

## DYNAMIC INCONSISTENCY, COOPERATION AND THE BENEVOLENT DISSEMBLING GOVERNMENT

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The paper investigates the circumstances under which the problem of dynamic inconsistency arises, and discusses its implications for control theory and optimal policy-making. The problem arises when the government does not have non-distortionary control instruments at its disposal and when expectations of future variables are relevant to current private sector decisions. It can also arise if the policy maker's utility function differs from that of the representative individual. The problem may disappear if cooperative behavior can be induced. The problem does not preclude the use of optimal control theory in economic policy analysis, but raises serious issues about the types of optimal control paths that are most relevant for policy-making.

### 1. Introduction

The problem of the dynamic inconsistency of optimal policy in a macro-economic context has received considerable attention, in this issue of the JEDC and elsewhere, since it was raised by Kydland and Prescott (1977).<sup>1</sup> The problem occurs when optimal policy calculated at time zero, setting time paths for the control variables, implies values of the control variables at some later time,  $t$ , that will not be optimal when policy is re-examined at  $t$ .

An example studied by Kydland and Prescott (1977, 1980) and examined at length in this paper, makes the point. Consider a government that spends on a public good, financed by proportional taxes on labor and capital income. Current period government spending is optimally financed by non-distortionary capital taxation. But it is not generally optimal from today's perspective to have people believe that only capital taxation will be used in future, since that belief unduly restricts current capital accumulation. In a rational expectations equilibrium today's announced optimal policy will promise taxation of both labor and capital income in future periods.

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<sup>1</sup>Articles by Chow, Kydland and Prescott, and Taylor in this issue, and papers by Calvo (1978), Prescott (1977), and Taylor (1979) are relevant. Auernheimer (1974), Bulow (1978), Lancaster (1973), Maskin and Newbery (1978), and Phelps and Pollak (1968) discuss related problems. There is also an extensive literature, starting from the classic paper by Strotz (1956), on the problem of dynamic inconsistency for an individual. Elster (1979) discusses inconsistency in a more general and philosophical context, providing many non-economics references.

However, when the future becomes the present, it becomes optimal to use only capital taxation in the current period. Hence optimal policy in this case is dynamically inconsistent.

The natural reaction of one schooled on Bellman's Principle of Optimality is to say that the inconsistency is the result of the failure to optimize backwards, since policy at each moment ought to be based on the principle that the past is irrelevant – and policy in earlier periods ought to take the later use of the principle into account. Backward optimization will indeed produce a consistent time path for policy. But the consistent policy is inferior to the optimal policy when the latter is dynamically inconsistent.

More homely examples than the optimal taxation case are plentiful. Exams are a case in point. Optimal policy at the beginning of a course is to plan to have an exam at the end. However, on the morning of the exam, once the students have prepared themselves, the optimal policy is to cancel the exam, saving the students the trouble of writing, and the instructor the trouble of grading. The consistent policy, optimizing backwards, recognizes that the exam will not be held. But the outcome of the course will clearly be inferior in that case.

The purposes of this paper are to investigate the circumstances under which the problem of dynamic inconsistency arises, and to discuss its implications for control theory and optimal policy-making. The major emphasis is on the calculation of optimal, consistent, and other solutions in a stripped-down version of the optimal tax problem studied by Kydland and Prescott in this issue. The model is a convenient peg on which to hang the discussion both because it is about the simplest set-up that will produce dynamic inconsistency and because it makes it clear that dynamic inconsistency can occur even when the policy-maker maximizes the welfare of the representative consumer, who is himself a rational maximizer.<sup>2</sup>

The optimal tax problem is set up in section 2 and a variety of solutions studied in sections 3–7. The role of differences between the maximization problems faced by the controller and the representative individual is examined in section 8. Sections 9 and 10 discuss the implications of inconsistency for optimal control theory and for economic policy respectively. Conclusions are contained in section 11.

