Time Consistency and Optimal Policy Design*

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The standard framework for economic policy design consists of a model to predict how people will behave under alternative policies and a criterion to compare the outcomes of alternative policies. Given a model, the policy design problem is to use the model to choose the best policy under the criterion.

Although this process seems straightforward, in practice solving the design problem is far from simple. The main difficulty is developing models that accurately predict private behavior under alternative policies. In most situations, people's current decisions depend on their expectations of future policies, and forecasting how these expectations will change in response to current policy changes is a difficult task. For example, investment decisions depend on investors' expectations of future after-tax rates of return. If investors expect future returns to be high, then they'll invest more today; if low, then less today. Consequently, policy designers can't predict how investment will respond to a tax cut today unless they know how people's expectations of future tax rates have changed as a result of the cut.

Lucas (1976) suggests an elegant way around this problem of forecasting changes in expectations following policy changes. He argues that although people's decisions vary systematically with their expectations of future policies, it is reasonable to suppose that *some* features of the economy do not change even if current and expected future policies change. For example, people don't make decisions arbitrarily; rather, their decisions are made to maximize their objective functions, given current and expected future policies.

It is now standard practice to suppose that private agents' objective functions do not change when policy changes. If policy designers know the objective functions people seek to maximize and their expectations of future policies, they can predict people's decisions for each policy. Because objective functions don't change with policy changes, historical data can be used to estimate them (as, for instance, in Hansen and Sargent 1980). And the expectations of future policies can easily be predicted in situations where the government chooses an entire *sequence* of policies today (or possibly, *rules* describing policy choices in various contingencies) and people believe those policies will be implemented in the future. Such a sequence of policies is called a *policy regime*. Given a policy regime, private agents' objective functions are used to compute their optimal decisions. Then the policy criterion is applied to compare the outcomes of alternative regimes, and the best policy regime is selected. This procedure has its origins in the public finance tradition stemming from

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Ramsey (1927), so I call the best sequence of policies *Ramsey policies* and the associated outcomes *Ramsey outcomes.*[1]

Suppose, then, that policymakers have chosen a Ramsey policy regime. At some future date, suppose the policymakers ask whether it is wise to continue with that regime. To reevaluate, they calculate the optimal policies in precisely the same way they had done at the original date. If the optimal policies chosen at the future date coincide with the original plan, the policymakers will stick to that plan, and the policy regime is *time consistent.*[2] If, however, the policymakers want to renege on the original plan, the policies of the regime are *time inconsistent.*

In a series of graphic examples, Kydland and Prescott (1977), Calvo (1978), and Fischer (1980) show that Ramsey policies are often time inconsistent. Their examples suggest that time inconsistency problems arise when people's current decisions depend on expectations of future policies and their current choices affect future opportunity sets. Since their decisions have been made by the time the future date arrives, the government often has an incentive to renege on the Ramsey policies. If Ramsey policies are time inconsistent, people realize that these policies will not be followed in the future. But Ramsey policies are computed under the assumption that people believe they will be carried out. If people expect a different set of future policies, the Ramsey policies may no longer be optimal.

The problem of time inconsistency can be illustrated quite simply in a model where the only sources of government revenue are proportional taxes on capital and labor income. Suppose the government chooses a sequence of tax rates for current and future periods and then evaluates outcomes assuming people believe that this sequence will be carried out. If the government wants to maximize the welfare of consumers, how should it choose the sequence of tax rates? To solve this problem, the government needs to know how capital and labor will respond. The stock of capital changes slowly over time, since investment is only a small fraction of the stock; however, people can change their labor supplies relatively quickly. Furthermore, the key determinant of investment decisions is the after-tax return expected in the future, whereas the current after-tax wage rate is the key variable for labor supply decisions. So the government's best policy for current tax rates is to tax capital at high rates and labor at low rates. As a result of this policy, capital supply decisions aren't affected very much and labor supply is stimulated. For future tax rates, the government's best policy is to lower rates on capital to stimulate investment, and to raise the rest of the needed revenues with higher rates on labor.

But what will the government do when that future date arrives? At that point the government has an incentive to tax capital income heavily, since the investments that created the capital stock have already been made, and to tax labor lightly to increase work effort. The Ramsey policies are therefore time inconsistent.

Of course, people recognize this incentive to renege. Since they know that the government cannot commit to its policies, people rationally choose low levels of investment because they expect high future tax rates on capital income. Consequently, the procedure of designing a once-and-for-all policy sequence is useful only in environments where the government can commit to such policies, or—to use the terminology of Chari, Kehoe, and Prescott (1988)—in environments where a *commitment technology* is available. When the government commits to a policy regime, by definition it cannot change policies in the future, and the time inconsistency of the Ramsey policies is therefore irrelevant. In such situations it is appropriate to refer to the Ramsey policies and outcomes as a *Ramsey equilibrium.*

In many situations it is implausible to think that a commitment technology is available. Governments often make policy choices sequentially, with no ability to commit to future policies. What can be said about policies and outcomes in such situations? Suppose that at each date, the policies are chosen to maximize society's welfare taking into account, exactly as in the Ramsey problem, that private agents respond optimally. Since the policies must maximize society's

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[1]Frank Plumpton Ramsey (1903–30), a brilliant British mathematical economist, first posed and solved the problem of designing optimal excise tax rates in an economy with many goods (see Ramsey 1927). A government requires a fixed amount of revenue raised by excise taxes on the goods. Given the taxes, prices and quantities are determined in a competitive equilibrium. The government's problem is to choose tax rates to maximize the welfare of consumers. It turns out that this problem is formally equivalent to choosing tax rates on labor over time. (The intuition behind this equivalence is as follows: think of labor at each date as a different good and interest rates as the relative prices of the goods.)

