real tax revenue for period t at the value T_t. The precise nature of the taxes is left unspecified. However, these levies are assumed to be distorting in such a way that the policymaker wishes to minimize the overall expected deadweight loss, as given from the perspective of an initial date, time 0, by

$$E_0 \sum_{j=1}^{\infty} w_j (T_{j+1} - T_j)^2 \tag{1}$$

where the $w_j > 0$ are weighting factors. The idea here is that variations in taxes over time cause distortions that the government would like to avoid. This objective will motivate smoothness in the T_j across time and states.[1]

If one think about levies on the tax base, such as income, consumption, or property, then distortions are likely to increase more than in proportion with the amount of taxes when expressed in relation to the tax base. Therefore, T_t and G_t should be construed as ratios to the tax base. Uncertainty with regard to the tax base is analogous to uncertainty with respect to the level of public outlays, and a rise in G_t can be viewed alternatively as an increase in government expenditure or a decrease in the tax base.

Indexed public debt issued at time t pays the certain real amounts $B_{t1}, B_{t2}, \ldots$, in periods $t+1, t+2, \ldots$ These payouts can represent coupons or principal. The real market prices of this debt at time t are $P_{t1}, P_{t2}, \ldots$. These asset prices are taken to be exogenous and stochastic, although the model could be extended to allow the choices of debt policy to affect the asset prices.

The government will also wish, in this model, to issue debt with payouts that are contingent on the realizations of the G_t. The amount of this debt issued at date 0 and due at date t can be structured so that it pays off one unit less for each unit by which G_t exceeds its date-zero expectation, $E_0 G_t$.[2] This debt can also be set up so that it pays a (positive or negative) non-contingent amount at date t, expressed as $\beta_{0t} E_0 G_t$. This amount is assumed to be set so that the market value of contingent debt at date 0 is

[1] The form of equation (1) is natural for consumption taxes in the absence of a labor-leisure choice. In that case, distortions reflect only variations in tax rates over time, not the levels of tax rates. With a labor-leisure choice, terms involving the levels of consumption or labor-income tax rates would also appear. The tax-smoothing behavior considered below is sometimes optimal in this extended setting. See Zhu (1992) for a general discussion of the optimality of tax smoothing.

[2] The debt therefore pays off badly when public outlays are surprisingly high or when the tax base is surprisingly low. The latter contingency is analogous to the GDP-linked bonds described by Shiller (1993).

nil. That is, β_{0t} is the premium (set at time zero) per unit of G-contingency. The amount payable in each period t on the contingent debt is therefore

$$\beta_{0t}E_0G_t + (E_0G_t - G_t)$$

Since a high G_t represents bad times-because high public outlay and a low tax base will typically be associated with low consumption-and the contingent debt pays off badly at these times, the premium β_{0t} tends to be positive.

The government can achieve perfect tax smoothing in this model, that is, it can minimize the sum in equation (1) by attaining $T_1 = T_2 = \cdots = T$. First, the government issues the kind of G-contingent debt that has just been described. This issue effectively converts the path of uncertain outlays, $G_{1,}G_2, \ldots$ into a path of known outlays, $\hat{G}_1 = E_0G_1(1+\beta_{01}), \hat{G}_2 = E_0G_2(1+\beta_{02}), \ldots$. This contingent debt issue ensures that the government's tax smoothing will not be disturbed by surprises in the future levels of public outlays (and tax bases).

Second, the government has to manage its non-contingent debt to get the timing of taxes right, in other words, to ensure equal values of the T_t even when the certainty-equivalent outlays, $\hat{G}_t$, vary over time. This problem would be simple if the future prices of non-contingent debt, P_{tj}, were known with certainty at date 0, that is, if riskless real interest rates were not subject to fluctuation. In that case, any maturity structure of the non-contingent debt — for example, one-period debt — could be used. The only concern, as in Barro (1979), would be to get the total quantity of debt issue correct in each period. However, this procedure does not work if the P_{tj} are subject to uncertainty. In this case, unanticipated shifts in these asset prices-and, hence, in the government's refinancing costs-can affect the government's budget constraint and thereby disturb the smoothing of taxes.

