Time Consistency of Fiscal and Monetary Policy

Persson, Mats, Torsten Persson and Lars E.O. Svensson

Working Paper No. 57
September 1986

TIME CONSISTENCY OF FISCAL AND MONETARY POLICY[1]

by

Mats Persson*, Torsten Persson** and Lars E.O. Svensson**

Working Paper No 57

September 1986

Abstract: The problem of time inconsistency arises from two different sources. First, as shown by Calvo (1978), there is an incentive for each government to engage in an initial unanticipated inflation. Second, as discussed by Lucas and Stokey (1983), there is an incentive for each government to deviate from the path of taxes announced by the preceding government. In this paper it is shown that these two sources of time inconsistency can be removed by a particular method of debt management involving both nominal and indexed government bonds of various maturities.

* Institute for International Economic Studies

** Institute for International Economic Studies and

Rochester Center for Economic Research

1. INTRODUCTION

To find the optimal combination of income taxation and borrowing for financing government expenditure is an intertemporal optimal taxation problem. In Lucas and Stokey (1983), a path of distortionary income taxes is chosen so as to finance a given path of government expenditure at minimal welfare losses. Any excess of the optimally chosen taxes over expenditures in a given period is covered by borrowing. With fiat money, government expenditures can also be financed by the inflation tax. Such a tax is distortionary by yielding positive nominal interest rates that drive real balances below Friedman's optimum quantity of money. Phelps (1973) was the first to seriously discuss the "general macroeconomic public finance problem", namely how to find the optimal combination of the two taxes. It is well known that the solution in general requires that both the inflation tax and the income tax be used for financing government expenditures.

These aspects of the optimal combination of income taxes, inflation tax and borrowing applies when the government can commit itself to a particular policy. It is well known after Kydland and Prescott (1977) that a government under discretion usually has incentive to deviate from previously announced policy, and hence that the optimal policy under commitment is not time-consistent under discretion. Further, the optimal time-inconsistent policy under discretion usually leads to welfare losses relative to the optimal policy under commitment.

Several suggestions have been forwarded how the time-consistency problem can be avoided and welfare improved. Some researchers, like Kydland and Prescott, have advocated fixed rules for policy rather than discretion (the credibility of these rules has typically been assumed rather than analyzed, however). Others, like Barro and Gordon (1983), have suggested that when expectations of future policy depend on current policy, reputational considerations may impose restrictions on governments which improve welfare. In their study of the intertemporal optimal tax problem mentioned above, Lucas and Stokey (1983) suggest a third alternative. They show that a carefully managed maturity structure for the national debt may induce later governments to follow a previously announced policy, and that the optimal policy under commitment can actually be made time-consistent under discretion. Their suggestion involves a partial commitment, namely to honour previous debt, but no commitment about taxes. These results are further extended and interpreted by Persson and Svensson (1984, 1986a).

Lucas and Stokey's result applies to a situation without money. They argue, in line with previous literature such as Calvo (1978), that the time-consistency problem is unavoidable whenever there is a fiat money. The argument is that when taxes are distortionary the government has always an incentive to create a surprise inflation and thus effectively impose a lump-sum tax by reducing the real value of the private sector's nominal assets. The only way out of this dilemma, it has been argued, is a commitment to a continuous path for nominal prices, hence a commitment not to cause surprise inflations. It has indeed been claimed (Chamley (1985)) that a commitment to a continuous price path is both a necessary and sufficient condition for a time-consistent inflation tax.

In this paper we shall reconsider the problem of an optimal combination of income taxes, inflation tax and borrowing to finance government expenditure. We focus on the time-consistency issues rather than on characterizing the optimal policy. Counter to previous literature, we show that the optimal policy under commitment can be made time-consistent under discretion in a monetary economy, <u>without</u> a commitment to a continuous price path. We show that this can be done by careful management of the national debt, both with regard to its maturity and its composition into nominal and indexed debt.

The time-consistency problems arise from basically two different sources. The first source is the incentive we have already mentioned to engage in a surprise inflation, thereby eroding the real value of money and other nominal assets in a lump-sum fashion. We remove this incentive by specifying that each government leaves to its successor net nominal claims on the private sector equal to the money stock. This way the gains and losses from a surprise inflation balance.

The second source of time inconsistency is the following. When choosing the optimal path for income taxes and money growth (and hence indirectly the inflation tax) each government trades off the relevant distortion (income taxes and positive nominal interest rates) against the effects on government wealth. The latter is weighed by the cost of public funds (the level of tax distortion) since an increase in government wealth means that taxes can be lowered. The incentive to affect government wealth by changing the time path for taxes and money growth varies over time with the cost of public funds; hence the time-consistency problem.

If, however, each government inherits just the right maturity structure of its nominal debt, the incentive to change the path for the money growth is removed, as we shall see. Furthermore, if each government inherits from its predecessor just the right maturity structure of the indexed debt, the incentive to change the time path for income taxes is also removed. This latter rule is the solution to the time-consistency problem in a barter economy discussed by Lucas and Stokey (1983), and by Persson and Svensson (1984). It is thus crucial that the governments trade in both real (indexed) and nominal bonds, something that previous literature has failed to realize.

The outline is as follows. Section 2 presents the model, and Section 3 deals with the optimal policy under commitment. Section 4 shows how that policy can be made time-consistent under discretion, and Section 5 includes some conclusions.

2. THE MODEL

We consider a closed one-good monetary economy without investment, and without uncertainty[2]. The model is a variant of that of Lucas and Stokey (1983) and Persson and Svensson (1984, 1986a).