[2]Robert H. Strotz introduced the issue of time consistency (see Strotz 1955–56). He considered the problem of a decision maker whose tastes change over time, showing that this person might have an incentive to change a planned course of action. It is easy to show, as Strotz did, that if a person's tastes remain unchanged over time, a course of action that initially maximizes the objective function continues to do so at all future dates. The remarkable feature of the modern literature on time consistency is that tastes do not change; rather, the time inconsistency problem, as discussed in my paper, arises because there is more than one decision maker.

welfare at each date, the policies are *sequentially rational* for the government. Optimal behavior by private agents requires that they forecast future policies as being sequentially rational for the government. A sequence of private outcomes and policy rules satisfying optimality by private agents and sequential rationality in policy choice is a *sustainable equilibrium.*[3] The associated policy rules and outcomes are referred to as *sustainable policies* and *sustainable outcomes.*

In this paper I develop two classic models to illustrate the time inconsistency of Ramsey policies and to show how sustainable policies and outcomes can be computed. The first is a model of capital taxation and the second, a model of default on government debt. In the capital taxation model, investment decisions depend on expected tax rates. In the default model, decisions to purchase government debt depend on expectations of future default. In both models, once private decisions are made, people are vulnerable to policy changes.

I consider both finite and infinite horizon versions of the models. I show that when the horizon is finite, Ramsey policies and sustainable policies are quite different: the Ramsey policies yield higher welfare than the sustainable ones. Thus, if a commitment technology is available, it should certainly be used to prevent governments from deviating from the Ramsey policies. If a commitment technology is not available, then the best that can be done is the sustainable policies. When the horizon is infinite, the set of sustainable policies and outcomes is much larger. In fact, it is sometimes possible to sustain even Ramsey policies in equilibrium. Essentially this works because people believe that if the government has followed the Ramsey policies in the past, it will continue to do so. If, however, the government ever deviates, then people believe the government will revert to finite horizon sustainable policies. The government, faced with these beliefs, has no incentive to renege. Such policies are called *trigger strategies,* since small changes in one player's decision trigger large changes by other players.[4]

Although the result that the Ramsey policies are sometimes sustainable is appealing, the use of trigger strategies to support such policies implies that people's beliefs about future policies change drastically in response to even small policy changes. In fact, discontinuous changes in beliefs are necessary to support Ramsey policies as equilibria. This discontinuity suggests a difficulty in designing good policies: A policy change that policymakers view as desirable might lead the public to expect a change in the policy regime, thereby inducing undesirable outcomes.

In this sense, these results reinforce the Lucas critique of econometric policy evaluation. Lucas argues that models used for policy evaluation must take into account how people's expectations change in response to policy changes. Given the *practical* difficulties in forecasting how people's expectations change when current policy changes, Lucas (1980) suggests that economists can give reliable policy advice only in situations where the rules determining policy are well understood by the public. I argue that there are also *theoretical* reasons why forecasting people's expectations after policy changes may be difficult. These theoretical reasons arise from the fact that in many sustainable equilibria, people's beliefs about out-of-equilibrium actions are critical in sustaining equilibrium actions. Since out-of-equilibrium actions, by definition, will never be observed, it is often impossible to use historical data to deduce these beliefs.

One way the government can forestall this problem of deducing beliefs is to undertake policy changes only after extensive public debate. Such debate has the advantage of educating policymakers about people's expectations and people about the proposed policy. In that case, the difficult problem of forecasting how people's expectations will change in response to current policy changes no longer needs to be solved.

The Capital Taxation Model

Kydland and Prescott (1977, 1980) first analyzed the time inconsistency of capital taxation. Fischer (1980) constructed a particularly simple capital taxation model to illustrate the time inconsistency problem. In this section, I consider a version of Fischer's model, modified along the lines of Chari and Kehoe (1988a). Initially, I consider a one-period version of the model.

A Single-Period Version

Consider an economy with a large number of identical consumers and a government. Consumers make decisions at two distinct points in time, the *first stage* and

[3]This terminology is borrowed from Chari and Kehoe (1988a,b) and Chari, Kehoe, and Prescott (1988). *Sustainability* requires that decisions be optimal at each date they are made. It is closely related to the notions of *subgame perfection* (see Selten 1975) and *sequential equilibrium* (see Kreps and Wilson 1982) in game theory. *Sustainable equilibrium* extends these ideas to environments with anonymous, competitive private agents (see Chari and Kehoe 1988a for details).

[4]An extensive literature in game theory uses trigger strategies to describe equilibrium outcomes in infinite horizon environments. See Friedman 1971, Fudenberg and Maskin 1986, Green 1980, Green and Porter 1984, and Abreu 1988. In the macroeconomics literature, Barro and Gordon 1983 was the first to use trigger strategies.

the *second stage.* At the first stage, consumers are endowed with w units of a consumption good from which they consume c_1 units and store k units. A storage technology transforms the stored units into Rk units at the second stage. In addition, consumers can work at the second stage. The marginal product of labor is 1, so if a consumer works l units, output at the second stage is l. The government must finance G units per capita in spending at the second stage. Revenues are raised from proportional taxes on capital and labor. The tax rates on capital and labor are denoted by δ and τ, respectively. Thus, a consumer's second-stage income is $(1-\delta)Rk+(1-\tau)l$.

Each consumer's preferences over consumption and labor[5] are denoted by a utility function $U(c_1+c_2,l)$. Each consumer seeks to maximize the value of this function, given the tax rates δ and τ. I write this problem as follows: choose (c_1,k,c_2,l) to solve[6]

$$(1) \qquad \max U(c_1+c_2,l)$$

subject to

$$(2) \qquad c_1+k \leq w$$

$$(3) \qquad c_2 \leq (1-\delta)Rk+(1-\tau)l.$$

The constraints to this programming problem say that first-stage consumption and savings cannot exceed the consumer's endowment, and second-stage consumption cannot exceed after-tax earnings on capital and wages.

The government in turn must meet its expenditure requirements. Let K and L denote the per capita input of capital and labor in the economy. Then the government must meet a budget constraint of the form

$$(4) \qquad G \leq \delta RK+\tau L.$$

That is, government spending cannot exceed tax revenues from capital and labor.

I assume that government spending G is large enough so that labor must always be taxed.[7] The government uses a social welfare function to compare the outcomes of various policies. In this world with identical consumers, a natural objective for the government is to maximize the welfare of each consumer. The social welfare function is given by $U(C_1+C_2,L)$, where C_1 and C_2 denote per capita levels of consumption at the first and second stages and where L denotes labor supply.

