

## *Comment*

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### *1. Introduction*

In this paper, Nancy Stokey presents two examples in which the time-consistency problem arises in a macroeconomic policymaking context. I consider these two examples to be extremely well chosen, for several reasons. First, each example deals with an important problem—the choice of a monetary policy instrument or the choice of a capital income tax rate—that is of considerable interest in and of itself. Second, each serves to introduce us to some powerful analytic techniques that recently have been developed by researchers working at the frontiers of economic science. The examples show us how far this branch of the literature has come, from a technical perspective, in the twenty-five years since the publication of Kydland and Prescott's (1977) original paper.

But, third and perhaps most important of all, I consider these two examples to be well chosen because each uses a model that shares its most basic features with all of the other models that have been developed in the literature that builds on Kydland and Prescott (1977). Thus, each of Nancy's models has implications for a wide range of issues that have already been studied extensively, and, by the same token, each remains silent on some important issues that have yet to be fully discussed, much less satisfactorily resolved, in the literature as it stands now.

In fact, because Nancy's models are so representative of others from this branch of the literature, I will be able to use one of them here in my discussion to provide answers of my own to two more basic and fundamental questions. First, what have we learned about the time-consistency problem in the twenty-five years since Kydland and Prescott (1977)? And second, what more might we hope to learn about the problem over the next twenty-five years?

### *2. The Model*

My model is a simplified version of one of Nancy's: the model that she uses to study the trade-off between tightness and observability in the choice of a monetary policy instrument. My version of the model is simplified in that it eliminates the random and unobservable elements that play a key role in Nancy's analysis, but are less essential for my purposes. For the most part, I borrow my notation directly from Nancy's paper, al-

though I make a few minor changes here and there, when they serve to make the results cleaner and easier to understand.

My model describes the behavior of a central bank, which chooses the rate of price inflation  $\pi$ , and a representative household, whose actions determine the rate of wage inflation  $w$ . As explained in more detail below, the representative household sets the rate of wage inflation based on its expectations of the central bank's choice of  $\pi$ . In this model, therefore, the variable  $w$  also serves as a convenient proxy for expected inflation.

The central bank's objectives are summarized by the single-period return or payoff function

$$R(\pi; w) = - \left( \frac{1}{2} \pi^2 + \frac{b}{2} (w - \pi + \alpha)^2 \right),$$

where the parameters  $b$  and  $\alpha$  are both nonnegative. The first term in this objective function captures the costs of inflation or, more precisely, penalizes deviations of the inflation rate  $\pi$  from the central bank's target of zero. To interpret the second term, consider the expectational Phillips curve

$$U = U^n - (\pi - w),$$

where  $U$  denotes the actual rate of unemployment, where  $U^n$  denotes the natural rate of unemployment, and where, since  $w$  measures expected inflation,  $\pi - w$  serves as a measure of surprise inflation. Then

$$w - \pi + \alpha = U - (U^n - \alpha),$$

indicating that, according to the objective function  $R$ , the central bank sets a target  $U^n - \alpha$  for the unemployment rate that lies *below* the natural rate. The parameter  $b$  measures the weight that the central bank places on achieving this goal for unemployment, relative to its goal for inflation.

The representative household in this model has a very simple objective: it wishes to set  $w$  as close as possible to the central bank's choice of  $\pi$ . The representative household has rational expectations, which here in the absence of shocks translates into perfect foresight. Thus, the household always accomplishes its goal by setting  $w$  exactly equal to  $\pi$ .

This condition,  $w = \pi$ , must always hold in equilibrium: it summarizes the implications of the household's optimizing behavior. What Kydland and Prescott's (1977) original paper teaches us is that macroeconomic outcomes depend critically on whether or not the central bank also views

this equilibrium condition as a constraint that links its choice of  $\pi$  to the representative household's choice of  $w$ . To see this, let's consider the two basic cases.

**CASE 1: COMMITMENT** In this first case, the central bank has the willingness and the ability to precommit to a choice for  $\pi$  at the beginning of the period, before the household embeds its expectations into a particular choice of  $w$ . Since the central bank moves first, it views the equilibrium condition  $w = \pi$  as a constraint that links its choice of  $\pi$  to a subsequent setting for  $w$ . In this case, therefore, the central bank solves the constrained optimization problem

$$\max_{\pi} R(\pi; w) \quad \text{subject to} \quad w = \pi.$$

The first-order condition for this problem implies that the optimal inflation rate with commitment, denoted by  $\pi^c$ , equals zero:

$$\pi^c = 0.$$

When the central bank precommits to a choice for  $\pi$ , it recognizes that it is losing any ability it might otherwise have to surprise the representative household and thereby exploit the Phillips curve. Hence, in this case with commitment, the central bank abandons any idea of pushing unemployment below the natural rate, and instead focuses exclusively on achieving its goal of zero inflation.