There is discrete time, $t = \ldots, -1, 0, 1, \ldots$ The technology is linear, and one unit of labor produces one unit of the good for private or public consumption. Labor endowment, y_t, is exogenous. It can be used for leisure, x_t, private consumption, c_t, and public consumption, g_t, according to the resource constraint

$$(2.1) \qquad y_t \geq x_t + c_t + g_t.$$

We assume that the sequence $\{g_t\}_0^\infty$ is an exogenously given stream of government expenditures. There is a representative consumer with preferences over private consumption, leisure and real balances, $m_t \equiv \pi_t M_t$ (π_t is the reciprocal of the price level P_t, and M_t is the nominal money stock), given by the utility function

(2.2) $$\Sigma_0^\infty \beta^t U(c_t, x_t, \pi_t M_t), \qquad 0 < \beta < 1.$$

The usual disclaimer for money in the utility function applies. We have assumed $\pi_t M_t$ to be an argument in (2.2) in order to introduce a monetary distortion into the model in the simplest possible way. Any other distortion will also do; in fact, the arguments in this paper will go through equally well within the framework of a cash-in-advance model[3]. The utility function has the standard properties. In addition we restrict it to be additively separable in real balances and the other arguments:

(2.3) $$U_{cm} = U_{xm} = 0.$$

This is done solely in order to simplify some of the derivations; additive separability of real balances is not important for our argument.

The consumer enters each period t with money balances and with claims on the government, consisting of indexed and nominal bonds. The consumer also receives wage income net of taxes to the government. The consumer purchases consumption goods, adjusts his money and bond holdings and leaves the period with new holdings of money and bonds according to the budget constraint

(2.4) $$p_t c_t + p_t \pi_t M_t + \Sigma_{t+1}^\infty p_s({}_{t+1}b_s + \pi_s\, {}_{t+1}B_s) \leq$$
$$p_t \pi_t M_{t-1} + \Sigma_t^\infty p_s({}_t b_s + \pi_s\, {}_t B_s) + p_t(1 - \tau_t)(y_t - x_t).$$

Here p_t is the present value in period 0 of goods in period t, and $\pi_t \equiv 1/P_t$ is the current goods value of money in period t. We let $\{{}_t b_s\}_{s=t}^\infty$ denote claims (possibly negative), held when entering period t, to goods to be delivered in period s. We may identify ${}_tb_s$ with the total debt service, the sum of interest payment and amortization, in period s on indexed bonds. Similarly, $\{{}_tB_s\}_{s=t}^{\infty}$ denotes claims to money to be delivered in period s, i.e. the total debt service on nominal debt. The term $y_t - x_t$ is labor supply. The wage rate is unity. The tax rate is τ_t, and after-tax income is hence $(1 - \tau_t)(y_t - x_t)$. With this notation, the terms on the right-hand side of (2.4) are initial real balances, the value of the initial claims on the government, and the after-tax income. The terms on the left-hand side of (2.4) are consumption expenditures, new money holdings, and new bond holdings

Let us define the nominal interest rate i_{t+1} from period t to t+1 in the standard way by

(2.5) $$1/(1 + i_{t+1}) = p_{t+1}\,\pi_{t+1}/p_t\,\pi_t$$

Then the budget constraints for each t can be added and simplified to give the present-value budget constraint in period 0:

(2.6) $$\Sigma_0^{\infty}\, p_t c_t \le p_0\pi_0 M_{-1} + \Sigma_0^{\infty}\, p_t({}_0b_t + \pi_t\,{}_0B_t) + \Sigma_0^{\infty}\, p_t(1 - \tau_t)(y_t - x_t) - \Sigma_0^{\infty}\, p_t\,\frac{i_{t+1}}{1+i_{t+1}}\,m_t.$$

The first-order conditions for maximizing (2.2) over $\{c_t, x_t, M_t\}_0^{\infty}$ subject to (2.6), can be written

(2.7a) $$p_t = \beta^t U_{ct},$$

(2.7b) $$\tau_t = 1 - U_{xt}/U_{ct}, \text{ and}$$

(2.7c) $$i_{t+1}/(1+i_{t+1}) = U_{mt}/U_{ct},$$

The condition (2.7a) says that present value prices equal the discounted marginal utility of consumption (the Lagrange multiplier is unity by a suitable normalization of prices). Condition (2.7b) expresses the distortion, caused by proportional income taxes, between the marginal rate of substitution between leisure and consumption in consumption (U_{xt}/U_{ct}) and in production (unity). The condition (2.7c) is the familiar relation between the nominal interest rate and the marginal utility of real balances, which implicitly defines the demand for real balances (conditional on c_t and x_t) as a decreasing function of the nominal interest rate. Note that as long as i_{t+1} is positive, the usual Friedmanian distortion is present, namely that the marginal benefit of real balances (U_{mt}) is above their marginal production cost (zero).

The behaviour of the consumer is summarized by (2 6) (with equality) and (2.7). The solutions to these equations give $\{c_t, x_t, M_t\}_0^\infty$ for given $\{p_t, \tau_t, \pi_t, g_t, {}_0b_t, {}_0B_t\}_0^\infty$ and given M_{-1}. In the following discussion of the optimization problem of the government it will be practical to look at consumer behavior in a different way. We will therefore consider (2.7) as defining functions

(2.8a) $\qquad p_t = p_t(c_t, x_t)$,

(2.8b) $\qquad \tau_t = \tau(c_t, x_t)$ and

(2.8c) $\qquad i_{t+1} = i(c_t, x_t, m_t)$,

of consumption, leisure and real balances[4]. We can interpret (2.8) as the present value prices, tax rates and nominal interest rates that, given an initial price level π_0, support a given allocation $\{c_t, x_t, m_t\}_0^\infty$ of consumption, leisure and real balances.

We shall end this section by formulating the constraints facing the government in period 0. The government has an initial debt $\{{}_0b_t, {}_0B_t\}_0^\infty$ to the consumer. It finances given expenditures $\{g_t\}_0^\infty$ by taxing wage income, by borrowing, and by money creation. Taxation of debt and interest payment is excluded. From the consumers' intertemporal budget constraint (2.6) and the resource constraints (2.1), the government's intertemporal budget constraint is

$$\text{(2.9)} \qquad \Sigma_0^\infty p_t g_t \le \Sigma_0^\infty p_t \tau_t (y_t - x_t) + \Sigma_0^\infty p_t \frac{i_{t+1}}{1+i_{t+1}} m_t - \Sigma_0^\infty p_t ({}_0b_t + \pi_t \, {}_0B_t) - p_0 \pi_0 M_{-1}$$

It is also practical to express the government's intertemporal budget constraints by defining real and nominal "cash-flows", like in Persson and Svensson (1984). For t = 0, 1,... we hence define the real cash-flow ${}_0z_t$ and the nominal cash-flow ${}_0Z_t$ according to

$$\text{(2.10a)} \qquad {}_0z_t \equiv \tau_t (y_t - x_t) - g_t - {}_0b_t \text{ and}$$

$$\text{(2.10b)} \qquad {}_0Z_t \equiv M_t - M_{t-1} - {}_0B_t.$$

The real cash-flow in period t is the excess of taxes over expenditures and real debt service. The nominal cash-flow in period t is the excess of the increase in money supply over nominal debt service. The government's intertemporal budget constraint can then be written

$$\text{(2.10c)} \qquad \Sigma_0^\infty p_t ({}_0z_t + \pi_t \, {}_0Z_t) \ge 0.$$

That is, the present value of government expenditure must not exceed the present value of the sum of income taxes and nominal money growth less the value of the initial debt.