□ *With Commitment*

I model the government's ability to commit to a policy plan by assuming that it chooses policies *before* consumers make their first-stage decisions. A *policy,* denoted by π, is simply a choice of tax rates (δ,τ). Given a policy, consumers respond optimally by solving problem (1). Denote the resulting aggregate choices for each policy by

$$(5) \qquad F(\pi)=(C_1(\pi),K(\pi),C_2(\pi),L(\pi)).$$

A *Ramsey equilibrium* is a policy π and an aggregate choice $F(\pi)$ which have the properties that for every policy, consumers choose their decisions by solving problem (1) and, given the aggregate choice functions, the government's policy maximizes its utility subject to its budget constraint.

Notice that consumers' decisions are required to be optimal for each policy. Had I required their decisions to be optimal only at the government's chosen policy, absurd outcomes could be part of an equilibrium, including *any* policy that satisfies the government's budget constraint. Consider, for example, a choice function F for consumers that specifies optimal behavior at some arbitrary policy π^* and zero labor supply otherwise. The government, confronted with this function, optimally chooses the policy π^*. Obviously, such an aggregate choice function is not a rational response by consumers to policies other than π^*. Thus, a Ramsey equilibrium imposes rationality at every point where a consumer must make a decision.

The Ramsey policies and outcomes are easy to characterize. The tax on labor distorts labor supply decisions. The *social* return to work is the sum of the private return and the return to the government. Since each unit of labor supply yields one unit of the good, the social return is unity. But consumers care only about the private return, which is $1-\tau$. This divergence between social and private returns causes consumers' labor

[5]Usually, preferences are described over consumption and leisure. Since the sum of leisure and labor must equal the fixed endowment of time available, the two representations are equivalent.

[6]In this problem, if the tax rate on capital is set so that $(1-\delta)R=1$, consumers are indifferent about how much to save, because c_1+c_2 is independent of the saving decision. I assume that in such a case, consumers save their entire endowments.

[7]Formally, this requires that $G > Rw$, so even if consumers save their entire endowments, a tax on labor is necessary.

supply decisions to be distorted.[8] As a result, the government would like to set tax rates on labor as low as possible.

Yet the government must find some way to raise enough revenues to finance its consumption. Suppose it sets the tax rate on capital so high that $(1-\delta)R<1$. The after-tax return to saving is then so low that consumers rationally consume their entire first-stage endowments. Hence, no revenues are raised from capital taxation. Suppose, now, that the government sets the tax rate on capital at a low enough level that $(1-\delta)R>1$. Then consumers save their entire endowments and continue to do so as long as $(1-\delta)R \geq 1$. The government therefore raises the tax rate on capital until consumers are just indifferent between consumption and saving, that is, to the point where $(1-\delta)R=1$. It raises the rest of the needed revenues by labor taxation. Thus, the Ramsey capital tax rate is set so that $(1-\delta)R = 1$ (or $\delta=1-1/R$), and consumers save their entire endowments.

□ *Without Commitment*

I model the inability to commit by assuming that the government sets its policy *after* private agents have made their first-stage decisions. The government seeks to maximize the same utility function as in the Ramsey problem. To see how the government solves its problem, it is useful to start with the second-stage decisions of consumers. Given their first-stage decisions and government policy, consumers rationally make their consumption and labor supply decisions by maximizing their utility functions. This maximization induces aggregate choice functions at the second stage. Given these functions and first-stage decisions, the government in turn chooses its policies optimally. These optimal policies are then used to solve for the consumers' first-stage decisions. A *sustainable equilibrium* consists of a first-stage decision by consumers, a government policy, and a second-stage decision function which together satisfy two conditions: consumers' maximization problems at each stage and the government's maximization problem.

Notice that consumers' second-stage decisions must be described as a function. This requirement is imposed because the government must be able to evaluate the outcomes of alternative policies. Consumers, however, view the government's policies as a fixed pair of tax rates, since no single consumer perceives that a person's own actions have any effect on the government's policy. Thus, consumers behave competitively, whereas the government does not.

It is easy to describe sustainable equilibrium outcomes in this model. First, I claim that aggregate savings will be zero. The supporting argument is by contradiction. Suppose aggregate savings are not zero. By an argument parallel to the Ramsey case, the government should tax capital fully, since this policy reduces the need to resort to the distorting labor tax. Anticipating that capital income will be fully taxed, consumers choose not to save at all. Since savings are zero, the government must raise all the needed revenues through distorting labor taxation. In short, consumers rationally anticipate the government's policy, and the government chooses its policies rationally, given consumers' first-stage decisions.

I now show that the government's utility is strictly higher in the Ramsey equilibrium than in the sustainable equilibrium. In the environment with commitment, it is *feasible* for the government to choose a tax rate on capital of unity and the same tax rate on labor as in the sustainable equilibrium. If it chose these policies, consumers would choose not to save at all, and the outcomes would coincide with those in the sustainable equilibrium. Therefore, in an environment with commitment, the government can always realize at least the utility level of the sustainable equilibrium. Since the government chooses a different set of policies in the environment with commitment than in the one without, it is clearly better off in the Ramsey equilibrium.

It is also clear that the Ramsey policies are time inconsistent. Since the Ramsey policies specify low tax rates on capital, consumers save their entire endowments. If the government could change its policies in midstream, it would have every incentive to tax capital fully to reduce reliance on labor taxation. So Ramsey policies make sense only if the government can commit to them. In other words, the Ramsey policies are not sustainable in a world without commitment.

Note, furthermore, that the time inconsistency problem does not arise because the government's preferences changed in midstream. In fact, in this example the government is a benevolent one that seeks to do well by its citizens. Rather, the problem arises because capital, once put in place, cannot readily be reconverted into consumption. Since consumers have already committed to their decisions, even a benevolent

[8] This distortion can be understood by contrasting the environment in the text with one where lump-sum taxes are available. A tax is *lump sum* if it is unrelated to any economic activity. Thus, if each consumer had to pay G units to the government regardless of the consumer's other decisions, every extra unit of labor would give consumption of one unit, which is the social return.

government has an incentive to renege on the very policies that led to the capital accumulation. This incentive, then, is the source of the time inconsistency problem. Given a government's inability to commit, the best that policymakers can choose is the sustainable equilibrium.

