

## NOTE

# CREDIBILITY AND INTERTEMPORAL CONSISTENCY

## *A Note on Strategic Macroeconomic Policy Models*

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The credibility criterion commonly used in the strategic macroeconomic policy literature, subgame perfection or its variants, ignores a critical problem concerning intertemporal consistency of policy announcements. To capture this additional credibility constraint, this note applies two distinct notions of Renegotiation-Proof, originally proposed in the context of two-person repeated games. Macroeconomic policy games, where the benevolent government interacts with atomistic private agents, offers a new testing ground for these criteria to be evaluated. This note discusses the relative strengths and weaknesses of these criteria.

**Keywords:** Credibility, Intertemporal Consistency, Renegotiation-Proof, Symmetric Punishment

### 1. INTRODUCTION

This note calls attention to one unsatisfactory feature of reputational models of macroeconomic policies. The literature on strategic macroeconomic policy design [see Persson and Tabellini (1994)] ignores a critical problem concerning intertemporal consistency of policy announcements. The credibility criterion used in the literature, subgame perfection or its variants, cannot address this issue. To express such an additional credibility constraint, I apply two distinct criteria of Renegotiation-Proof, originally proposed in the context of two-person repeated games: one by Farrell and Maskin (1989) and the other by Pearce (1987). Unlike subgame perfection, these criteria remain controversial, which makes it all the more important to apply these concepts to policy games.<sup>1</sup> Macroeconomic policy games in particular offer a different testing ground for evaluating these two criteria. This is because, in policy games, the dominant player, the government, interacts with atomistic private agents, and there is no conflict of interest in the case of

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the benevolent government. The relative strengths and weaknesses of these two criteria in macroeconomic policy games is discussed.

## 2. RULES, DISCRETION, AND REPUTATION

Since Kydland and Prescott (1977), it has been widely recognized that even a benevolent government, one that maximizes social welfare, might need to tie its hands and to commit a future macroeconomic policy. For example, consider the economy in which the market equilibrium leads to an underemployment when the private agents rationally anticipate the inflation rate. Suppose, furthermore, that the nominal wage must be set in a labor contract prior to the setting of money supply. Then, the central bank would have an incentive to conduct surprise inflation so as to trick the public into working harder. Recognizing such an activist temptation, intelligent citizens anticipate high inflation and set higher nominal wages. The outcome would be inflation much higher than the efficient level without any gain in employment. To avoid this dismal consequence, it might be necessary to impose legal constraints on monetary policy. This time-consistency problem provides strong support for rules over discretion in the debate of macroeconomic policy design.

In responding to this, advocates of discretionary policies would argue that, even without any legal mechanism, the central bank refrains itself from pursuing myopic policies in order to maintain its credibility. Because monetary policy involves repeated interaction between the central bank and the public, reputational forces can mitigate or even eliminate the time-consistency problem, thereby obviating the need for legal constraints. Using explicit game theoretic formulation, the strategic monetary policy literature has shown that low inflation outcomes would arise in an equilibrium as long as the central bank's discount factor is sufficiently high. The credibility criterion used in these studies is that of subgame perfect equilibrium (for perfect information games) or its variant, a sequential equilibrium (for imperfect information games).

## 3. MULTIPLICITY PROBLEM

The major difficulty of these types of models is that they generate a multiplicity of equilibria and therefore pose a serious coordination problem. For example, in the infinite-horizon game studied by Barro and Gordon (1983), a broad range of inflation rates can be supported by subgame perfect equilibria, including the high inflation outcome that would prevail if the central bank would ignore any reputational effect. However, many studies focus on the lowest inflation outcome attainable.

One, and arguably the only, possible justification for this is to assume that, at the beginning of the game, the central bank is capable of selecting the optimal equilibrium from the set of all subgame perfect (or sequential) equilibria. Essentially, this is to say that the central bank makes announcements about its monetary policy

path for the entire future, including one followed in the event of the central bank's deviation from the announced policies. The public accepts the announcements as credible, provided that the central bank has no incentive to conduct surprise inflation after the public believes the announced policies and signs nominal wage contracts.<sup>2</sup>

#### 4. PROBLEM WITH OPTIMAL SUBGAME (SEQUENTIAL) EQUILIBRIA

Once we accept the central bank's ability to select an equilibrium *ex ante*, however, it is difficult to deny its ability to select another equilibrium *ex post*. This creates an additional credibility problem, which cannot be taken care of either by subgame perfection or by sequentiality. For example, in the Barro and Gordon model, Rogoff (1987) considered Abreu's (1986) "stick-and-carrot" enforcement mechanism, which supports low inflation outcomes in subgame perfect equilibria. In these equilibria, the central bank is deterred from causing surprise inflation only because the announced policy path dictates that the central bank would punish itself (and the public) by causing high inflation if it ever deviated. It is motivated to carry out the self-punishment because, if it failed to do so, the punishment period would be extended. Therefore, if the central bank were actually to deviate, it has an incentive to abandon the punishment path in favor of a more attractive equilibrium. (Such an attractive equilibrium is always available because of the stationarity of an infinitely repeated game environment.) *Ex post*, such a policy change increases the central bank's payoff (and social welfare) but it undermines the deterrence effect of the punishment and therefore the credibility of the original policy path. In this sense, the optimal policy, albeit subgame perfect, lacks intertemporal consistency.