**CASE 2: NO COMMITMENT** In this second case, the central bank is either unwilling or unable to precommit, and effectively makes its choice of  $\pi$  after the representative household has embedded its expectations into a particular choice of  $w$ . Since the central bank moves second, it no longer perceives  $w = \pi$  as a constraint. Instead, the central bank simply takes  $w$  as given, and solves the unconstrained optimization problem

$$\max_{\pi} R(\pi; w).$$

The first-order condition for this problem dictates that the central bank's optimal choice without commitment, denoted by  $\pi^{nc}$ , is given by

$$\pi^{nc} = \frac{b}{1+b}(w + \alpha).$$

In equilibrium, however, the condition  $w = \pi$  must still hold: in particular, the representative household perfectly anticipates the central bank's ac-

tions, and sets  $w = \pi^{\text{nc}}$ . Combining this equilibrium condition with the central bank's first-order condition reveals that in this case without commitment,

$$\pi^{\text{nc}} = b\alpha \geq 0.$$

Comparing the outcomes with and without commitment,  $\pi^c = 0$  and  $\pi^{\text{nc}} = b\alpha \geq 0$ , serves to crystalize Kydland and Prescott's (1977) original message. The central bank that is either unwilling or unable to precommit to a choice of  $\pi$  finds itself tempted to exploit the expectational Phillips curve, in an effort to achieve its goal of pushing unemployment below the natural rate. The representative household has rational expectations, however, and understands that the central bank faces this temptation to inflate. The household, therefore, builds these inflationary expectations into its wage-setting decisions, so that unemployment remains at its natural rate. The central bank's efforts to exploit the Phillips curve lead only to a suboptimally high rate of inflation.

### 3. *What Have We Learned since Kydland and Prescott (1977)?*

But what else have we learned about the time-consistency problem in the twenty-five years since the publication of Kydland and Prescott's (1977) original paper? Comparing the outcomes  $\pi^c = 0$  and  $\pi^{\text{nc}} = b\alpha$  immediately reveals that in this simple version of Nancy's model,  $b\alpha$  conveniently measures the inflationary bias that results when the central bank does not precommit to its choice for  $\pi$ . This expression,  $b\alpha$ , also suggests that there are at least two promising strategies that policymakers can use to minimize the inflationary bias, and thereby improve welfare.

One possibility involves setting the parameter  $\alpha$  equal to zero, that is, instructing the central bank to stop targeting an unemployment rate that lies below the natural rate. McCallum (1995) argues passionately in favor of this solution to the central bank's time-consistency problem, and Blinder (1997) suggests that in practice, Federal Reserve officials have acted to minimize the importance of the time-consistency problem by behaving as if  $\alpha = 0$ . In fact, when  $\alpha = 0$  in the simple model considered here, the time-consistency problem vanishes: outcomes with and without commitment coincide.

A second possibility involves setting the parameter  $b$  equal to zero, that is, instructing the central bank to stop caring so much about unemployment in the first place. This proposed solution to the time-consistency

problem corresponds, of course, to Rogoff's (1985) suggestion that the appointment of a conservative central banker can lead to preferred outcomes in cases where monetary precommitment is impossible. And again, in the context of this simple model, outcomes with and without commitment coincide when  $b = 0$ .

Much of the recent literature that builds on Kydland and Prescott's (1977) original study focuses on the choice between these two solutions to the time-consistency problem for monetary policymaking. As noted above, both solutions work perfectly well in the context of the simple nonstochastic model used here. However, in more complicated models where random shocks give rise to a trade-off between the *variability* as well as the *levels* of inflation on one hand and unemployment on the other, Clarida, Gali, and Gertler (1999), Herrendorf and Lockwood (1997), and Svensson (1997) find that in addition to the *inflationary bias* that arises here, a *stabilization bias* also emerges in the absence of commitment: the discretionary central bank works too hard to stabilize unemployment, and not hard enough to stabilize inflation, in response to the shocks that hit the economy.

All three of these recent papers demonstrate that while the inflationary bias vanishes when  $\alpha = 0$ , so that the central bank's target for unemployment coincides with the natural rate, the stabilization bias remains. All three of these papers also suggest that the alternative solution of appointing a conservative central banker, with a lower value of  $b$ , can work to minimize both the inflationary bias and the stabilization bias, especially in cases where the conservative central banker is also offered an inflation contract of the kind first proposed by Walsh (1995). This, in my view, represents one of the most important lessons to have come out of the literature that builds on Kydland and Prescott (1977): that in situations where the time-consistency problem arises, it can be desirable to appoint policymakers whose preferences or incentives differ systematically from those of society as a whole.