Multiperiod Versions

A natural extension of Fischer's capital taxation model involves allowing consumers to make decisions over many periods. So I now consider a finite repetition of the single-period model just discussed. For simplicity, I do not allow capital to accumulate between periods. Thus, within each period, consumers face exactly the same problem as in (1). The consumers' utility functions are given by

$$(6) \qquad \Sigma_{t=0}^{T}\beta^t U(c_{1t}+c_{2t}, l_t)$$

where T is the length of the horizon, β is a discount factor between zero and one, and (c_{1t}, c_{2t}, l_t) is consumption at the first and second stages and labor supply in period t. The government's utility function is the same as each consumer's.

□ *With Commitment*

When a commitment technology is available, the government chooses an entire sequence of policies. Thus, before consumers make their decisions, the government chooses tax rates for every period. Since this problem is simply a finite repetition of the single-period problem, the Ramsey policies and outcomes are also finite repetitions of the single-period Ramsey policies and outcomes: In each period, consumers save their entire first-stage endowments and the government sets the tax rate on capital to make the after-tax return on capital equal to one.

□ *Without Commitment*

What if a commitment technology is not available? Then how is a sustainable equilibrium defined? Since consumers' beliefs about future policies may well depend on current policies, a policy choice in any period must now be thought of as a *function* of past policies. Given a sequence of policy functions, one for every period, consumers make their decisions optimally. Thus, the consumers' maximization problems can be solved to generate a sequence of consumers' aggregate choice functions that also depend on the history of past policies. The government chooses policies to maximize its objective function, given these aggregate choice functions. A sustainable equilibrium consists of sequences of policy functions and aggregate choice functions that solve, respectively, the government's maximization problems and consumers' maximization problems at each date and for every history. (A precise mathematical definition of sustainable equilibrium is given in Appendix A.)

What can be said about sustainable policies and outcomes? The answer depends on whether the horizon is finite or infinite. First, consider the finite horizon problem. It will be useful to proceed from the last period, T. Clearly, the problem here is identical to a single-period problem. Thus, sustainable equilibrium policies and outcomes coincide with those in the single-period case, and this result holds *regardless* of past policies and outcomes. Now consider the problem at $T-1$. Since what happens in this next-to-last period has no effect on outcomes in the final period, none of the government's policy choices can have any effect on consumers' beliefs about policies in period T. Rational consumers realize that in the last period, the government will follow the single-period sustainable policy. So the problems faced by both governments and consumers reduce to the single-period problem, as do the resulting policies and outcomes. By the same line of reasoning, it is clear that in every period, sustainable policies and outcomes are identical to those in the single-period problem.

Second, consider a situation where the horizon is infinite. Since there is no last period, the finite horizon argument doesn't apply. However, if repeated forever, the single-period sustainable policies and outcomes are also equilibrium outcomes with an infinite horizon. Suppose consumers believe that no matter what the government chooses today, it will choose single-period sustainable policies forever in the future. Given these beliefs, the government's problem reduces to the static single-period problem. Clearly, the best policy, given these beliefs, is to tax capital fully. Recognizing this as the best policy, consumers at the first stage choose not to save, and the result is the static sustainable outcome. This outcome, however, is not a unique equilibrium.

Consider the following set of beliefs held by consumers. They believe that as long as the government has chosen Ramsey policies in the past, it will continue to do so; but if the government has ever deviated, it will tax capital fully from then on. Now consider the problem faced by the government when consumers have saved their entire endowments. It can choose to tax capital at higher rates than the Ramsey plan. In doing so, it realizes a gain in the current period, but it knows that consumers will never again save in the future. Therefore, it would suffer a utility loss in all subsequent periods. If future utility is not discounted too much, the current gain is more than offset by the future losses. Thus, the government is induced to tax capital at the Ramsey rates.

Note that the beliefs of consumers are rational. If the government has taxed capital heavily in the past, given consumers beliefs about future policies, the best policy for the government is to tax capital heavily today. However, if the government has not deviated in the past, it realizes that deviating will trigger a bad outcome. Therefore, it rationally chooses not to tax capital heavily. In both situations, consumers' expectations are fulfilled.

At this point a reasonable question to ask is, Why aren't Ramsey policies sustainable when the horizon is finite but long? They aren't sustainable because consumers' beliefs that Ramsey policies will be chosen in the future are irrational. Consumers realize that in the last period, for example, it will never be rational for the government to pursue Ramsey policies. Thus, their beliefs are pinned down in the last period and, by backward induction, in all previous periods.[9]

Some Implications

The capital taxation example offers some implications for policy design. In the equilibria that support Ramsey policies, consumers' beliefs necessarily change sharply in response to some kinds of small policy changes. If beliefs did not change sharply, the Ramsey policies could not be supported. For example, suppose consumers believe that Ramsey policies will be followed in the future if the current capital tax rate is slightly higher than the Ramsey rate. Correctly anticipating no utility loss in future periods, the government would then deviate to a higher tax rate. This incentive to deviate remains in all periods. Recall, though, that at the Ramsey rate, consumers were just indifferent about their consumption and savings decisions. With a higher tax rate, they will choose not to save at all. Consequently, these beliefs do not constitute an equilibrium. To support Ramsey policies as part of an equilibrium, consumers must anticipate large changes in future policies in response to small changes in current policy. This discontinuity in beliefs implies that it is dangerous for policymakers to suppose small policy changes will always have small effects on the economy's operating characteristics.

It should also be pointed out that there are many sustainable outcomes in the infinite horizon version of this model. To take an extreme example, suppose the government chooses Ramsey policies in even periods and the single-period sustainable policies in odd periods. Consumers expect that any deviation in an even period will be followed by deviations in all subsequent even periods. Again, with sufficiently little discounting, the even–odd policy is sustainable. An observer of this economy might suggest that the government has taxed capital fully in the past (in odd periods) without noticeable harm; therefore, a tax in a current even period should do no harm. Obviously, the consequences will be disastrous: consumers will never save and the economy is pushed into a bad outcome. The point here is that it is often difficult to discern from past data how expectations will respond to current policy changes.