## 2. The optimum problem and the command optimum

There are two periods. The consumer has only a savings decision to make

<sup>2</sup>Both Calvo (1978) and Kydland and Prescott have emphasized this result. In some examples in the literature, the dynamic inconsistency problem disappears if the private sector behavioral functions are derived from optimization of the same utility function as the government is maximizing. This applies, for instance, to the example on pp. 475–477 of Kydland and Prescott (1977).

in the first period and labor-supply and consumption decisions in the second period. The government undertakes no actions in the first period. In the second period it taxes capital and labor income and chooses the level of government spending. The utility of the representative individual is

$$U(c_1, c_2, g_2) = \ln c_1 + \delta(\ln c_2 + \alpha \ln(\bar{n} - n_2)) + \beta \ln g_2, \quad (1)$$

where  $c_i$  is the rate of consumption in period  $i$ ,  $n_2$  is the amount of work, and  $g_2$  is the level of government spending in period 2.

The production function is linear, with the marginal product of labor a constant equal to  $a$ , and the marginal product of capital a constant equal to  $b$ . The initial capital stock,  $k_1$ , is given. The technological constraints faced by the economy are

$$c_1 + k_2 \leq (1 + b)k_1 \equiv Rk_1, \quad (2)$$

$$c_2 + g_2 \leq an_2 + Rk_2. \quad (3)$$

No work is done in the first period.<sup>3</sup>

Before we include taxes explicitly, we examine the command optimum that would be chosen by a government maximizing (1) subject only to the constraints (2) and (3). This is a straightforward calculus exercise, which implies

$$c_1 = [1 + \delta(1 + \alpha + \beta)]^{-1} [a\bar{n}/R + Rk_1], \quad (4)$$

$$c_2 = \delta R c_1, \quad (5)$$

$$\bar{n} - n_2 = \alpha c_2 / a, \quad (6)$$

$$g_2 = \beta c_2. \quad (7)$$

This command optimum does not exhibit dynamic inconsistency. Given the choice of  $c_1$  implied by (4), and hence  $k_2$ , the government will still choose the allocation implied by (5) through (7) when period two arrives. The command optimum is the best allocation possible, given the technological constraints faced by the economy. It is also a Pareto optimum, but we shall refer to it by the more distinctive and less ambiguous name.

A command optimum could exhibit dynamic inconsistency of the Strotz (1956) or Pollak (1968) type, essentially because tastes change. For instance, in a problem with a longer horizon, there will be dynamic inconsistency if

<sup>3</sup>The inequalities in the constraints will henceforth be ignored. It is also necessary to require  $k_2 \geq 0$ , a constraint which will be assumed satisfied at the various optima.

the marginal rate of substitution between consumption in periods  $t$  and  $t+1$  differs when viewed from  $\tau$  ( $\tau < t$ ) and from  $\tau+1$ .

### 3. The optimal tax problem

Suppose the government has to use taxes rather than command to finance government spending. Each consumer will optimize (1), subject to constraints reflecting future tax rates. The consumer's constraints are

$$c_1 + k_2 = Rk_1, \quad (8)$$

$$c_2 = R_2 k_2 + a(1 - \tau_2)n_2. \quad (9)$$

Here  $R_2$  is the after-tax rate of return on capital and  $\tau_2$  is the tax rate on labor income.

The consumer treats  $R_2$  and  $\tau_2$ , as well as  $g_2$ , parametrically. For any given set of expected government policy variables, the result of the consumer's maximization problem is a first period consumption function and second period consumption and labor supply functions,

$$c_1 = [1 + \delta(1 + \alpha)]^{-1} [a\bar{n}((1 - \tau_2^e)/R_2^e) + Rk_1], \quad (10)$$

$$c_2 = \delta R_2^e c_1, \quad (11)$$

$$\bar{n} - n_2 = \alpha c_2 / a(1 - \tau_2^e). \quad (12)$$

Superscript  $e$  denotes the expected level of a variable. The absence of  $g_2^e$  from the behavioral functions results from the separability of the utility function.