The government in period 0 leaves a new debt structure $\{{}_1b_t, {}_1B_t\}_1^\infty$ to its successor. This debt structure obeys

$$\text{(2.10d)} \qquad \Sigma_1^\infty p_t [{}_1b_t - {}_0b_t + \pi_t ({}_1B_t - {}_0B_t)] \ge -p_0 ({}_0z_0 + \pi_0 \, {}_0Z_0),$$

which says that deficits in the cash-flow in period 0 is covered by issue of new debt.

3. OPTIMUM POLICY UNDER COMMITMENT

The government of date 0 thus faces an inherited national debt with a maturity structure described by $\{{}_0b_t\}_0^\infty$ and $\{{}_0B_t\}_0^\infty$. Suppose it can commit itself and future governments to the policy instruments $\{\tau_t\}_0^\infty$ and $\{M_t\}_0^\infty$ for the indefinite future. Its decision problem is to choose these policy instruments in order to finance the exogenously given consumption stream $\{g_t\}_0^\infty$ in such a way that the consumer's welfare is maximized. It then leaves a debt structure $\{{}_1b_t, {}_1B_t\}_1^\infty$, of real and nominal debt, fulfilling (2.10d), to its successor, the government at date 1.

Formally, the government maximizes (2.2) subject to consumer behavior summarized in (2.8), the solvency constraint (2.10), and the resource constraints (2.1). This is an intertemporal optimal taxation problem, which amounts to finding at each date an optimal mix of borrowing and two distortionary taxes - the tax on labor income and the inflation tax. It also involves undertaking a surprise inflation if the consumer's nominal assets are positive (surprise deflation if the consumer's nominal assets are negative). We assume that any such surprise inflation/deflation nevertheless results in a finite positive price level, maybe because of limited printing capacity of the mint.

The solution to this decision problem under commitment is a sequence of values of the policy instruments $\{\tau_{0t}, M_{0t}\}_0^\infty$, an allocation $\{c_t, x_t, m_t\}_0^\infty$ of sequences of consumption, leisure and real balances, and a debt structure $\{{}_1b_t, {}_1B_t\}_1^\infty$ left to the government in period 1. If future governments are committed to fulfill the chosen policy, the economy will develop according to this allocation. The problem we want to deal with, though, is whether future governments can be induced to follow this policy also if they have discretion.

4. TIME CONSISTENCY UNDER DISCRETION

Suppose now that each government in office at time $\theta = 1,\ldots\infty$ (from now on Government θ) has discretion, and solves the same type of problem as did Government 0. Each government thus chooses a path for its policy instruments $\{M_t, \tau_t\}_\theta^\infty$ to maximize the consumer's welfare. From the discussion in Section 2, we know that a particular path for M_t and τ_t is equivalent to a particular path for c_t, x_t and m_t, and a particular value of π_θ. For our purposes it is more convenient to formulate the tax problem over the latter set of variables. The Lagrangean for Government θ can then be written as

$$
\begin{aligned}
(4.1)\qquad L_\theta = {} & \Sigma_\theta^\infty \beta^t U(c_t, x_t, m_t) + \lambda_\theta[\Sigma_\theta^\infty p_t({}_\theta z_t + \frac{i_{t+1}}{1+i_{t+1}} m_t) \\
& - p_\theta \pi_\theta \Sigma_\theta^\infty ({}_\theta B_t\ \Pi_\theta^t \frac{1}{1+i_s}) - p_\theta \pi_\theta M_{\theta-1}] \\
& + \Sigma_\theta^\infty \mu_{\theta t}(y_t - x_t - c_t - g_t)
\end{aligned}
$$

where λ_θ is the multiplier on Government θ's wealth constraint and $\mu_{\theta t}$ is the multiplier on the resource constraint at t. It is understood that p_t, τ_t and i_{t+1} appearing in (4.1) depend on c_t, x_t and m_t according to (2.8)[5].

In order to understand the different trade-offs Government θ faces as well as the sources of the time-consistency problems, it is instructive to look at the optimum conditions one by one.

Let us first consider the first-order condition for the choice of π_θ, the initial price level, which corresponds to the condition for M_θ, the initial level of the money stock. It is

$$(4.2) \qquad \frac{dL_\theta}{d\pi_\theta} = - \lambda_\theta p_\theta [M_{\theta-1} + \Sigma_\theta^\infty ({}_\theta B_t \, \Pi_\theta^t \frac{1}{1+i_s})] = 0.$$

The expression within square brackets is the outstanding stock of money plus the market value of the inherited nominal debt. A decrease in π_θ, that is an increase in the initial price level, reduces the real value of those nominal obligations. The resulting improvement in government wealth is welfare-improving in that less revenue has to be raised by distortionary taxes on labor income or money balances. This is why the bracketed expression is multiplied by λ_θ, the multiplier on Government θ's wealth constraint, which we refer to as the "cost of public funds".

Obviously, Government θ has an incentive to engage in a surprise inflation (deflation) and drive π_θ towards zero (infinity) if its inherited nominal obligations are positive (negative). Carrying the surprise inflation out would, however, make the plans of the previous governments and, in particular, the optimal policy under commitment dynamically inconsistent. This is, of course, the capital levy problem of monetary policy, known since Auernheimer (1974) and Calvo (1978).