The model also illustrates the advantages of instituting delays in implementing policies. For example, suppose that policies are implemented with a one-period lag. At the second stage of a period t, the government chooses policies that are implemented in $t+1$. It is not possible for the government to commit to policies for periods $t+2$, $t+3$, and so on. In such a situation, even though a commitment technology is not available, the outcomes are the same as in the Ramsey equilibrium. Since the policies are, in effect, chosen before private agents have made their savings decisions, the government optimally chooses to tax capital at rates low enough to induce investment. Because delays in implementing policies allow the government to take account of the effect of the policy on current decisions, they help in resolving the time inconsistency problem. Of course, the result that the outcomes with delays coincide with the Ramsey equilibrium depends on the special repetitive structure of the model, and this result would be altered by allowing for capital accumulation from one period to the next. Nevertheless, the essential message—that delays in implementing policies result in better outcomes—still holds. Such delays are a particularly easy form of partial commitment. For

[9] Because this result depends sensitively on the horizon being infinite, it may well be questioned on the grounds that it is sheer vanity to suppose humanity is immortal. However, there is every reason to question the finite horizon result, especially when the horizon is long, rather than the infinite horizon result. Kreps and others (1982) show that introducing a tiny element of strategic uncertainty can overturn the finite horizon results. For example, suppose there is an infinitesimally small probability that the government will irrationally choose Ramsey policies in the last period. Then in a finite but long horizon model, every government has an incentive to develop a reputation for choosing Ramsey policies. Kreps and others show that no matter how small this probability, as long as it is positive, good outcomes are sustainable in economies with finite but long horizons.

example, the requirement that two-thirds of U.S. state legislatures must approve constitutional amendments delays implementation and helps resolve time inconsistency problems.

The Debt and Default Model

I turn now to a model of debt and default to analyze a second problem in time consistency—the problem of default on the public debt. (Prescott 1977 was the first to address this issue in the time consistency literature.) I introduce this example for two reasons: First, it has substantive interest in its own right. Second, it illustrates more vividly than the capital taxation example the problem of using historical data to deduce consumers' beliefs following policy changes.

The Role of Public Debt

The public debt serves an important role by smoothing fluctuations in tax revenues over time. If the government could never issue debt, the budget would then have to be balanced in each period. A balanced budget would be undesirable, since government spending fluctuates over time—thanks to wars and varying needs for public services. For example, to balance the budget during a war, tax rates must be intolerably high, reducing work effort precisely when needed most. By issuing debt, wartime tax rates can be kept relatively low. Of course, in the ensuing peacetime, taxes have to be raised to pay off the debt. The higher peacetime taxes reduce work effort, but this reduction is the cost of relatively low wartime taxes.

Consider the problem facing the government when it inherits a large public debt and current government spending is low. Tax revenues must be used to pay off the public debt. These taxes distort private decisions, particularly those about labor supply. If the government defaulted on the debt, tax rates could be lowered and the size of the economic pie increased. People, of course, recognize this incentive, so they will not buy debt issued in wartime if they believe the government will default. Thus, the benefits of tax smoothing are lost. Clearly, in this case a commitment technology is valuable. Given the government's ability to commit, a promise not to default in the future is credible. But what if a commitment technology is not available? In that case an important source of discipline for the government is that if it defaults, people may be unwilling to buy debt in the future. As a result, the government can't finance future wars by issuing debt, and this outcome may then deter the government from defaulting on the current debt.[10] I explore this possibility in the model.

The Economy

Consider an economy populated by a large number of identical people who live from period 0 through T (where T is possibly infinite). In each period, a nonstorable consumption good is produced from labor. One unit of labor input produces one unit of the good. Part of the output is used for government consumption and the remainder is available for private consumption. The per capita level of government consumption G_t is exogenously given and varies over time. The national income identity is

$$(7) \qquad C_t + G_t = L_t$$

where C_t and L_t denote per capita private consumption and labor input.

The government raises revenues from a proportional tax on labor income. The tax rate in period t is denoted by τ_t. Thus, after-tax income is given by $(1-\tau_t)L_t$. The government also issues public debt in the form of one-period discount bonds with a face value of one unit of the consumption good. To accommodate the possibility of default, I assume the government can levy a tax on the outstanding debt. The tax rate on debt is denoted by δ_t. If the tax rate on debt equals unity, the government is said to have *defaulted* on the debt. Of course, the price of the discount bonds issued in the current period depends on market interest rates and the public's expectations of future taxes on debt. Denote the price of new debt in period t by q_t. In each period the government faces a budget constraint of the form

$$(8) \qquad \tau_t L_t + q_t B_{t+1} = G_t + (1-\delta_t)B_t$$

where B_t is the public debt outstanding in period t. The left side of (8) gives the revenues raised from taxation and the sale of new debt, and the right side gives expenditures on government consumption and retirement of outstanding debt. The price of new debt issues is determined by

$$(9) \qquad q_t = (1-\delta_{t+1})/(1+{}_tr_{t+1})$$

where ${}_tr_{t+1}$ is the one-period interest rate between t and $t+1$ and δ_{t+1} is the tax rate expected to prevail in $t+1$. For example, if a 60 percent tax rate is anticipated, the

[10]In stable democracies, explicit default on the public debt seems unlikely. However, unanticipated inflation serves, in effect, as a partial default on nominal obligations. Furthermore, as shown here, the incentive to default may be low in infinite horizon economies.

discount bond is equivalent to a tax-exempt bond with a face value of 40 cents.

The preferences of consumers over consumption and labor are given by

$$(10) \quad \Sigma_{t=0}^{T} \beta^t U(C_t, L_t).$$

I assume that in addition to government debt, consumers can borrow and lend among themselves in default-free, single-period discount bonds. The consumer's budget constraint at some date t is given by

$$(11) \quad C_t + D_{t+1}/(1 + {}_t r_{t+1}) + q_t B_{t+1} = (1-\tau_t)L_t + (1-\delta_t)B_t + D_t$$

where B_t is the stock of government debt and D_t the stock of private debt held by the consumer. The terminal conditions are that $B_{T+1} = D_{T+1} = 0$.

Given a sequence of one-period interest rates and a sequence of tax rates, the consumer makes consumption, labor supply, and debt-holding decisions to maximize the utility function, subject to the budget constraints. Since the consumption good is nonstorable, market clearing requires that the net quantity of private debt be zero and that government debt issues be held willingly.