The government's problem is to maximize (1) subject to the private sector's behavioral responses, (10)–(12), and the government budget constraint

$$g_2 = (R - R_2)k_2 + \tau_2 a n_2. \quad (13)$$

Obviously, the government has to know private sector beliefs,  $R_2^e$  and  $\tau_2^e$ , to make its plans. In a rational expectations equilibrium, it is assumed that  $R_2$  and  $R_2^e$ , and  $\tau_2$  and  $\tau_2^e$ , coincide. Assuming rational expectations, considerable calculation and substitution based on the first-order conditions for the optimal tax rates results in two equations for  $\tau_2$  and  $R_2$ ,

$$a\bar{n}(1 - R/R_2)((1 - \tau_2)/\alpha\delta R_2) + \tau_2 Rk_1/(1 - \tau_2) = 0, \quad (14)$$

$$\begin{aligned} & [R^2 k_1 \delta(1 + \alpha) + a\bar{n}(1 + \delta)] - \delta Rk_1 R_2 [1 + \alpha/(1 - \tau_2) + \beta] \\ & = a\bar{n}(1 - \tau_2)[R/R_2 + (1 + \beta)\delta]. \end{aligned} \quad (15)$$

The conditions are sufficiently non-linear that no convenient formulae for the optimal tax rates emerge. The first-order conditions imply that

$$g_2 = \beta c_2, \quad (16)$$

so that, as should be expected, the government optimally equates the marginal utility of private spending to that of government spending.

Given that the government can only use distortionary proportional taxation, and the rational expectations assumption, the tax rates  $\tau_2$  and  $(R - R_2)$  implied by (14) and (15) are the optimal taxes that are both believed and carried out. It is this solution that is generally referred to as the optimal solution though it is better referred to as the optimal open loop control, the term we shall use. The relevant solutions to (14) and (15) will be denoted  $\tau_2^*$  and  $R_2^*$ .

#### 4. The problem of inconsistency

The problem of inconsistency emerges when it is recognized that in the second period it is no longer optimal for the government to use tax rates  $\tau_2^*$  and  $(R - R_2^*)$ . In the second period, taking history (that is,  $k_2$ ) as given, the private sector maximizes

$$U_2(\quad) = \ln c_2 + \alpha \ln(\bar{n} - n_2) + \beta \ln g_2, \quad (17)$$

subject to

$$c_2 = R_2 k_2 + (1 - \tau_2) a n_2, \quad (18)$$

and taking  $R_2$ ,  $\tau_2$ , and  $g_2$  as given. The optimum implies

$$c_2 = (1/(1 + \alpha)) [a \bar{n} (1 - \tau_2) + R_2 k_2], \quad (19)$$

$$\bar{n} - n_2 = \alpha c_2 / a (1 - \tau_2). \quad (20)$$

The government in turn maximizes the same utility function, subject to the government budget constraint

$$g_2 = \tau_2 a n_2 + (R - R_2) k_2, \quad (21)$$

and the private sector behavioral functions (19) and (20). The resultant first order conditions imply

$$\tau_2 = 0, \quad (22)$$

$$R_2 = [1 + \alpha + \beta]^{-1} [R(1 + \alpha) - \beta a \bar{n} / k_2]. \quad (23)$$

Since the government has a non-distortionary tax on capital or its income available, it is optimal not to tax labor and thereby, as (20) shows, reduce labor supply. The use of capital taxation causes no distortions in the second period. Indeed, (18)–(23) imply exactly the same allocation of resources as would a second period command optimum, taking  $k_2$  as given.

We have now seen that the inconsistency problem can arise even when the government maximizes the utility of the representative individual. But it is important to note that it occurs only because the government has no non-distorting taxes (or their equivalent) available. If the policy maker were assumed to have an *ex ante* lump sum tax available in the second period, he could simply announce in the first period that lump sum taxes equal to  $g_2$ , as implied by (7) for the command optimum, would be levied in the second period. The resulting rational expectations equilibrium would duplicate the command optimum's allocation implied by (4)–(7), even though the allocative mechanism is now decentralized. Equivalently, if the government could both levy taxes in the first period and operate capital as efficiently as the private sector it could impose taxes on capital in the first period such that the capital would accumulate by period 2 to the level of  $g_2$  implied by (7).