The first-order conditions for m_t, real balances at t, correspond to the conditions for the money growth at t. For each $t \geq \theta$, we have the condition

$$(4.3) \qquad \frac{dL_\theta}{dm_t} = \beta^t U_{mt} + \lambda_\theta \{p_t \frac{i_{t+1}}{1+i_{t+1}} + p_t m_t [\partial(\frac{i_{t+1}}{1+i_{t+1}})/\partial m_t]$$

$$- p_\theta \pi_\theta [\Sigma_{s=t+1}^\infty ({}_\theta B_s \, \Pi_{\substack{\sigma=\theta \\ \sigma \neq t+1}}^s \frac{1}{1+i_\sigma})] \; \partial(\frac{i_{t+1}}{1+i_{t+1}})/\partial m_t\} = 0.$$

The optimum level of m_t requires that the distortion, measured by U_{mt}, is traded off against the comprehensive government wealth effect, measured by the term within { }. The wealth effect of a change in m_t includes the change in the revenue from the inflation tax (the first two terms) and the change in the value of the nominal debt obligations (the last term)[6]. Notice that the cost of public funds λ_θ enters into (4.3) in the same way for all t. Therefore, the distortion on the last unit of government wealth is the same in all periods in an optimum.

Here we encounter another source of time inconsistency of the optimal policy under commitment. As we will show formally below, the cost of public funds changes over time, that is λ_θ, $\theta = 1, \ldots,$ does not stay constant and equal to λ_0, the cost of public funds underlying the optimal policy under commitment. The trade-off in (4.3) thus looks different, ceteris paribus, for Government θ than for Government $\theta-1$.

At a general level, the problem arises because the governments at different θ do not face the same constraints in their optimization problem although they do share the same objective function. At a specific level, they face a different level of net indebtedness to the consumer, and as we show below the change in λ_θ over time is indeed directly proportional to the change in net government debt outstanding.

The last set of first-order conditions is for the optimal choice of c_t and x_t along the resource constraint, which corresponds to the condition for the optimal tax rate τ_t. With an understanding that the derivatives are evaluated for a small change in the allocation at t $(dc_t, dx_t) = (dc_t, -dc_t)$, we have for each $t \geq \theta$,

$$\begin{aligned}(4.4)\qquad \frac{dL_\theta}{dc_t} = {} & \beta^t (U_{ct} - U_{xt}) + \lambda_\theta \Big\{ \big({}_\theta z_t + \frac{i_{t+1}}{1+i_{t+1}} m_t\big) \frac{\partial p_t}{\partial c_t} \\ & + p_t \frac{\partial[\tau_t (y_t - x_t)]}{\partial c_t} + p_t m_t \, \partial\big(\frac{i_{t+1}}{1+i_{t+1}}\big)/\partial c_t \\ & + p_\theta \pi_\theta \big[\Sigma_{s=t+1}^{\infty} \big({}_\theta B_s \prod_{\substack{\sigma=\theta \\ \sigma \neq t+1}}^{s} \frac{1}{1+i_\sigma}\big)\big] \, \partial\big(\frac{i_{t+1}}{1+i_{t+1}}\big)/\partial c_t \Big\} = 0\end{aligned}$$

Again the distortion, here from the income tax and measured by $U_{ct} - U_{xt}$, should be traded off against the effect on government wealth. The latter includes the "intertemporal terms-of-trade effect" from a change in the real interest rate (see further Persson and Svensson (1984)), the change in revenue from the labor and inflation taxes, and finally the devaluation of the nominal debt obligations[7]. By the same logic as for m_t, the value of c_t chosen in the optimal policy under commitment may be time inconsistent because λ_θ changes over time.

The main result in the paper is that this problem and the other time-consistency problems we have mentioned, can actually be resolved by a careful management of the government debt. More precisely, at each $\theta = 1,\ldots\infty$, there exists a unique maturity structure of the government debt $\{{}_\theta b_t, {}_\theta B_t\}_\theta^\infty$ that makes it optimal for Government θ to choose the same allocation as Government 0. In other words, if Government θ-1 leaves its successor with this maturity structure the optimal policy under commitment is time-consistent under discretion.

We shall prove this result as follows: Consider freezing all the prices and quantities, except the debt instruments, at their values in the optimum under commitment. We then show that there exists a debt structure $\{{}_\theta b_t, {}_\theta B_t\}_\theta^\infty$ that satisfies all the first-order conditions in (4.2) - (4.4), that this debt structure is unique, and that it fulfills the solvency requirement, namely that the present value of Government θ's cash flows satisfies the analog of (2.10),

(4.5) $$\Sigma_\theta^\infty p_t({}_\theta z_t + \pi_t\, {}_\theta Z_t) = 0.$$

To fulfill (4.2), we simply set

$$(4.6) \qquad \Sigma_{\theta}^{\infty}({}_{\theta}B_t\ \Pi_{\theta}^{t}\ \frac{1}{1+i_s}) = -M_{\theta-1}.$$

Government θ-1 should thus leave to its successor net nominal claims on the private sector with a market value equal to the money stock[8]. Then Government θ has a zero position in nominal terms vis-a-vis the private sector, which clearly eliminates the incentives of a surprise inflation. Notice that (4 6) rules out the government's incentive for surprise inflation but not for anticipated inflation. As long as the private sector is willing to hold a non-interest bearing asset - i.e. money - there is still a base for the inflation tax.

The next step is to show how the conditions (4.3) can be satisfied. Suppose that for each t, we set

$$(4.7a) \qquad p_{\theta}\pi_{\theta}[\Sigma_{s=t+1}^{\infty}({}_{\theta}B_s\ \Pi_{\substack{\sigma\neq\theta \\ \sigma\neq t+1}}^{s}\ \frac{1}{1+i_{\sigma}})] = \frac{1}{\lambda_{\theta}}E_t + F_t,$$

where E_t and F_t are defined by

$$(4.7b) \qquad E_t \equiv \beta^t U_{mt}[\partial(\frac{i_{t+1}}{1+i_{t+1}})/\partial m_t]^{-1}, \text{ and}$$

$$(4.7c) \qquad F_t \equiv p_t m_t + p_t \frac{i_{t+1}}{1+i_{t+1}} [\partial(\frac{i_{t+1}}{1+i_{t+1}})/\partial m_t]^{-1}$$

Then (4.3) is fulfilled identically and there is no incentive for Government θ to choose a different m_t than Government θ-1 even though λ_{θ} is different from $\lambda_{\theta-1}$. Notice that (4.7) should hold for each t. This obviously fixes all the nominal obligations from period θ+1 and onwards. Condition (4.7) determines the short-term nominal obligations, and given λ_{θ} (4.6) and (4.7) thus yield a unique nominal debt structure $\{{}_{\theta}B_t\}_{\theta}^{\infty}$ that Government θ-1 should leave to its successor.