I denote the sequence of tax rates by

$$(12) \quad \pi = (\delta_t, \tau_t)_{t=0}^{T}.$$

Given a policy π, a *competitive equilibrium* is a sequence of consumption, labor supply, and debt-holding decisions $(C_t, L_t, B_{t+1}, D_{t+1})_{t=0}^{T}$ and a sequence of one-period interest rates $({}_t r_{t+1})_{t=0}^{T}$ that meet the following conditions:

- Consumers' decisions maximize (10) subject to (11), where q_t is defined in (9), given the sequence of interest rates and B_0, D_0.
- The debt market clears; that is, $D_t = 0$ for all t.

For future reference, it is convenient to denote the policy-induced competitive equilibrium decisions of consumers by the function $F(\pi)$ and the sequence of equilibrium interest rates by the function $r(\pi)$.

The policy instruments available to the government are its tax policies. As in the capital taxation model, the government chooses these instruments to maximize the welfare of the representative consumer, which is given by

$$(13) \quad \Sigma_{t=0}^{T} \beta^t U(C_t, L_t).$$

□ *With Commitment*

In an environment with commitment, the government first chooses its policies for all periods. Consumers then make their decisions, taking the policies and market interest rates as given. The interest rates in turn are determined by market-clearing conditions. The government chooses the policy that maximizes its utility subject to its budget constraints (8), given the competitive equilibrium functions $F(\pi)$ and $r(\pi)$. Such a policy and the policy-induced competitive equilibrium functions constitute a *Ramsey equilibrium*.

At least two features of the Ramsey equilibrium deserve comment. First, as Chari and Kehoe (1988b) show, attention can be restricted to equilibria where the government does not tax the debt in periods 1 through T. If there is any positive debt outstanding at period 0, it is best to default on that debt. Note that this immediately raises the possibility that Ramsey policies are time inconsistent. Second, Lucas and Stokey (1983) show that in any two periods where government spending is the same, the government chooses the same tax policies. In fact, this result also generalizes to situations where government spending fluctuates stochastically over time. This result is somewhat surprising. (A detailed exposition of how this result is reached appears in Appendix B.)

Here I provide some intuition for their result: Consumers prefer smooth rather than variable streams of consumption and labor supply over time. Now consider any two periods with the same value of government spending. By choosing the same policy on both dates, consumption as well as labor supply is equated on those dates. Consumers prefer such an outcome and, therefore, so does the government. (Note that on any two dates with unequal levels of government spending, the national income identity implies that both consumption and labor supply cannot be equated on those dates.) The result that policies should be the same even if government spending fluctuates stochastically follows from the same type of reasoning. Barro (1979), Aschauer (1988), and others argue that increases in government consumption that are expected to last for a long time should be accompanied by higher tax rates than increases that are viewed as temporary. This model, in contrast, suggests the policies should be the same in both situations.[11]

[11] There are two reasons for the different policy implications. First, Lucas and Stokey (1983) consider a richer class of government policies. In particular,

□ *Without Commitment*

I turn now to an environment without commitment. For simplicity, I assume that the government can never own claims on consumers, so the government's debt is never negative. In a finite horizon model, the backward induction technique used in the capital taxation example immediately implies that the government's budget is necessarily balanced period by period. Consumers realize that in the final period, the government will default on any outstanding debt. Consequently, the market price of new debt issues in $T-1$ is necessarily zero, and no revenues can be gained from issuing new debt. Hence in $T-1$, the government finds it best to default on the debt it inherits. Backward induction implies that the government's budget is always balanced. However, in a Ramsey equilibrium the ability to issue debt allows for tax smoothing. Labor taxes can be lowered in periods of high government spending and raised in periods of low government spending. Thus, work effort is stimulated when most needed. Consumers and the government are therefore better off in a Ramsey equilibrium than in a sustainable equilibrium. But Ramsey policies are not sustainable without commitment. If the government inherits positive debt, it will default. Recognizing this incentive to default, consumers will not buy any debt issued by the government. As a result, the only sustainable outcome is a balanced budget.

The common perception is that governments do not default because they fear they will be permanently denied access to financial markets. This intuition is confirmed by examining the infinite horizon version of the model. As in the capital taxation example, an equilibrium outcome has the government's budget being balanced in every period. This equilibrium is sustained by consumers' beliefs that the government will always default. Again, as in the taxation example, better equilibria can be sustained. If consumers believe that a current default signals defaults forever in the future, then they will be unwilling to purchase new debt issues in the event of a default. The government, realizing this, does not default because it loses the tax-smoothing benefits obtained from debt sales forever in the future. So with sufficiently little discounting of the future, the government rationally chooses not to default.

Some Implications

Consider the implications of this analysis for policy design. Suppose that the economy is in an infinite horizon equilibrium with Ramsey outcomes supported by consumers' beliefs, as just discussed. An analyst, understanding the effect of tax distortions, points out the burden caused by public debt and suggests that the government default on the debt and then never do so again. Clearly, the resulting outcomes will be bad: the government is forced to balance its budget in all succeeding periods. It is also clear that most people would immediately point out the possibility that debt would never be bought again, so the analyst's recommendation is likely to go unheeded. In slightly more sophisticated contexts, however, it is more difficult to discern erroneous analysis of this kind.

To see the difficulty in discerning this kind of faulty analysis, consider a variation on the debt and default model. Suppose government spending fluctuates stochastically over time. For simplicity, suppose that the economy is either in wartime or peacetime and that these states are equally likely. Government spending is high in war and low in peace, and the government can issue single-period discount bonds to smooth tax revenues.

Consider the policy design problem in an environment with commitment. Suppose at date 0 the economy is in wartime with no inherited debt. What do the Ramsey policies look like? The government runs a deficit in the current period. It must also form a contingency plan describing what it will do tomorrow if the war continues or if peace breaks out. If the government runs a deficit today, it will clearly run a surplus tomorrow in peacetime. What if the war continues? Surprisingly, it turns out that the best policy is to default on the debt. By following such a policy, the outstanding stock of debt is zero if the war continues and positive in peacetime. This policy ensures that distorting taxes do not have to be raised to pay off the debt when it is necessary to raise taxes to finance the war effort. Consumers are willing to buy debt issued in wartime at an appropriate price because there's a

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they allow for state-contingent debt, which has returns depend on the level of government consumption. For example, debt issued in wartime should have the feature that the return on the debt is low if the war continues and high if the war ends. The stock of outstanding debt is then low when government spending stays high, and the debt level is low when the outlook is for low government spending. Lucas and Stokey argue that this policy could be implemented by high inflation rates during wartime and a deflation after a war. Second, Barro (1979) and Aschauer (1988) implicitly assume that the interest rate is constant, independent of government policy. One rationalization of this assumption is that consumers and the government can borrow in the world market at constant interest rates. The problem with this rationalization is that in such an environment, consumption and labor supply are constant in every period, independent of the level of government consumption. This prediction clearly goes against the facts.