## 5. The consistent solution and cooperation

A consistent solution is still available even if there are no non-distortionary taxes. It is the solution implied by the use of the Principle of Optimality. Starting in the second period, taking  $k_2$  as given, both the representative individual and the government optimize. This is precisely the problem solved in (17)–(23) above. Then one period earlier, the consumer optimizes with respect to the consumption–savings decision, taking the government's future tax rates and spending plans as given.

The second period utility of the representative individual can be calculated from (17)–(23). The individual takes  $\tau_2$ ,  $R_2$ , and  $g_2$  as given when calculating the optimized value of his second period utility. The derived utility function for the individual in the second period, using (17)–(20) is

$$\begin{aligned} U_{2,H}^*(\ ) &= (1 + \alpha) \ln c_2 + \alpha \ln \alpha/a(1 - \tau_2) + \beta \ln g_2 \\ &= (1 + \alpha) \ln [a\bar{n}(1 - \tau_2) + R_2 k_2] \\ &\quad - (1 + \alpha) \ln (1 + \alpha) + \alpha \ln \alpha/a(1 - \tau_2) + \beta \ln g_2. \end{aligned} \quad (24)$$

One period earlier, the consumer maximizes

$$U_{1,H}(\ ) = \ln c_1 + \delta U_{2,H}^*(\ ),$$

taking  $\tau_2$ ,  $R_2$  and  $g_2$  as given. The choice variable in the first period is now  $k_2$ ; the only first period decision is the consumption–savings choice. The budget constraint is again (8) and the consumption function is the same as (10).

In the rational expectations equilibrium, actual and expected tax rates coincide, so that

$$c_1 = [1 + \delta(1 + \alpha)]^{-1} [a\bar{n}/R_2 + Rk_1], \quad (25)$$

and to solve for equilibrium  $k_2$  it is necessary to combine (25), the optimal tax rule (23), and the budget constraint (8). The result is a quadratic equation for  $R_2$ ,<sup>4</sup>

$$R_2^2 [Rk_1\delta(1 + \alpha + \beta)] - R_2 [a\bar{n}(1 - \beta\delta) + R^2(1 + \alpha)k_1\delta] + a\bar{n}R = 0. \quad (26)$$

Once (26) has been solved, the consistent optimal tax allocation is easily calculated. The optimized value of the utility function will in general be lower than for the optimal open loop tax program of section 3 above (since here we constrain  $\tau_2$  to zero), which is in turn lower than the utility level for the command optimum.

The assumption that individuals take  $\tau_2$ ,  $R_2$ , and  $g_2$  as given in calculating their first period actions is of great importance. For suppose there was only one first period decision-maker, who knew the government's second period tax and allocation rules, including the rule implied by (23) that

$$g_2 = \beta c_2. \quad (27)$$

Then the derived utility function would be

$$U_2^* = (1 + \alpha + \beta) \ln c_2 + \alpha \ln \alpha/a + \beta \ln \beta, \quad (28)$$

and, it may easily be confirmed, the implied allocation of resources would be the command optimum. The reason is that the government is trying to maximize the utility of the representative individual, so that there is no inherent conflict between its policies and the outcome the representative individual would want. It is only because each individual takes the actions of others and the government as given that the optimal tax allocations are inferior to the command optimum.<sup>5</sup>

<sup>4</sup>One of the roots of (26) in general implies higher utility than the other.

<sup>5</sup>The optimal open loop allocation would also become the command optimum if the government announced tax rules instead of rates and if there were only a single individual on the other side.

There is an externality at work here in which each person, acting individually, and taking the actions of others (including the government) as given, ends up worse off than if coordinated action were possible. The rational expectations optimum tax allocations of this and the previous section are implicitly Nash equilibria in a game with very many players, whereas the command optimum corresponds to a cooperative equilibrium.