To get the required maturity structure of the indexed debt, we first divide (4.7a) by $i_{t+1}/(1 + i_{t+1})$ and substitute into (4.4). Next, we divide the resulting expression by $\lambda_\theta(\partial p_t/\partial c_t)$. These operations yield

$$(4.8a) \qquad {}_\theta z_t = \frac{1}{\lambda_\theta} G_t + H_t,$$

where the definitions of G_t and H_t are

$$(4.8b) \qquad G_t \equiv -\beta^t(U_{ct} - U_{xt}) - E_t[\partial p_t/\partial c_t]^{-1}$$

$$(4.8c) \qquad H_t \equiv \left(\frac{\partial p_t}{\partial c_t}\right)^{-1}\{p_t \frac{\partial[\tau_t(y_t-x_t)]}{\partial c_t} + \frac{i_{t+1}}{1+i_{t+1}} m_t \frac{\partial p_t}{\partial c_t} - F_t\}$$

If (4.8) holds for each $t \geq \theta$ then the remaining first-order conditions (4.4) are satisfied identically. Given λ_θ and the definition of the real cash-flow (cf. (2.10a)), (4.8a) yields the unique indexed debt obligations $\{{}_\theta b_t\}_\theta^\infty$ that Government $\theta-1$ should leave to its successor to support the choice of $\{c_t\}_\theta^\infty$ in the optimal policy under commitment.

How do we get a value for λ_θ? To this end multiply (4.8a) by p_t and sum these conditions over $t = \theta,\ldots,\infty$. Then sum the resulting expression and (4.6) and manipulate to get

$$(4.8) \qquad \Sigma_\theta^\infty p_t G_t + \lambda_\theta \Sigma_\theta^\infty p_t \tilde{H}_t + \lambda_\theta\{\Sigma_\theta^\infty(p_t\, {}_\theta z_t + \Sigma_\theta^\infty p_t \frac{i_{t+1}}{1+i_{t+1}} m_t - p_\theta \pi_\theta \Sigma_\theta^\infty({}_\theta B_t\, \Pi_\theta^t \frac{1}{1+i_s}) - p_\theta \pi_\theta M_{\theta-1}\} = 0,$$

where $\tilde{H}_t \equiv H_t - \frac{i_{t+1}}{1+i_{t+1}} m_t$. But the expression within { } is identically equal to $\Sigma_\theta^\infty p_t({}_\theta z_t + \pi_t\, {}_\theta Z_t)$. If we impose the solvency requirement on the restructuring scheme of Government $\theta-1$ we can set this expression equal to zero. Then we can solve for λ_θ as

$$(4.10)\qquad \lambda_\theta = - \frac{\Sigma_\theta^\infty p_t G_t}{\Sigma_\theta^\infty p_t \tilde{H}_t} .$$

This is the value of λ_θ that should be used when restructuring the debt according to (4.6)-(4.8). Having imposed solvency when solving for λ_θ, we have also ensured that the implied restructuring scheme satisfies the solvency requirement.

In summary, we have shown that for every government there is a unique maturity structure of the nominal as well as the indexed part of the public debt that removes the incentives to deviate from the optimal policy $\{\tau_t, M_t\}_0^\infty$ chosen and announced by Government θ.

Let us finally say something about how the debt structures of successive governments differ, that is let us characterize the restructuring scheme of the debt that Government θ-1 has to perform to impose time consistency on its successor. We recall that the restructuring scheme must obey the overall solvency requirement

$$(4.11)\qquad \Sigma_\theta^\infty p_t [{}_\theta b_t - {}_{\theta-1}b_t] + p_\theta \pi_\theta \Sigma_\theta^\infty (\Pi_\theta^t \frac{1}{1+i_s})({}_\theta B_t - {}_{\theta-1}B_t)$$

$$\geq - p_{\theta-1}({}_{\theta-1}z_{\theta-1} + \pi_{\theta-1}\, {}_{\theta-1}Z_{\theta-1}) .$$

One aspect of the restructuring scheme follows easily. From (4.6) and its θ-1 analog and the definitions of the nominal interest rate and the nominal cash-flow we know that the total nominal claims on the private sector should grow by

$$(4.12)\qquad - \Sigma_\theta^\infty (\Pi_\theta^t \frac{1}{1+i_s})({}_\theta B_t - {}_{\theta-1}B_t)$$

$$= {}_{t-1}Z_{\theta-1} - \frac{i_\theta}{1+i_\theta} M_{\theta-1} .$$

In other words, if each government uses its nominal cash-flow minus the revenue from the inflation tax to buy nominal bonds from the private sector, it leaves its successor with a zero nominal position.

To characterize the restructuring scheme further, we need to determine how the cost of public funds changes over time. Using (4.10) and its $\theta-1$ analog, we may derive

$$(4.13)\qquad \frac{\lambda_\theta - \lambda_{\theta-1}}{\lambda_{\theta-1}} = -(\Sigma_\theta^\infty p_t\tilde{H}_t)p_{\theta-1}[{}_{\theta-1}z_{\theta-1} - \frac{i_\theta}{1+i_\theta} m_{\theta-1}]$$

Notice that the expression in square brackets is the government's net lending to the private sector at $\theta-1$, which follows from (4.11) and (4.12). Further, $\Sigma_\theta^\infty p_t\tilde{H}_t$ is a positive number, which follows from (4.10) and from G_t beeing negative for each t by (2.8). Therefore, the cost of public funds at θ will be higher than at $\theta-1$ if the public debt outstanding is higher at θ due to Government $\theta-1$ beeing a net borrower.

The precise restructuring scheme for the indexed bonds follows from (4.8a) and the definition of real cash flow. For each $t \geq \theta$, we have

$$(4.14)\qquad {}_\theta b_t - {}_{\theta-1}b_t = G_t(\frac{1}{\lambda_{\theta-1}} - \frac{1}{\lambda_\theta}).$$

By (4.13) and (4.14), the scheme prescribes that any net borrowing (leading) at $\theta-1$ should be done by issuing (retiring) some indexed debt of <u>all</u> maturities.