50-50 chance they'll get their money back.[12]

Now consider the same problem in an environment without commitment. Again, with sufficiently little discounting, it is possible to construct consumers' beliefs that support Ramsey policies as equilibria. Defaults on the debt in wartime are part of the Ramsey policy. Consumers rationally anticipate such defaults and do not change their beliefs after defaults occur. However, defaults in peacetime trigger expectations of defaults in all future peacetimes, and the government loses the benefits of tax smoothing in the future.[13] An analyst observing such a history of policies and outcomes may be tempted to argue that past defaults have led to no change in the public's willingness to buy debt. Therefore, a current default, even in peacetime, should have no effect on the willingness to buy debt. The result of this recommendation is that the public never again buys debt. The government will be forced to balance its budget in every succeeding period. Clearly, such outcomes are undesirable.

This variation on the debt and default model shows that if policy analysis fails to consider the public's expectations that supported a particular equilibrium in the past, the analysis may lead to erroneous recommendations for the future. However, as mentioned earlier, such expectations are difficult to discern from past data. A solution—one already suggested by the capital taxation example—is to undertake policy changes only after public debate. Such debate has the advantages of educating the public about proposed policies and the policymakers about the public's responses.

The Policy Implications Summarized

From the two examples presented in this paper, three main policy implications emerge: First, the use of economic models to compare policy regimes is likely to be most effective in situations where commitment is possible. If societies can commit to policy rules, say through constitutions or other devices, they should do so while recognizing and resisting the incentives to renege in the future. If such a commitment technology is not available, policy choices that ignore how policies will be chosen in the future and, particularly, that ignore people's expectations of future policies—these policy choices will yield poor results. I have also argued that delays in implementing policies are equivalent to a form of limited commitment and are therefore desirable.

Second, expectations of future policies often depend critically on the history of past policies. For instance, is it best to default on the outstanding debt? Often, if the expectations of private agents about future policies are ignored, the answer is yes. In this situation it may be obvious that the effect of current policies on the public's expectations of future policies should be considered. In particular, there is a real possibility that the government will have to borrow at prohibitively high rates in the future if it defaults today. In other situations, the answer is less obvious. For instance, should an investment tax credit be instituted during a recession? If such a tax credit is instituted, the next recession might well be more severe as investors wait for a tax credit to be instituted or expanded. Consequently, policy prescriptions should take into account how changes in current policies affect expectations of future policies. A major difficulty here, of course, is that it is often impossible to deduce from the available data how these expectations will change. Given this difficulty, one possible method of evaluating policy regimes is to consider only the long-run or average operating characteristics of the economy under each regime. This criterion rules out the short-term gains that are at the heart of the time consistency problem.

Third, both examples have a bearing on the debate over rules versus discretion. Should policymakers be bound to rules prescribing their actions? Or should policies be changed whenever policymakers think it desirable? Friedman (1960) argues that policymakers and economists simply do not know enough about the economy to use discretion wisely. Lucas (1980, p. 205) also argues that rules are preferable:

> Our ability as economists to predict the responses of agents rests, in situations where expectations about the future matter, on our understanding of the stochastic environment agents believe themselves to be operating in. In practice, this limits the class of policies the consequences of which we can hope to assess in advance to policies generated by fixed, well understood, relatively permanent rules . . . .

Kydland and Prescott (1977) extend the argument further by suggesting that discretionary management would lead to time consistent outcomes inferior to the preferable Ramsey rules. Therefore, if a commitment technology is available, it should be used.

I have argued, here, that if a commitment technology is not available, policy recommendations that ignore

[12] Note that this state-contingent default is equivalent to state-contingent debt. If the government sold debt that promised payment in peacetime and no payment in wartime, the outcomes would be the same.

[13] Grossman and Van Huyck (1985) make a similar argument.

the effect of history on people's expectations will yield inferior outcomes. Apart from the practical considerations emphasized by Lucas, there are theoretical reasons why economists can offer reliable policy advice only in situations where policies are generated by well-understood, relatively permanent rules. Because historical data cannot provide information about consumers' beliefs about future policies following out-of-equilibrium actions, it is often illusory to think that economists can forecast changes in expectations following a policy change. Therefore, policy regimes should be viewed as institutions that are subject to change only after extensive public debate. This standpoint diminishes the role of economists as day-to-day managers, but enhances their role as designers of arrangements and constitutions.

Appendix A
More About the Capital Taxation Model

In this appendix I develop the infinite horizon capital taxation model. For a formal development, see Chari and Kehoe 1988a.

I make explicit the role of history in affecting people's expectations about the course of future policies. I start by considering the problem of a consumer at some date t. Suppose this consumer expects a sequence of tax rates, denoted by (δ_s^e, τ_s^e), for periods $s = t, t+1, \ldots$. The consumer chooses consumption, savings, and labor supply to solve the problem

$$\text{(A1)} \quad \max \textstyle\sum_{s=t}^{\infty} \beta^s U(c_{1s} + c_{2s}, l_s)$$

subject to

$$\text{(A2)} \quad c_{1s} + k_s = w$$

$$\text{(A3)} \quad c_{2s} = R(1-\delta_s^e)k_s + (1-\tau_s^e)l_s$$

for $s = t, t+1, \ldots$.