The quantities of non-contingent public debt of the various maturities at date 0 must satisfy the constraint:

$$\sum_{j=1}^{\infty} B_{0j}P_{0j} = V_0 \tag{2}$$

where V_0 is the total market value of government debt (plus or minus) outstanding at date 0. This equation says the government can rearrange its non-contingent debt as it wishes at the going market prices to achieve a desired distribution by maturity.

The government's full outlay for period 1-including the non-contingent payout B_{01} established at date 0-is $\hat{G}_1 + B_{01}$. This quantity is non-stochastic because the uncertainty in G_1 has been hedged by the issue of G-contingent debt. If taxes are successfully smoothed, then the revenue in each period is the same value, T. If there is a gap between the full outlay and revenue in period 1, then the difference must be financed by non-contingent debt issue (plus or minus) at the prices, P_{1j}, of non-contingent debt then prevailing. However, if each of these asset prices contains an independent random element, then any debt issue of this type will cause tax smoothing to fail, because the realizations of the asset prices will impact on required levels of future taxes.[3] Hence, full tax smoothing requires a balance between full outlay and revenue in period 1:

$$\hat{G}_1 + \beta_{01} = T \tag{3}$$

Since no new debt is issued and no old debt is retired in period 1, the full outlay for period 2 is $\hat{G}_2 + B_{02}$. The same reasoning as that applied to period 1 implies that this outlay for period 2 must equal the tax revenue, T. Proceeding forward in time, the conclusion is that the form of equation (3) must hold for every period t:

$$\hat{G}_t + B_{0t} = T \tag{4}$$

Multiplication of both sides of equation (4) by P_{0t} and summation from $t = 1$ to ∞ leads, after substitution from equation (2), to a formula for T :

$$T = \frac{V_0 + \sum_{j=1}^{\infty} P_{0j}\hat{G}_j}{\sum_{j=1}^{\infty} P_{0j}} \tag{5}$$

This result says that the constant flow of real taxes in each period equals the permanent flow of spending, which includes the required financing on the initial debt, V_0, plus the permanent, flow of outlay. The last quantity weighs each amount $\hat{G}_j$ by the present-value factor, P_{0j}. For example, if the one-period, non-contingent real interest rate were the constant r, so that $P_{0j} = 1/(1+r)^j$, then

$$T = r[V_0 + \sum_{j=1}^{\infty}(\frac{1}{1+r})^j \hat{G}_j] \tag{6}$$

Substitution of the result from equation (5) into equation (3) yields the amount of non-contingent debt of each maturity:

$$B_{0t} = \frac{V_0 + \sum_{j=1}^{\infty} P_{0j}\hat{G}_j}{\sum_{j=1}^{\infty} P_{0j}} - \hat{G}_t \tag{7}$$

[3]The assumption is that Ponzi games are precluded and, hence, an effect on the government's budget in any period must, for given pubic outlays, show up eventually in taxes.

Hence, the amount of debt with maturity t is the difference between permanent outlay (including the financing of any initial debt) and the certainty-equivalent outlay for period t.

Suppose, as an example, that each period has the same level of certainty-equivalent outlay, $\hat{G}_t$. In this case, the terms involving the outlays cancel in equation (7), and the quantity of debt for each period is a constant, given by[4]

$$B_{0t} = V_0 / \sum_{j=1}^{\infty} P_{0j} \tag{8}$$

One may to look at this answer, in terms of pure discount bonds, is that the maturity structure of the non-contingent debt has no holes:[5] the government arranges the debt at the outset so that the real amounts to be paid in each future period (up to $t = \infty$) are the same.[6] However, because of the discounting on future real payouts (that is, a declining time path of the P_{0j}), the current market value of the outstanding debt declines steadily with maturity.

From the standpoint of coupon bonds, the government should structure its debt as indexed perpetuities (consols).[7] These issues pay a uniform and perpetual stream of real coupons but have no principal payments.

The prescription for consols may seem to entail a maturity structure of the public debt that is much longer than that observed in practice. However, when governments issue real bonds, the stated maturity-and, more pertinently, the average duration of the real payouts-tent to be long. For example, when Britain was on the gold standard in the eighteenth and nineteenth centuries, nominal obligations were effectively real. At that time, the public debt was mainly long term (funded) and often took the form of consols.[8] TheU.S.debt issued under the gold standard before World War

[4] If the one-period, non-contingent real interest rate is the constant r, then $B_{0t} = rV_0$.