The restructuring scheme for the nominal debt is more complicated. Manipulating (4.7a) and its $\theta-1$ analog, and exploiting the definition of the nominal interest rate, one may derive

$$(4.15)\qquad p_t\pi_t({}_\theta B_t - {}_{\theta-1}B_t) = (E_{t-1} - E_t)(\frac{1}{\lambda_\theta} - \frac{1}{\lambda_{\theta-1}}),$$

for all $t \geq \theta+1$. Although we know that E_t and E_{t-1} are both negative, their difference may have any sign[9]. This means that Government $\theta-1$ in general should sell long-term nominal bonds of some maturities and buy long-term nominal bonds of other maturities. Whatever the net outcome of these operations, Government $\theta-1$ has to adjust its purchases of short-term (one-period) nominal bonds, so that its total open market operations in nominal bonds fulfill (4.6).

5. CONCLUDING REMARKS

We have shown that an optimal fiscal and monetary policy under commitment can be made time-consistent under discretion if each government leaves to its sucessor a particular maturity structure of the government debt. Generally speaking, each government can impose time-consistency on its sucessor because it is able to influence the constraints in the sucessor's optimization problem. Specifically, Government $\theta-1$ has 2T (where $T \to \infty$)(independent) instruments in the maturity structure of the nominal and indexed debt, $\{_\theta b_t\}_\theta^\infty$ and $\{_\theta B_t\}_\theta^\infty$. These instruments are used to influence the money stocks and the tax rates $\{M_t\}_\theta^\infty$ and $\{\tau_t\}_\theta^\infty$, the 2T choice variables in Government θ's optimal tax problem. The debt structure enters the problem in an essential way because each government can alter the real and nominal interest rates and thereby the value of its outstanding debt. This may not be the case in a small open economy and, as explained in Persson and Svensson (1986a), and time-consistency may thus fail for that reason.[10]

These remarks suggest a couple of interesting extensions. First, it may be interesting to study when each government has some instruments to influence its successor, but not many enough to support the optimum policy under commitment. We conjecture that the rules/discretion dilemma may be partly but not fully resolved in that situation. Second, a similar mechanism may work when succesive governments do not share the same preferences. The ability to influence the successor would then allow a government to, partly of fully, impose its preferred policy on a succeding government with different preferences.[11]

Our solution does not contribute to explaining time-consistency in debt and capital taxation. Like in Lucas and Stokey (1983), our solution relies on a commitment ot honor previous debt, and taxes on debt are not allowed. If there were capital, a commitment not to tax capital would be required. Maybe reputational considerations are necessary to rule out surprise taxation on capital and debt.

Finally, what we do in this paper is mainly to demonstrate the existence of a particular solution to the problem of time-consistent fiscal and monetary policy. It remains to characterize the solution in greater detail, for instance to examine whether fiscal and monetary policy is pro- or countercyclical. We hope to address that issue in future work.

Footnotes

[1] We have received helpful comments by participants in seminars at IIES, CEPREMAP, Paris, University of Chicago, University of Rochester, London School of Economics, Nuffield College, Oxford, Norwegian School of Economics, Bergen, Stockholm School of Economics, and University of Lund. In particular we would like to thank Robert Barro, Phil Brock, Daniel Cohen, Kent Kimborough and Alan Stockman. We gratefully acknowledge financial support from the Bank of Sweden Tercentenary Foundation and The National Science Foundation, and secretarial assistance by Karin Edenholm.

[2] Uncertainty can be incorporated like in Lucas and Stokey (1983), but our points can be made in a simpler way in a perfect-foresight set-up.

[3] It is important, though, that the liquidity services produced by money are equivalent to a final good (like increasing leisure by saving trips to the bank). If money is equivalent to an intermediate input, the optimal inflation tax is zero, in analogy with the optimum taxation result that production taxes should be zero. Cf. Kimborough (1985).

[4] Note that real balances m_t do not enter (2.8a) and (2.8b), by the additive separability between real balances and the other arguments of the utility function. This will simplify our derivations somewhat.

[5] The Government's wealth constraint within square brackets has been written on the same form as in (2.9) except that we have expressed the nominal

obligations in terms of nominal interest rates and the initial price level π_θ and that we have used the definition of the real cash flow ${}_\theta z_t$ (analogous to (2.10a)).

[6] Since a change in m_t affects the (expected) nominal interest rate i_{t+1} from t to t+1 only, it only changes the value of bonds with a maturity of $(t+1-\theta)$ and longer. The expression $\partial(\frac{i_{t+1}}{1+i_{t+1}})/\partial m_t$ denotes the partial derivative of the function $i(c_t, x_t, m_t)/[1+i(c_t, x_t, m_t)]$ with respect to m_t.

[7] The devaluation of the real debt obligations ${}_\theta b_t \frac{dp_t}{dc_t}$ is included in the term ${}_\theta z_t \frac{\partial p_t}{\partial c_t}$.

[8] The idea modifying this aspect of our scheme for time-consistency was first raised by Robert King at a seminar in Rochester.

[9] By mere discounting we would expect $E_{t-1} > E_t$ on average, however.

[10] The intuition offered in Lucas and Stokey (1983) and Persson and Svensson (1984) that it is the government's ability to affect the value of its debt that <u>causes</u> the time-consistency problem is mistaken. Rather, that ability is a necessary condition to help resolve the time-consistency problem.

[11] These two extensions are partly examined in Persson and Svensson (1986b).

References

Auernheimer, Leonardo (1974): "The Honest Government's Guide ot the Revenue from the Creation of Money", Journal of Policical Economy 82, 598-606.

Barro, Robert and David B. Gordon (1983): "Rules, Discretion and Reputation in a Model of Monetary Policy", Journal of Monetary Economics 12, 101-121.

Calvo, Guillermo A. (1978): "On the Time Consistency of Optimal Policy in a Monetary Economy", Econometrica 46, 1411-1428.