I now describe how the expectations of future policies in problem (A1) are formed. Since consumers' expectations may be affected by past policies, I define the *history of the economy* H_t at date t to be the record of all government policies up to and including t:

$$\text{(A4)} \quad H_t = (\pi_s)_{s=0}^{t}.$$

Consumers expect the government to follow a policy plan σ, which specifies government policies as a function of the history. For example, $\sigma_t(H_{t-1})$ specifies consumers' beliefs at the first stage of date t about the policies that will be chosen at t, given that the policies in the history H_{t-1} have been chosen in the past. Beliefs about future policies are inductively generated. For example, at the first stage of period t, consumers believe that the history the government confronts in period $t+1$ will be given by $(H_{t-1}, \sigma_t(H_{t-1}))$. The resulting policy will be given by $\sigma_{t+1}(H_{t-1}, \sigma_t(H_{t-1}))$. The same procedure can be used to derive consumers' expectations about policies in all subsequent periods. Of course, consumers could be wrong in their expectations. In such a case, they continue to use the policy plan σ to form expectations of future policies, given this new history.

At each date, the government maximizes its utility by choosing its current policy. Such a policy choice has two effects: first, it affects labor supply and second-stage consumption decisions in the current period; second, because it is now part of the history H_t, it affects consumers' expectations of future policies and their future decisions. The government must form expectations of how private decisions will be affected. Denote these expectations by functions $(C_{1t}(H_{t-1}), K_t(H_{t-1}), C_{2t}(H_t), L_t(H_t))$, which I call consumers' *contingency plans.* The government's problem at date t, given a history H_{t-1}, is

$$\text{(A5)} \quad \max \textstyle\sum_{s=t}^{\infty} \beta^s U(C_{1s}(H_{s-1}) + C_{2s}(H_s), L_s(H_s))$$

subject to

$$\text{(A6)} \quad C_{1s}(H_{s-1}) + K_s(H_{s-1}) = w$$

$$\text{(A7)} \quad C_{2s}(H_s) = R(1-\delta_s)K_s(H_{s-1}) + (1-\tau_s)L_s(H_s)$$

where the histories are induced from H_{t-1} by the chosen policies. Notice that by its policy choice, the government can affect histories and thereby expectations, but consumers assume that the evolution of the histories are beyond their control.

A *sustainable equilibrium* is a policy plan for the government and contingency plans for consumers such that for every history, the following conditions are met:

- Consumers' contingency plans solve problem (A1), given the policy plan.
- Given consumers' contingency plans, the government's policy plan solves problem (A5).

The set of sustainable outcomes are completely characterized by Chari and Kehoe (1988a). They show that the worst sustainable equilibrium (in terms of utility) is an infinite repetition of the single-period sustainable equilibrium. They also establish that with sufficiently little discounting, the Ramsey policies are sustainable. The plans supporting such outcomes specify that the government should follow Ramsey policies as long as these policies have been followed in the past. Consumers' contingency plans specify that for such histories, they should save their entire endowments. If the government has ever deviated from the Ramsey policies, consumers' plans specify that they save nothing. Given such plans, the government chooses optimally to continue the Ramsey policies in each period.

Appendix B
Computing Ramsey Policies for the Debt and Default Model

In this appendix, I show how to compute the Ramsey policies for the debt and default model. I also show that taxes on labor supply are the same on any two dates with the same level of government spending.

It is convenient to collapse the sequence of budget constraints faced by consumers into a single budget constraint. Let P_t denote the price at date 0 for delivery of one unit of the consumption good at date t. I can then represent the one-period interest rate between t and $t+1$ as

(B1) $\quad P_{t+1}/P_t = 1/(1+{}_tr_{t+1}).$

Of course, $P_0 = 1$. Alternatively, P_{t+1}/P_t can be thought of as the price of a default-free, single-period discount bond at t. Then, the consumer's budget constraint (11) can be written as

(B2) $$C_t + (P_{t+1}/P_t)D_{t+1} + [P_{t+1}(1-\delta_{t+1})/P_t]B_{t+1} = (1-\tau_t)C_t + (1-\delta_t)B_t + D_t.$$

Multiplying (B2) by P_t, adding across dates 0 through T, and using the terminal conditions that $B_{T+1} = D_{T+1} = D_0 = 0$, I get

(B3) $$\Sigma_{t=0}^{T} P_t C_t = \Sigma_{t=0}^{T} P_t(1-\tau_t)L_t + (1-\delta_0)B_0.$$

The consumer maximizes the utility function (10) subject to (B3). The first-order conditions to this problem are (B3),

(B4) $$\beta^t U_c(C_t, L_t) = \lambda P_t$$

and

(B5) $$\beta^t U_l(C_t, L_t) = -\lambda P_t(1-\tau_t)$$

where λ is the Lagrange multiplier associated with (B3).

For the government's budget constraints, I repeat the same process as for the consumer, collapsing the sequence of budget constraints (8) to get a single constraint given by

(B6) $$\Sigma_{t=0}^{T} P_t(\tau_t L_t) = \Sigma_{t=0}^{T} P_t G_t + (1-\delta_0)B_0.$$

The government maximizes its utility function subject to (B6). Unlike the consumer, the government does not take prices as given. It recognizes that the prices and consumers' decisions are implicitly given by the first-order conditions (B3)–(B5) and the national income identity (7). Substituting the consumers' first-order conditions into (B6), using the national income identity, and rearranging gives the government's budget constraint:

(B7) $$\Sigma_t \beta^t [C_t U_c(C_t, L_t) + L_t U_l(C_t, L_t)] = (1-\delta_0)B_0.$$

The government maximizes the utility function (13) subject to (B7) and the national income identity (7). Let μ denote the Lagrange multiplier on (B7), and let v_t denote the Lagrange multipliers on (7). The first-order conditions for the government's maximization problem are

(B8) $$\beta^t U_c + \mu\beta^t(U_c + C_t U_{cc} + L_t U_{cl}) - v_t = 0$$

and

(B9) $$\beta^t U_l + \mu\beta^t(U_l + C_t U_{cl} + L_t U_{ll}) + v_t = 0$$

where, for convenience, I have suppressed the time subscripts on the partial derivatives. Adding (B8) and (B9) and rearranging, I get

(B10) $$(1+\mu)/\mu = [C_t(U_{cc} + U_{cl}) + L_t(U_{ll} + U_{cl})]/(U_c + U_l).$$

The left side of (B10) is independent of the date and the value of government spending. Consequently, for any two dates with the same government spending, choosing the same values of consumption and labor supply solves (B10). Hence, the policies for any two such dates must be the same.

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