[5] This result on the desirable maturity structure of the public debt therefore differs from the suggestion of Friedman (1959, p.63): I can find no valid argument for the present policy of issuing a wide variety of securities... The alternative suggestion follows... Issue... debt in two standard forms, one short-term... the other moderately long-term, The short security might be a 90-day bill... The longer security might best be a consol-that is, a perpetuity... A less extreme break would be to make it, let us say, an eight- or ten-year maturity. I do not myself believe that the precise maturity of the debt outstanding is of great significance.

[6] Alesina, Prati, and Tabellini (1990) and Giavazzi and Pagano (1990) argue on different grounds-to avoid confidence crises-that similar amounts of public debt should come due in each period.

[7] Lucas and Stokey (1983) argue that consol debt may also be desirable on time-consistency grounds. In some situations, this maturity structure deters the government from making tax changes that would affect the term structure of real interest rates.

[8] See Mitchell and Deane(1962,pp.401-409).

I was also primarily long term; for example, most of the U.S. government bonds outstanding in 1916 had remaining maturities in excess of 20 years.[9]

Many developed countries have recently issued indexed bonds, and these securities tend to be long term. For example, the U.K. government has issued indexed coupon bonds with maturities as long as 38 years, which is nearly infinity. For other countries (as discussed in Bank of England [1995]), the issues of coupon bonds include Canada with 30-year maturity, Australia with 20 years, and Israel with 15 years. Sweden has issued discount bonds with maturities of 19 years — the duration of a consol would be 19 years if the real discount rate were around $5 - 1/2\%$. The United States, which began the issue of indexed bonds only in 1997, began with a 10-year maturity. More generally, the observed short maturity for public debt in modern times applies mainly to nominal bonds in the context of a paper monetary standard.[10] Nominal debt is considered in a later section.

Returning to equation (7), if the expected outlays differ across periods, then the debt structure no longer consists precisely of consols. A period with a high level of certainty-equivalent outlay has associated with it a correspondingly reduced level of debt coming due. For example, if a war or a major building project were anticipated for period t, then the debt would be structured at date 0 so that little debt would mature during period t. Otherwise, the government would have to borrow a lot in period t at financing cost that is uncertain at time 0. However, the practical relevance of this result is unclear, because it depends on the government having advance information about the future time pattern of public outlays.

If there were a positive drift in G_t-which has to be interpreted in the model as a drift in public spending as a ratio to GDP or some other measure of the tax base-then equation (7) calls for a negative trend in B_{0t}. Hence, the maturity structure of the debt would, in this case, be shorter term than a consol.

If the ratio of public outlay to the tax base had no drift but the levels of government spending and the tax were each drifting upward-as would be expected with secular growth of the economy-then the optimal B_{0t} would have a corresponding upward drift. Therefore, the maturity structure of the debt would be longer term than a consol in this situation.

3. A LIMITATION TO NON-CONTINGENT PUBLIC DEBT

A striking property of the previous solution is that the government arranges its debt obligations fully at date 0 and then never issues or buys

[9]See Board of Governors of the Federal Reserve System (1943, p. 411).

[10]The usually stated maturity for nominal bonds overstates the duration not only because of the coupon payments but also because no account is taken of the diminished real value of future payouts due to inflation.

back debt in subsequent periods. All the government does with respect to debt in future periods is, first, make contingent payments based on the realizations of the G_t and, second, make the previously agreed non-contingent payouts (of roughly consol form).

These findings rely on the assumption that the government can use G-contingent debt effectively to convert its path of uncertain outlays into a deterministic path. The results would be different if the government were precluded from issuing G-contingent debt. However, the reason for this preclusion would likely not be on technical grounds involving the construction of the appropriate type of instrument. In countries with sophisticated financial markets and in which national accounts data are available accurately without substantial delays, there would be no problem in creating this kind of debt contract.

The likely source of difficulty involves moral hazard-if debt payouts are contingent on the level of public outlay, then the government is likely to overspend, even perhaps to fight too many wars.[11] In addition, the government might be tempted to manipulate the statistics on spending to create the appearance of a contingency that warranted poor payouts on the debt. This problem might be acute because the relevant contingency involves not only the computation of the level of public outlays but also the scaling of these outlays in relation to some concept of a tax base.