Note that the government has different settings of the policy variables depending on private sector actions. The tax rule (23) applies throughout, but the second period tax rate differs depending on how the private sector acts in the first period. If the private sector acts cooperatively, taxes on capital will be low and we will be informed that of course low taxation produces capital accumulation. If the private sector acts non-cooperatively, taxes on capital will be high and of course high taxes discourage capital formation. But of course the causation goes the other way: the *level* of the second period tax rate depends on how the private sector behaved in the first period.

This example, *mutatis mutandis*, fits the case of wage-price controls well. Wage-price controls can be viewed as an attempt to enforce the command optimum in the face of the externality caused by each individual's taking the price-setting actions of others (including the second period reactions of the government) as given. By analogy with the optimal tax example, the second period money stock (and price level) will be higher if the private sector acts non-cooperatively than if it acts cooperatively, and we might well be told that of course loose money leads to high prices. But money is loose only because the government's policy, undertaken with the aim of maximizing the welfare of the representative individual, depends on private sector behavior.

## 6. The inconsistent solution

We have so far studied the command optimum, the optimal open loop policy, and the consistent policy. We also noted the inconsistency of the optimal open loop solution. We can refer to the solution obtained by (a) having individuals believe in the first period that the optimal open loop solution (of section 3) will be followed, and (b) imposing taxes that are optimal in the second period, as in (22) and (23), as the inconsistent solution.<sup>6</sup>

The question is whether the inconsistent solution is in some sense bad. The answer is no. The government, after all, is doing its best on behalf of the representative individual. In period 2 it can choose the previously believed tax rates if it so wishes. But it is not optimal to do so. Accordingly, realized

<sup>6</sup>There are of course many solutions in which expected and actual policy actions diverge.



utility in the inconsistent solution exceeds that in the optimal open loop solution, which exceeds that in the consistent solution.<sup>7</sup>

After the event, individuals are better off if the government is inconsistent – hence the benevolent dissembling government of the title. Of course, once we permit possible divergences between the first period beliefs of the representative individual and the second period actions of the government, many other allocations become possible. The command optimum is once more attainable: to produce it in our example, the private sector has only to be induced to save precisely the right amount in the first period, and only capital is then taxed in the second period. Combinations of  $\tau_2^e$  and  $R_2^e$  that will do the trick can be found by equating  $c_1$  as given by (4) and (10).

## 7. Numerical example

The nature of the solutions examined may be further clarified by a numerical example. Parameter values chosen are

$$R = 1.5, \quad k_1 = 2, \quad a = 1 = \bar{n}, \quad \alpha = 0.25, \quad \beta = 0.5, \quad \delta = 0.9. \quad (29)$$

Table 1 gives the realized value of the two period utility function (1) for each solution,<sup>8</sup> along with the allocation of resources, tax rates, and expected tax rates. In each case,  $g_2 = 0.5c_2$  is not shown.

Table 1  
Solutions for different types of policy.

| Solution          | $U^{**}$ | $c_1$ | $k_2$ | $c_2$ | $n_2$ | $R_2$  | $R_2^e$ | $\tau_2$ | $\tau_2^e$ |
|-------------------|----------|-------|-------|-------|-------|--------|---------|----------|------------|
| Command           | 0.759    | 1.424 | 1.576 | 1.922 | 0.519 |        |         |          |            |
| Optimal open-loop | 0.706    | 1.726 | 1.274 | 1.553 | 0.419 | 0.9996 | 0.9996  | 0.332    | 0.332      |
| Consistent        | 0.625    | 2.014 | 0.986 | 1.417 | 0.646 | 0.782  | 0.782   | 0        | 0          |
| Inconsistent      | 0.723    | 1.726 | 1.274 | 1.663 | 0.584 | 0.847  | 0.9996  | 0        | 0.332      |

The example makes clear the sources of utility differences among the policies. Comparing first the consistent and command solutions, we note the higher level of capital taxation in the consistent solution, which reduces the

<sup>7</sup>Over longer horizons, the inconsistent solution may be infeasible, and the loss of credibility of the government resulting from its use may be bad.