In the U.S. economy, therefore, consider Federal Reserve Chairmen Volker and Greenspan, both of whom might reasonably be described as conservative in the Rogoffian sense of caring more about inflation, and less about unemployment, than the average American consumer or worker. It is certainly legitimate to ask whether, in a representative democracy like ours, it is really appropriate to give men like Volker and Greenspan power over such an important component of macroeconomic policy. The literature that builds on Kydland and Prescott (1977), however, provides us with a compelling response to this concern, by demonstrating that in situations like monetary policymaking, where the time-consistency problem may arise, it makes sense to appoint conserva-

tive central bankers—even when the ultimate goal is to maximize the welfare of the economy’s representative household.

#### 4. *What More Can We Learn?*

And what additional lessons might we hope to learn over the next twenty-five years? As a first step in answering this question, consider following Barro and Gordon (1983) and Ireland (1997) in allowing the monetary policymaking game described above to be repeated over an infinite horizon, where time periods are indexed by  $t = 0, 1, 2, \dots$ . Suppose, as in Case 2 above, that the central bank does not precommit to its choice for inflation; but suppose, also, that the behavior of the representative household’s expectations provides the central bank with an incentive to maintain a reputation for keeping inflation low.

More specifically, suppose that at the beginning of period  $t = 0$ , the representative household expects the central bank to choose an inflation rate  $\pi_0 = \pi^{\text{rep}}$  for that period, where  $\pi^{\text{rep}}$  lies somewhere between  $\pi^c = 0$  and  $\pi^{\text{nc}} = b\alpha$ . Suppose, in addition, that in each period  $t = 1, 2, 3, \dots$ , the household continues to expect the central bank to choose  $\pi_t = \pi^{\text{rep}}$  so long as it has always done so in the past. If, however, the central bank deviates during some period  $t = 0, 1, 2, \dots$ , by choosing an inflation rate  $\pi_t$  that differs from  $\pi^{\text{rep}}$ , then the household’s expectations permanently shift, so that the no-commitment choice  $\pi^{\text{nc}} = b\alpha$  is expected forever after. Given the household’s objective of setting  $w$  in line with expected inflation, these assumptions imply that for  $t = 0$ ,  $w_0 = \pi^{\text{rep}}$ , while for all  $t = 1, 2, 3, \dots$ ,

$$w_t = \begin{cases} \pi^{\text{rep}} & \text{if } \pi_s = \pi^{\text{rep}} \text{ for all } s = 0, 1, \dots, t - 1, \\ \pi^{\text{nc}} = b\alpha, & \text{otherwise.} \end{cases}$$

The question now becomes: given this behavior of private-sector expectations, will the central bank choose to maintain its reputation for selecting the lower inflation rate  $\pi^{\text{rep}}$ ?

In the case where the central bank does maintain its reputation by choosing  $\pi_t = \pi^{\text{rep}}$  for all  $t = 0, 1, 2, \dots$ , its total discounted return over the infinite horizon is given by

$$\frac{1}{(1 - \beta)} R(\pi^{\text{rep}}; \pi^{\text{rep}}),$$

where  $\beta$ , the central bank’s discount factor, lies between zero and one. In the alternative case, where the central bank deviates, it will always find

it optimal to do so immediately, during period  $t = 0$ , by choosing  $\pi_0$  to solve the problem

$$\max_{\pi} R(\pi; \pi^{\text{rep}}).$$

Hence, in this case, the central bank chooses  $\pi_0 = \pi^{\text{dev}}$ , where

$$\pi^{\text{dev}} = \frac{b}{1+b}(\pi^{\text{rep}} + \alpha).$$

During each period thereafter, having lost its reputation, the best that the central bank can do is to select  $\pi_t = \pi^{\text{nc}} = b\alpha$  for all  $t = 1, 2, 3, \dots$ . Its total discounted return from deviating is therefore

$$R(\pi^{\text{dev}}; \pi^{\text{rep}}) + \frac{\beta}{1-\beta}R(\pi^{\text{nc}}; \pi^{\text{nc}}).$$