Suppose then that the government is limited to non-contingent debt, taken here to be indexed bonds of various maturities. It would be technically straightforward to carry out the exercise of smoothing taxes as much as possible in the sense of the objective in equation (1) while limiting the government to the use of non-contingent debt. (See, for example, Giavazzi [1997] for a sketch of this exercise.) Then, instead of using indexed debt that was an approximation to a consol, the government would want to

[11] Such illustrious economists as Adam Smith and David Ricardo argued that governments have an excessive tendency to fight wars when the available method of war finance is too convenient. In their contexts, the overly convenient method of finance was viewed as debt issue, rather than current taxation, but the point about moral hazard is the same. Smith (1791, p. 427) said: Were the expence of war to be defrayed always by a revenue raised within the year ... wars would in general be more speedily concluded and less wantonly undertaken. The people feeling, during the continuance of the war, the complete burden of it, would soon grow weary of it, and government, in order to humor them, would not be under the necessity of carrying it on longer than it was necessary to do so. Ricardo (1951,pp.186-87) pointed out that wartime spending could be financed by taxes, borrowing, and borrowing with the establishment of a sinking fund and then said: Of these three modes, we are decidedly of the opinion that the preference should be given to the first... When the pressure of war is felt at once, without mitigation, we shall be less disposed wantonly to engage in an expensive contest, and if engaged in it, we shall be sooner disposed to get out of it, unless it be a contest for some great national interest. Clearly, Ricardo copied this idea from Smith, and it is therefore odd that Ricardo went on to point out the economic equivalence of the three methods of paying for government spending (a point that Smith did not seem to recognize).

exploit any covariances between the future G_t and the future prices of non-contingent debt, P_{tj}. For example, it is likely that a surprisingly high level of public outlay, G_t, would be associated with high riskless real interests and, hence, lower than expected values of the P_{tj}. Moreover, this effect tends to be greater at longer maturities, where asset prices are more sensitive to changes in real discount rates. (This effect depends also on the extent to which a current surprise in G_t signals a long-term change in the level of public outlays.) The likely conclusion is that the government could usefully hedge some of the uncertainty in the G_t by tilting the maturity structure toward more long-term debt and less short-term debt (or even toward the holding of short-term assets). Hence, the optimal maturity structure would tend to be even more long term than the consol structure derived before.

This kind of analysis would be valid if the rationale for the omission of G-contingent debt were technical problems in setting up the right kinds of financial contracts. In this case, it might be desirable to create the G-contingency indirectly by exploiting the covariances between G_t and some other variable, such as the P_{tj}, for which contingencies were feasible (in the case above by selecting the maturity structure of the non-contingent debt).

However, the argument is invalid if — as seems plausible — the main reason for the omission of the G-contingent debt involves moral-hazard problems of the sort described earlier. In that case, the same moral-hazard problem arises when the contingency on G_t is attained indirectly. For example, if the maturity structure of the non-contingent public debt were skewed toward the long end, and if an increase in G_t tends to depress the prices of long-term debt relative to short-term debt, then the government would still have an excessive incentive to spend, including to fight too many wars. (The government would, however, not have an incentive to overstate the statistics on G_t, unless the asset prices reacted to the stated values of the G_t, rather than the actual values.)

If the moral-hazard problem is so serious that it motivates the government to use explicitly G-contingent debt to a zero extent, then it seems that it would also motivate the government to use indirectly G-contingent debt to a zero extent. That is because the indirect contingency has the same moral-hazard problem but is otherwise less efficient than the direct method. For example, the indirect contingency achieved by skewing the maturity structure of non-contingent debt toward the long end has the problem of creating sensitivity of the government's future financing costs to shifts in the P_{ij} that are independent of the movements in the G_t. The avoidance of this sensitivity was the rationale for the consol financing in the first place.

Thus, my conjecture is that the full solution to the model with moral hazard — when this hazard is sufficient to preclude G-contingent debt issue

— is that the government will also optimally avoid the exploitation of the covariance between the G_t and the P_{tj}. To avoid this exploitation, the government will have to maintain the maturity structure of the indexed debt that was optimal when G-contingent debt was available, that is, the consol-type structure.