<sup>8</sup>These solutions (except the command optimum) have their counterparts, under different names, in Maskin and Newbery (1978).

capital stock substantially compared with the command optimum.<sup>9</sup> The optimal open loop solution is not constrained to use only capital taxation in the second period and therefore promises lower capital taxation, inducing more capital accumulation. Much less work is done in the second period under the optimal open loop solution, which taxes labor, than in the consistent solution.<sup>10</sup> Finally, the inconsistent solution is not constrained by any hobgoblins and, having induced the higher second period  $k_2$ , can then use optimal non-distortionary taxes. Labor works more in period 2 in the inconsistent than in the optimal open loop policy but not – thanks to the higher level of the capital stock – as hard as in the consistent solution.

## 8. Taste differences

We have so far confined attention to situations where the government maximizes the welfare of the representative individual, and have seen that dynamic inconsistency arises when the government has no non-distortionary taxes at its disposal. We want next to ask whether differences between the utility functions maximized by the government and the representative individual can produce inconsistency. The answer is yes.

Suppose that the representative individual continues to maximize the utility function (1), and that the government maximizes a function with the same functional form, but in which the discount rate is  $\rho$  instead of  $\delta$ , and the weight on leisure is  $\gamma$  instead of  $\alpha$ . The parameter  $\beta$  is the same in both utility functions. We assume in addition that a non-distortionary lump sum tax is available in the second period. This ensures that there would be no dynamic inconsistency if tastes were the same. Denote by  $\theta_2$  the amount of the lump sum tax levied on the representative individual in the second period. Finally assume that labor, but not capital, income can be taxed in the second period.

We will this time leave it to the reader to work through the details of the optimal open loop policy. But the source of its inconsistency can be readily explained. The important point is that in the presence of taste differences, the government will want to use labor income taxation in the second period to ensure that the rates of substitution chosen by the private sector are socially optimal. If it uses a labor income tax in the second period to produce the right allocation between second period consumption and leisure, it then has to use the lump sum tax to affect both the first period savings decision and the second period private-government spending decision. But once the

<sup>9</sup>The expected use of capital taxation does not always (i.e., with other utility functions) reduce  $k_2$ , but it does move  $k_2$  away from the level implied by the command optimum.

<sup>10</sup>Cf. footnote 9, *mutatis mutandis*.

second period arrives, the lump sum and labor income tax can be used to achieve an optimal second period allocation.

Hence, differences in utility functions between the private and public sectors can produce dynamic inconsistency where it would not otherwise occur. It is, incidentally, interesting to note that the inconsistency can be attributed to the government's shortage of instruments. The government has three goals in the first period, first, to induce optimal capital accumulation, second, to induce the right marginal second period choice between private consumption and leisure, and third, to choose the correct private–public consumption margin. But by assumption it has only two instruments for these purposes. One period later it has only two goals but still has two instruments at its disposal. Now the instruments can be deployed without worrying about capital accumulation, and the optimal settings change.

Although we have emphasized the identity of utility functions between the government and the representative individual in previous sections, there is a sense in which utility functions differ even in those cases. The maximization problems faced by individuals and the government differ when there is dynamic inconsistency. The constraints faced by the representative individual and by the government differ; if we use backward optimization, the derived second period utility functions differ, because the individual does not maximize with respect to  $g_2$ .

We could consider an alternative set-up in which two players optimize the same utility function, each having some decision variables under its direct control, and each facing the same constraints. For instance, consider the command optimum of section 2. Suppose the government is responsible for choosing  $g_2$  and announcing  $g_2$  to the representative individual, who then chooses  $c_1$ ,  $c_2$ , and  $n_2$ . Each side is subject to the constraints (2) and (3). The solution is of course consistent.

In this latter case, the controller and the controlled indeed have the same optimization problem. The only difference between their problems is in the variables under their control. There is thus a sense in which we can say that dynamic inconsistency occurs only if the maximization problems faced by the government and the representative individual differ.