It follows that the policy choice  $\pi_t = \pi^{\text{rep}}$  for all  $t = 0, 1, 2, \dots$  is sustainable in this type of reputational equilibrium if and only if the incentive-compatibility constraint

$$R(\pi^{\text{rep}}; \pi^{\text{rep}}) \geq (1-\beta)R(\pi^{\text{dev}}; \pi^{\text{rep}}) + \beta R(\pi^{\text{nc}}; \pi^{\text{nc}})$$

holds. Using the solutions  $\pi^{\text{dev}} = [b/(1+b)](\pi^{\text{rep}} + \alpha)$  and  $\pi^{\text{nc}} = b\alpha$ , this incentive constraint can be rewritten as

$$[\beta(2+b) - 1](b\alpha)^2 + 2(1-\beta)b\alpha\pi^{\text{rep}} - (\beta b + 1)(\pi^{\text{rep}})^2 \geq 0.$$

This last expression indicates that the zero-inflation policy that is optimal under commitment can be supported in a reputational equilibrium whenever  $\beta \geq 1/(2+b)$ . And since  $b$  is nonnegative, this condition almost certainly holds: it is satisfied for any value of  $\beta$  exceeding  $1/2$ . Here, therefore, we have another lesson to have emerged from the literature since Kydland and Prescott (1977): a central bank that is sufficiently patient, and that is lucky enough to be endowed with a reputation for keeping inflation low, will find it optimal to maintain its reputation even if it lacks the ability to commit.

One can also show, however, that if  $\beta \geq 1/(2+b)$ , so that the central bank's incentive constraint holds with  $\pi^{\text{rep}} = 0$ , then the incentive constraint also holds for *any* value of  $\pi^{\text{rep}}$  between  $\pi^c = 0$  and  $\pi^{\text{nc}} = b\alpha$ . In this case, therefore, the model features multiple equilibria, supporting infla-

tion rates that range all the way from zero to  $b\alpha$ . To see why this is a problem, consider a reputational equilibrium in which  $\pi^{\text{rep}}$  lies below  $\pi^{\text{nc}} = b\alpha$ , but closer to  $\pi^{\text{nc}} = b\alpha$  than to  $\pi^c = 0$ . In such an equilibrium, the central bank benefits from maintaining its reputation: it achieves an outcome that improves upon the endless repetition of the one-shot outcome without commitment. At the same time, however, the central bank knows that even better equilibria exist, with even lower inflation rates. Yet the model provides absolutely no advice as to how the central bank might steer the economy towards these preferred, low-inflation equilibria.

Taylor (1982) suggests that a central bank ought to build credibility for a low-inflation policy by adopting that policy unilaterally and by demonstrating that it will stick with the policy, even if it imposes short-run costs on the economy. Taylor's pragmatic approach has considerable intuitive appeal, and may be a good strategy for any real-world central bank to follow. But it simply will not work in the context of the example considered here. In fact, the triggerlike behavior of the representative household's expectations that help support the reputational equilibria with  $\pi^{\text{rep}} < \pi^{\text{nc}} = b\alpha$  dictates that expected inflation will actually jump *higher*, to  $\pi^{\text{nc}} = b\alpha$ , should the central bank deviate from  $\pi^{\text{rep}}$  by unexpectedly trying to disinflate.

How can a central bank establish a reputation for fighting inflation, or build credibility for a welfare-improving disinflationary program? In the literature that follows Kydland and Prescott (1977), work towards answering this question has only just begun. Significantly, providing answers to this question would seem to require departing in some way from the rational-expectations hypothesis, since, after all, the reputational equilibria in which inflation is stuck forever between  $\pi^c = 0$  and  $\pi^{\text{nc}} = b\alpha$  are bona fide rational-expectations equilibria. Cho and Matsui (1995) and Ireland (2000), for instance, both develop models of macroeconomic policymaking in which private agents are assumed to be boundedly rational. The objective of both of these papers is to identify restrictions on private-expectation formation that are weak enough to allow Taylor's (1982) pragmatic approach to work, but strong enough to prevent the policymaker from repeatedly fooling the boundedly rational agents. Still, much more work needs to be done along these lines: we have much to learn, over the next twenty-five years, about how governments can build credibility for the policies—like low inflation and low capital income tax rates—that we'd like them to pursue.

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## Comment<sup>1</sup>

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Nancy Stokey's interesting and thought-provoking paper has two main parts. Section 2, "Reputation Building," discusses the choice of monetary-policy instruments by relying on Atkeson and Kehoe (2001). This discussion is in terms of a trade-off between observability and "tightness" (the correlation with the monetary-policy goal). Section 3, "Robustness," discusses the choice between discretion and commitment to a simple rule. This discussion is in terms of a trade-off between flexibility and myopia on the one hand and rigidity and farsightedness on the other.

I believe Section 2 is better described as concerned with the choice of an *intermediate target* for monetary policy rather than a monetary-policy *instrument*. The setting of the monetary-policy instrument (the Fed funds rate in the United States) is usually directly observable, whereas the rela-

1. I thank Annika Andreasson for secretarial and editorial assistance.