Chamley, Christophe (1985): "On a Simple Rule for the Optimal Inflation Rate in Second Best Taxation", Journal of Public Economics 26, 35-50

Kimbrough, Kent P. (1985): "The Optimum Quantity of Money Rule in the Theory of Public Finance", mimeo, Duke University, Journal of Monetary Economics, forthcoming.

Kydland, Finn E. and Edward C. Prescott (1977): "Rules Rather than Discretion: The Inconsistency of Optimal Plans", Journal of PoliticalEconomy 85, 473-492.

Lucas, Robert E. and Nancy L. Stokey (1983): "Optimal Fiscal and Monetary Policy in an Economy Without Capital", Journal of Monetary Economics 12, 55-93.

Persson, Torsten and Lars E.O. Svensson (1984): "Time-Consistent Fiscal Policy and Government Cash-Flow", Journal of Monetary Economics 14, 365-374.

Persson, Torsten and Lars E.O. Svensson (1986a): "International Borrowing and Time-Consistent Fiscal Policy", The Scandinavian Journal of Economics 88, 273-295

Persson, Torsten and Lars E.O. Svensson (1986b): "Checks and Balances on the Government Budget", in preparation.

Phelps, Edmund S. (1973): "Inflation in the Theory of Public Finance", The Swedish Journal of Economics 75, 67-82.

Rochester Center for Economic Research
University of Rochester
Department of Economics
Rochester, NY 14627

1985-86 DISCUSSION PAPERS

WP#1 GOVERNMENT SPENDING, INTEREST RATES, PRICES AND BUDGET DEFICITS IN THE UNITED KINGDOM, 1730-1918
by Robert J. Barro, March 1985

WP#2 TAX EFFECTS AND TRANSACTION COSTS FOR SHORT TERM MARKET DISCOUNT BONDS
by Paul M. Romer, March 1985

WP#3 CAPITAL FLOWS, INVESTMENT, AND EXCHANGE RATES
by Alan C. Stockman and Lars E.O. Svensson, March 1985

WP#4 THE THEORY OF INTERNATIONAL FACTOR FLOWS: THE BASIC MODEL
by Ronald W. Jones, Isaias Coelho, and Stephen T. Easton, March 1985

WP#5 MONOTONICITY PROPERTIES OF BARGAINING SOLUTIONS WHEN APPLIED TO ECONOMICS
by Youngsub Chun and William Thomson, April 1985

WP#6 TWO ASPECTS OF AXIOMATIC THEORY OF BARGAINING
by William Thomson, April 1985

WP#7 THE EMERGENCE OF DYNAMIC COMPLEXITIES IN MODELS OF OPTIMAL GROWTH: THE ROLE OF IMPATIENCE
by Michele Boldrin and Luigi Montrucchio, April 1985

WP#8 RECURSIVE COMPETITIVE EQUILIBRIUM WITH NONCONVEXITIES: AN EQUILIBRIUM MODEL OF HOURS PER WORKER AND EMPLOYMENT
by Richard Rogerson, April 1985

WP#9 AN EQUILIBRIUM MODEL OF INVOLUNTARY UNEMPLOYMENT
by Richard Rogerson, April 1985

WP#10 INDIVISIBLE LABOUR, LOTTERIES AND EQUILIBRIUM
by Richard Rogerson, April 1985

WP#11 HOURS PER WORKER, EMPLOYMENT, UNEMPLOYMENT AND DURATION OF UNEMPLOYMENT: AN EQUILIBRIUM MODEL
by Richard Rogerson, April 1985

WP#12 RECENT DEVELOPMENTS IN THE THEORY OF RULES VERSUS DISCRETION
by Robert J. Barro, May 1985

WP#13 CAKE EATING, CHATTERING, AND JUMPS: EXISTENCE RESULTS FOR VARIATIONAL PROBLEMS
by Paul M. Romer, 1985

WP#14 AVERAGE MARGINAL TAX RATES FROM SOCIAL SECURITY AND THE INDIVIDUAL INCOME TAX
by Robert J. Barro and Chaipat Sahasakul, June 1985

WP#15 MINUTE BY MINUTE: EFFICIENCY, NORMALITY, AND RANDOMNESS IN INTRADAILY ASSET PRICES
by Lauren J. Feinstone, June 1985

WP#16 A POSITIVE ANALYSIS OF MULTIPRODUCT FIRMS IN MARKET EQUILIBRIUM
by Glenn M. MacDonald and Alan D. Slivinski, July 1985

WP#17 REPUTATION IN A MODEL OF MONETARY POLICY WITH INCOMPLETE INFORMATION
by Robert J. Barro, July 1985

WP#18 REGULATORY RISK, INVESTMENT AND WELFARE
by Glenn A. Woroch, July 1985

WP#19 MONOTONICALLY DECREASING NATURAL RESOURCES PRICES UNDER PERFECT FORESIGHT
by Paul M. Romer and Hiroo Sasaki, February 1984

WP#20 CREDIBLE PRICING AND THE POSSIBILITY OF HARMFUL REGULATION
by Glenn A. Woroch, September 1985

WP#21 THE EFFECT OF COHORT SIZE ON EARNINGS: AN EXAMINATION OF SUBSTITUTION RELATIONSHIPS
by Nabeel Alsalam, September 1985

WP#22 INTERNATIONAL BORROWING AND TIME-CONSISTENT FISCAL POLICY
by Torsten Persson and Lars. E.O. Svensson, August 1985

WP#23 THE DYNAMIC BEHAVIOR OF COLLEGE ENROLLMENT RATES: THE EFFECT OF BABY BOOMS AND BUSTS
by Nabeel Alsalam, October 1985

WP#24 ON THE INDETERMINACY OF CAPITAL ACCUMULATION PATHS
by Michele Boldrin and Luigi Montrucchio, August 1985

WP#25 EXCHANGE CONTROLS, CAPITAL CONTROLS, AND INTERNATIONAL FINANCIAL MARKETS
by Alan C. Stockman and Alejandro Hernandez D., September 1985

WP#26 A REFORMULATION OF THE ECONOMIC THEORY OF FERTILITY
by Gary S. Becker and Robert J. Barro, October 1985