## **9. Inconsistency, the applicability of optimal control, and rational expectations**

The inconsistency of the optimal open loop policy does not raise any fundamental issues about the use of optimal control theory in policy analysis – if one views control theory as providing a set of tools for the calculation of optimal policies, typically from some restricted class, and typically in dynamic models. As shown in this issue, control theory can be used to calculate paths that are optimal in the sense that they are the best plans

possible in the class of pre-announced, believed, and carried-through, policies. The optimal open loop path of section 3 is one such path. Or control theory can be used to find the best consistent policy, or the best linear feedback rule when expectations are rational, or the best linear feedback rule when expectations are adaptive, and so on.

It is nonetheless important to know when the optimal open loop policy is inconsistent since there are in that case incentives to depart from the plan. A simple diagnostic test suggests itself when expectations are rational. The test is to apply the backward optimization process used in constructing the consistent solution. At the same time, treat expectations of earlier periods as distinct control variables, and optimize with respect to them. If optimized values of the expectations are equal to optimized values of the corresponding control variables or values of endogenous variables implied by the optimal settings of the control variables, there is no inconsistency problem. Otherwise there is.

This test shows why the inconsistency problem was detected first in applications of optimal control in models with rational expectations. But inconsistency can occur even if expectations are not fully rational, so long as they depend in some way on announcements of future policy. If expectations were purely adaptive, dependent only on the past behavior of policy or other variables, the inconsistency problem would not arise unless the controller's tastes changed over time.

## 10. Dynamic inconsistency and economic policy

Although the possibility of dynamic inconsistency does not preclude the use of optimal control theory, it does raise serious issues about economic policy. When dynamic inconsistency is present, there is a standing temptation not to follow previously announced plans. At the same time, the non-optimality of the consistent path provides an incentive not to follow that path.

How important is the issue? The circumstances under which dynamic inconsistency arises – the need to use distorting taxes, or differences in tastes between the government and the representative individual – are pervasive. We should thus expect the issue to emerge even in well-defined optimization problems where no macroeconomic ad hocery is involved.

What does the issue imply about policy? Dynamic inconsistency has been suggested as an argument for the use of some form of precommitment, for example, for rules rather than discretion. Simple rules have the advantage of being easy to analyze, and frequently imply that no great disaster can occur. But there will still generally be an incentive to break the rules. And rule breaking does good, at least in the short run. In the example of section

6, individuals are better off if the government deceives them. The view, to which I among others have subscribed, that policy that fools people cannot do good, is not right when there are distortions in the economy.

The examples in this paper are hardly conclusive, however, because they do not study the consequences of repeated inconsistency. At some stage repeated deception cannot deceive, and the inconsistent policy becomes consistent – and we know such a policy may produce poor outcomes. Kydland and Prescott (1977) study several cases in which the use in each period of the first period control for the open loop policy starting that period does very badly indeed relative to simple rules.

But it is not at all clear that it is optimal to stick to expected policies (or simple rules) always, even though it is clearly not optimal to violate them always. In an emergency it may be desirable to do that which is expedient. And it may be that certain policies are saved for emergency use. For example, wealth taxes are sometimes imposed during a war but not in normal times. Central banks behave differently in crises than in regular times, lending against assets they would reject in less exciting times. And that may be the best thing to do. It thus becomes clear that it is necessary to investigate the consequences of failing to carry through on announced or expected plans.

Examination of table 1 raises the possibility that some consistent combination of the optimal open loop and inconsistent policy may outperform the pure open loop policy, even if it is adhered to. This suggests that a randomized policy that is rationally expected may do better than non-stochastic optimal open loop policy.<sup>11</sup> But there are of course severe problems in ensuring that government adhere to a randomized policy. It may be that the only way to ensure consistency of a randomized policy is to tie specific policies to specific events, such as wars. There is clearly a wide range of interesting questions in this area.

## 11. Conclusions

The examples studied in this paper suggest<sup>12</sup>

- (1) Dynamic inconsistency can occur even when the government maximizes the utility of the representative individual. It will not occur in this case if the government has sufficient non-distorting control instruments at its disposal. Dynamic inconsistency can be thought of as resulting from the

<sup>11</sup>Eric Maskin has constructed an example based on the exam analogy in the introduction, in which the optimal policy is to have exams at random. Guillermo Calvo has pointed out to me that Weiss (1976) has obtained results similar to those conjectured here.