Even if the last conjecture is correct, the preclusion of G-contingent debt is important because it implies that the government will have to react to the realizations of the G_t by altering the amount of debt outstanding. For example, a surprisingly high level of public outlay-as in a war-will be accompanied by the issue of new consol debt. In contrast, surprisingly low levels of outlay will cause retirement of outstanding debt. This form of action describes pretty well the observed behavior of the British government over more than two centuries (see Barro [1987]).

4. NOMINAL BONDS

Suppose now that the government can issue nominal debt with varying maturities. Let b_{0j} be the nominal amount committed in period 0 to be paid in period j and p_{0j} the associated time 0 real market price of these bonds. The real value of the future payouts depends on the realizations of future price levels. Future real prices of the nominal bonds, p_{tj}, depend on the price level for period t and on the prospects at time t for future inflation and real interest rates (which together determine nominal discount rates).

The probability distribution for inflation is treated here as exogenous to the government's fiscal choices, and the distortions caused by inflation are assumed not to interact with those of other taxes. Bohn (1990) also takes this approach.

The stochastic properties of inflation are assumed to reflect some empirical regularities. One of these regularities, applicable to the paper monetary standards of modern times, is that innovations to inflation are highly persistent. In fact, the inflation rate is close to being non-stationary in post-World War II data, say for the United States and the United Kingdom.

Another apparent regularity is that innovations to inflation tend to signal bad times ahead in the long run. As a reflection of this pattern, for U.S. quarterly data from 1957 to 1994, the contemporaneous correlation for a measure of unexpected inflation with the real return on the stock market is negative and surprisingly large in magnitude, -0.4.[12] In contrast, the

[12] The series on expected inflation is an updated version of the one constructed in Barro (1992). These values come from an ARMA process with deterministic seasonals for CPI inflation, with the estimated coefficients updated each quarter to use only lagged data. The inflation rate is computed from monthly, seasonally unadjusted values of the

short-term relation between the inflation rate and real GDP tends to be positive; that is, inflation is mildly procyclical.[13]

An additional feature of inflation is its positive correlation with wartime spending, especially for such large conflicts as World Wars I and II and the Napoleonic Wars (see Barro [1987]). However, for the moderate fluctuations of government spending that show up in the U.S. data since World War II, there is no significant relation between innovations to inflation and movements in government expenditure.

In the model set out at the outset, where G-contingent and indexed debt instruments were available, the issue of nominal public debt would be a mistake. The resulting fluctuations in financing costs, because of unanticipated inflation and unanticipated changes in the future prices of nominal debt, would create unnecessary variations in taxes and thereby generate some departure from perfect tax smoothing in the sense of the objective in equation (1).

If indexed bonds are unavailable and the government is therefore forced to issue nominal bonds, then the maturity of the nominal debt could be designed to hold down fluctuations in taxes. Since innovations to inflation tend to persist, the prices of long-term nominal bonds would be more volatile that those of short-term bonds. Therefore, the greater the volatility and persistence of inflation, the more the government would shift toward short-term issues to minimize the effect of unanticipated inflation on financing costs.

For example, in the United States, the average maturity of the public debt (weighted by nominal amounts of principal outstanding) fell from around nine years in 1946 to less than three years in 1976, then returned to five-to-six years at recent times.[14] It seems reasonable that these changes were caused by shifts in the variance of inflation, which was low from the mid 1950s to the early 1970s, high from then to the mid 1980s, and reduced again in recent years. Although a shortened maturity of the public debt is a sensible response to more volatile inflation-given that the debt takes a nominal form-this shift also makes the government's refunding costs more sensitive to movements in real interest rates. The whole point of the use of indexed consols in the original model was to leave the government's financing expenses-and, hence, its path of real taxes-invariant with changes in riskless real interest rates. This insulation is lost by a reliance on short-term nominal (or real) debt.[15]

CPI for January, April, July, and October. Real stock returns are the growth rate of the S&P 500 index less CPI inflation plus the S&P 500 dividend yield.

[13]The departure of the price level from its trend tends, however, to be countercyclical. See Kydland and Prescott (1990) and Barro and Grilli (1994, pp. 14,15).

[14]See Council of Economic Advisers, Economic Report of the President, 1966, 1997.