WP#27 INREASING RETURNS AND LONG RUN GROWTH
by Paul M. Romer, October 1985

WP#28 INVESTMENT BANKING CONTRACTS IN A SPECULATIVE ATTACK ENVIRONMENT. EVIDENCE FROM THE 1890's
by Vittorio Grilli, November 1985

WP#29 THE SOLIDARITY AXIOM FOR QUASI-LINEAR SOCIAL CHOICE PROBLEMS
by Youngsub Chun, November 1985

WP#30 THE CYCLICAL BEHAVIOR OF MARGINAL COST AND PRICE
by Mark Bils, (Revised) November, 1985

WP#31 PRICING IN A CUSTOMER MARKET
by Mark Bils, September 1985

WP#32 STICKY GOODS PRICES, FLEXIBLE ASSET PRICES, MONOPOLISTIC COMPETITION, AND MONETARY POLICY
by Lars E.O. Svensson, (Revised) September 1985

WP#33 OIL PRICE SHOCKS AND THE DISPERSION HYPOTHESIS, 1900 - 1980
by Prakash Loungani, January 1986

WP#34 RISK SHARING, INDIVISIBLE LABOR AND AGGREGATE FLUCTUATIONS
by Richard Rogerson, (Revised) February 1986

WP#35 PRICE CONTRACTS, OUTPUT, AND MONETARY DISTURBANCES
by Alan C. Stockman, October 1985

WP#36 FISCAL POLICIES AND INTERNATIONAL FINANCIAL MARKETS
by Alan C. Stockman, March 1986

WP#37 LARGE-SCALE TAX REFORM: THE EXAMPLE OF EMPLOYER-PAID HEALTH INSURANCE PREMIUMS
by Charles E. Phelps, March 1986

WP#38 INVESTMENT, CAPACITY UTILIZATION AND THE REAL BUSINESS CYCLE
by Jeremy Greenwood and Zvi Hercowitz, April 1986

WP#39 THE ECONOMICS OF SCHOOLING: PRODUCTION AND EFFICIENCY IN PUBLIC SCHOOLS
by Eric A. Hanushek, April 1986

WP#40 EMPLOYMENT RELATIONS IN DUAL LABOR MARKETS (IT'S NICE WORK IF YOU CAN GET IT!)
by Walter Y. Oi, April 1986.

WP#41 SECTORAL DISTURBANCES, GOVERNMENT POLICIES, AND INDUSTRIAL OUTPUT IN SEVEN EUROPEAN COUNTRIES
by Alan C. Stockman, April 1986

WP#42 SMOOOTH VALUATIONS FUNCTIONS AND DETERMINANCY WITH INFINITELY LIVED CONSUMERS
by Timothy J. Kehoe, David K. Levine and Paul R. Romer, April 1986.

WP#43 AN OPERATIONAL THEORY OF MONOPOLY UNION-COMPETITIVE FIRM INTERACTION by Glenn M. MacDonald and Chris Robinson, June 1986.

WP#44 JOB MOBILITY AND THE INFORMATION CONTENT OF EQUILIBRIUM WAGES: PART 1, by Glenn M. MacDonald, June 1986.

WP#45 SKI-LIFT PRICING, WITH AN APPLICATION TO THE LABOR MARKET by Robert J. Barro and Paul M. Romer. May 1986.

WP#46 FORMULA BUDGETING: THE ECONOMICS AND ANALYTICS OF FISCAL POLICY UNDER RULES, by Eric A. Hanushek, June 1986.

WP#47 AN OPERATIONAL THEORY OF MONOPOLY UNION-COMPETITIVE FIRM INTERACTION by Glenn M. MacDonald and Chris Robinson, June 1986.

WP#48 EXCHANGE RATE POLICY, WAGE FORMATION, AND CREDIBILITY by Henrik Horn and Torsten Persson June 1986.

WP#49 MONEY AND BUSINESS CYCLES: COMMENTS ON BERNANKE AND RELATED LITERATURE, by Robert G. King, July 1986.

WP#50 NOMINAL SURPRISES, REAL FACTORS AND PROPAGATION MECHANISMS by Robert G. King and Charles I. Plosser, Final Draft: July 1986.

WP#51 JOB MOBILITY IN MARKET EQUILIBRIUM by Glenn M. MacDonald, August 1986.

WP#52 SECRECY, SPECULATION AND POLICY by Robert G. King, (revised) August 1986.

WP#53 THE TULIPMANIA LEGEND by Peter M. Garber, July 1986.

WP#54 THE WELFARE THEOREMS AND ECONOMIES WITH LAND AND A FINITE NUMBER OF TRADERS, by Marcus Berliant and Karl Dunz, July 1986

WP#55 NONLABOR SUPPLY RESPONSES TO THE INCOME MAINTENANCE EXPERIMENTS by Eric A. Hanushek, August 1986

WP#56 INDIVISIBLE LABOR, EXPERIENCE AND INTERTEMPORAL ALLOCATIONS by Vittorio U. Grilli and Richard Rogerson, September 1986.

WP#57 TIME CONSISTENCY OF FISCAL AND MONETARY POLICY by Mats Persson, Torsten Persson and Lars E. O. Svensson, September 1986

WP#58 ON THE NATURE OF UNEMPLOYMENT IN ECONOMIES WITH EFFICIENT RISK SHARING, by Richard Rogerson and Randall Wright, September 1986.

To order copies of the above papers complete the attached invoice and return to Christine Massaro, W. Allen Wallis Institute of Political Economy, RCER, 109B Harkness Hall, University of Rochester, Rochester, NY 14627. Three (3) papers per year will be provided free of charge as requested below. Each additional paper will require a $5.00 service fee which must be enclosed with your order. For your convenience an invoice is provided below in order that you may request payment from your institution as necessary. Please make your check payable to the **Rochester Center for Economic Research**. **Checks must be drawn from a U.S. bank and in U.S. dollars**.

W. Allen Wallis Institute for Political Economy

Rochester Center for Economic Research, Working Paper Series

OFFICIAL INVOICE

Requestor's Name ______________________________

Requestor's Address ______________________________

____

____

____

Please send me the following papers free of charge (**Limit: 3 free per year**).

WP# ______ WP# ______ WP# ______

I understand there is a $5.00 fee for each additional paper. Enclosed is my check or money order in the amount of $__________. Please send me the following papers.

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______