<sup>12</sup>The fundamental result, (1), is due to Kydland and Prescott (1977) and Calvo (1978).

- presence of distortions. Consistent equilibria can be computed, but these result in worse outcomes than sticking to the optimal open loop policy.
- (2) If inconsistency occurs when the government is maximizing the utility of the representative individual, there will be utility gains if individuals can be induced to act cooperatively. Wage-price controls can be viewed as an attempt to reach a cooperative equilibrium that will avoid inconsistency.
  - (3) Differences in utility functions between the public and private sectors can produce dynamic inconsistency where it would not otherwise occur. There is a sense in which all dynamic inconsistency occurs because the maximization problems of the controller and the representative individual differ. There will be no dynamic inconsistency if the government and the representative individual face exactly the same optimization problem except for the variables they control.
  - (4) Dynamic inconsistency can occur when expectations are not rational, but its presence does require expectations of future policy actions or their consequences to affect current private sector decisions.
  - (5) Inconsistency pays if it has no longer run consequences. Individuals may be deceived for their own good.
  - (6) The inconsistency problem does not preclude the use of control theory in economics as a set of techniques finding optima from some restricted class of policies.
  - (7) The inconsistency problem does raise serious questions about the types of optimal control paths that are most relevant for economic policy making. The incentives are not to follow consistent policies, and not to stick to policy rules. The consequences of occasional (optimal) deviation from planned policy paths, or policy rules, may be desirable, but that remains a matter for further investigation.

## References

- Auernheimer, Leonardo, 1974, The honest government's guide to the revenue from the creation of money, *Journal of Political Economy* 3, 598–606.
- Bulow, Jeremy I., 1978, Durable goods, monopolists, Unpublished working paper (M.I.T., Cambridge, MA).
- Calvo, Guillermo, 1978, On the time consistency of optimal policy in a monetary economy, *Econometrica* 6, 1411–1428.
- Chow, Gregory, 1980, Econometric policy evaluation and optimization with rational expectations, This issue.
- Elster, Jon, 1979, *Ulysses and the Sirens; Studies in rationality and irrationality* (Cambridge University Press, Cambridge).
- Kydland, Finn E. and Edward C. Prescott, 1977, Rules rather than discretion: The inconsistency of optimal plans, *Journal of Political Economy* 3, 473–492.
- Kydland, Finn E. and Edward C. Prescott, 1980, Dynamic optimal taxation, rational expectations, and control theory, This issue.

- Lancaster, Kelvin, 1973, The dynamic inefficiency of capitalism, *Journal of Political Economy* 5, 1092–1109.
- Maskin, Eric and David Newbery, 1978, Rational expectations with market power – the paradox of the disadvantageous tariff on oil, Working paper no. 227 (Massachusetts Institute of Technology, Cambridge, MA).
- Phelps, Edmund S. and Robert A. Pollak, 1968, On second-best national saving and game-equilibrium growth, *Review of Economic Studies* 2, 185–199.
- Pollak, Robert A., 1968, Consistent planning, *Review of Economic Studies* 2, 201–208.
- Prescott, Edward C., 1977, Should control theory be used for economic stabilization?, in: Karl Brunner and Allan H. Meltzer, eds., *Carnegie-Rochester Conference Series on Public Policy*, Vol. 7: Optimal policies, control theory and technology exports (North-Holland, Amsterdam) 13–38.
- Strotz, Robert H., 1956, Myopia and inconsistency in dynamic utility maximization, *Review of Economic Studies*, 165–180.
- Taylor, John B., 1979, Estimation and control of a macroeconomic model with rational expectations, *Econometrica*, 1267–1286.
- Taylor, John B., 1980, Output and price stability: An international comparison, This issue.
- Weiss, Laurence, 1976, The desirability of cheating incentives and randomness in the optimal income tax, *Journal of Political Economy* 84, 1343–1352.