[15]The significance of this lost insulation depends on the volatility of riskless real interest rates. From an empirical standpoint, the extent of this volatility can be gauged

Bohn (1988, 1990) and Calvo and Guidotti(1990) argue that nominal debt may be a desirable from of funding because of the covariance of inflation with other variables, such as the G_t in the present model. The usual idea is that high G_t tends to go along with high inflation. This pattern reflects partly the positive correlation between inflation and government spending (especially apparent for large wars) and partly the negative correlation between inflation and long-run economic activity (and, hence, the tax base). Since nominal bonds pay off badly in real terms when inflation is surprisingly high, this kind of debt has some of the characteristics of the G-contingent debt that was considered before. As an example, the presence of nominal bonds allows the government to effect partial default via inflation during wartime.

The covariance between inflation and G_t would be of no advantage and would provide no case for nominal public debt issue if G-contingent debt were already available and exploited. However, if this type of debt were precluded, then it might seem worthwhile to issue nominal bonds. The gain from the negative covariance of the real returns on these bonds with G_t might outweigh the costs from independent variation in inflation-which would generate volatility in the real returns on nominal debt and thereby adversely impact the stability of real taxes.

The problem with this line of argument is the same as the one that arose in the previous discussion of the maturity structure of indexed bonds. If the reason for the exclusion of G-contingent debt is the moral-hazard problem, then this same problem arises for indirectly G-contingent debt. In the previous section, therefore, it did not seem desirable to skew the maturity structure of indexed bonds to create a negative covariance between G_t and the government's financing costs. Similarly, it seems inadvisable to use nominal debt as another way to generate a negative covariance between G_t and financing costs. Nominal debt seems always to be inferior to explicitly G-contingent debt because it entails the same moral hazard but also introduces unnecessary randomness in real financing costs and, hence, in real taxes.

One way to generate a role for nominal government bonds is to assume that the government is already involved with nominal obligations in some other way. For example, the government has nominal obligations outstanding. Surprise increases in inflation (likely engineered by the monetary authority) benefit the government's budget by depreciating the outstanding real cash balances and perhaps by signaling a higher prospective flow of seignorage income. But then the government would have to hold nominal

from the U.K. experience with indexed government bonds. From 1982 to 1995, the 2-year-ahead real forward rate (for the subsequent 6 months) ranged from around 2% to $5 - 1/2\%$, whereas the rate 20 years ahead varied from about $2 - 1/2\%$ to $4 - 1/2\%$.

assets-not debts-to offset this effect and thereby insulate the overall budget situation from surprise inflation.[16]

Similarly, if the indexing of government bonds involves a lag in the formula — that is, if the adjustments of nominal coupons and principal are based on lagged inflation — then the government effectively already has some nominal debt outstanding. The way to offset this exposure of real obligations to inflation would be for the government to hold some other nominal assets.

A rationale for a positive quantity of nominal government bonds along these lines would require the government to have other outstanding claims that suffer in real value when inflation is surprisingly high. Under some circumstances, the tax system can have this feature, especially if liabilities are specified in nominal terms and taxpayers have opportunities for delaying payment to the government. Then the nominal public debt could be an instrument that keeps the government's budget constraint invariant overall with shocks to inflation. In this case, however, the previous analysis of indexed and G-contingent debt would be fully separable from the behavior of inflation and nominal debt. In particular, the consol form of indexed financing would still be desirable.

5. CONCLUDING OBSERVATIONS

This analysis has analyzed public-debt management from an optimal-tax perspective. This approach seems inevitably to favor indexed bonds that have long, consol-like durations. Possibly one could explain the observed tendency for indexed debt to be shorter term than consols by allowing for the potential of government default.

The analysis suggests little role for nominal government bonds, except perhaps as devices to offset other kinds of nominal exposure that the government possesses. Possibly one can go further here by introducing commitment problems into the optimal-tax problem, but it is hard to see how these considerations will favor the use of nominal public debt.

One possible reaction to these results is that the case for nominal government bonds must rely not on orthodox public-finance considerations but rather on short-run macroeconomics, which is often thought to have something to do with sticky prices. This is reassuring-to understand the desirable role for nominal government bonds one has only to understand macroeconomics and business fluctuations. These are things that I have always wanted to understand in any case.

[16]Persson, Persson, and Svensson (1987) argue that the insulation of the government's budget constraint from surprise inflation can also be desirable on time-consistency grounds, that is, to deter the government from engineering surprise changes in inflation.

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