In objecting to this, one might say that surprise inflation, once conducted, would tarnish the central bank's authority, and reduce its ability to select an equilibrium. Indeed, my argument presumes a certain stationarity regarding the credibility of policy announcements, but the stationarity seems to be consistent with the situation I have in mind, where no significance is attached to the initial period.<sup>3</sup> Moreover, such an objection would rather strengthen my point that subgame perfection alone cannot capture the whole issue of credibility.

The idea of the *ex post* ability to select an equilibrium causing a credibility problem might be less objectionable if the public cannot perfectly monitor the central bank's actions, as in the model of Canzoneri (1985), where, facing inflation higher than normal, the public is unable to tell whether this is due to the central bank's forecast errors or to its deliberate action to cause surprise inflation. In such an environment, the central bank can support lower expected inflation in a sequential equilibrium by using Abreu et al.'s (1986) optimal punishment strategies. In these equilibria, the economy enters a punishment phase if the actual inflation falls into a certain prespecified region. Because the central bank's action influences the distribution of actual inflation, it is induced to target low inflation. Note that, in this case, the economy suffers from periodic bouts of high inflation even though the central bank never cheats (in equilibrium); that is, the punishment is not an off-equilibrium event. Therefore, if the central bank announces a shift to a more

favorable alternative equilibrium, following an adverse realization of the random variable (the forecast errors), the public would find it hard to accept the policy change. Again, however, this ex post ability to select an equilibrium undermines the deterrence effect.

5. INTERTEMPORAL CONSISTENCY

For a policy path announced by the central bank to be credible, it must satisfy not only the subgame perfection (or sequentiality) requirement (i.e., the central bank has no incentive to conduct surprise inflation after the public has signed nominal wage contracts) but also intertemporal consistency requirement (i.e., the central bank has no incentive to announce a policy change before the public signs nominal wage contracts in the future periods). The question is then how to formalize the idea of intertemporal consistency.

Farrell and Maskin (1989) and Pearce (1987) addressed the similar concerns in a two-person infinitely repeated game and each developed a distinct concept of Renegotiation-Proof, which can be applied to policy games.<sup>4</sup> To discuss their criteria, some notations should be introduced.<sup>5</sup> In infinitely repeated monetary policy games, a policy path,  $p$ , is a collection of policy functions  $\{p_t\}$  ( $t = 1, 2, \dots, +\infty$ ), where  $p_t$  represents the target rate of inflation at period  $t$  as a function of  $h_t$ , a history up to period  $t$ . History  $h_t$  includes all actual inflation rates in the past,  $\pi_s (1 \leq s \leq t - 1)$ , and the public's expectations on  $\pi_t$ . In a perfect monitoring game like Barro and Gordon's,  $p_t = \pi_t$ , whereas, in an imperfect monitoring game like Canzoneri's, the target rate affects distribution of actual rate of inflation,  $f(\pi_t; p_t)$ . For each  $p$  and  $h_t$ ,  $p | h_t$  represents the part of  $p$  specifying a monetary policy path after  $t$  when history up to  $t$  is given by  $h_t$ . Although  $p | h_t$  starts from period  $t$ , it can be identified with a policy path starting from  $t = 1$ ,  $p'$ , by putting  $p'_s = p_{t+s-1} | h_t$  for all  $s \geq 1$ . In particular,  $p = p | h_1$ . Let  $p^*$  be the policy path taken if the government would ignore any reputational effect, the only equilibrium path that is history independent.

For each subgame perfect equilibrium (SPE), or sequential equilibrium (SE), policy path  $p$ , let  $Z(p)$  denote the average value of the central bank's payoff:

$$Z(p) \equiv (1 - \beta)E_0 \sum_{s=1}^{\infty} \beta^{s-1} z(\pi_s, E_{s-1}\pi_s),$$

where  $E_{t-1}$  is the expectation operator given by history up to period  $t$ ,  $\beta$  is the discount factor, and  $z_t = z(\pi_t, E_{t-1}\pi_t)$  is the central bank's one-period payoff at period  $t$ . When  $p$  is SPE (or SE),  $p | h_t$  is also a SPE (or SE) and hence its average value to the central bank (or its continuation value) can be defined similarly, as

$$Z(p | h_t) \equiv (1 - \beta)E_{t-1} \sum_{s=1}^{\infty} \beta^{s-1} z_{s+t-1}.$$

Then, the set of continuation values for  $p$  is defined by  $C(p) \equiv \cup Z(p | h)$ , where the union is taken over every possible history.

The basic idea of the Farrell–Maskin criterion is that, after any history  $h$ , the central bank should not have an incentive to change its policy path from  $p | h$  to the original path  $p$  or any part of it. This is to say that, for  $p$  to be credible,  $C(p)$  needs to be a singleton set. The implication is very devastating, because the only monetary policy that survives this criterion is  $p^*$ .

Proof. When  $C(p)$  is a singleton set, the future payoff is not allowed to vary. Then, the central bank has no incentive to choose a policy other than the myopic one  $p^*$  because the policy choice would not affect its future payoff.

*According to the Farrell–Maskin criterion, reputational forces cannot deter the central bank from attempting to conduct surprise inflation.*

In objecting to this, one may say that this criterion, when applied to this class of games, lead to a self-contradiction, for the following reason. Imagine a SPE (or SE) policy  $p$ , whose set of continuation values is a doubleton set:  $C(p) = \{Z^+, Z^-\}$  ( $Z^+ > Z^-$ ), and  $Z(p) = Z^+$ . Most reputational equilibria discussed in the literature have this property. The game starts with  $p$ , whose value remains to be  $Z^+$ , until, after some history  $h$  has transpired, the economy enters a punishment phase [ $Z(p | h) = Z^-$ ]. Then, when the punishment ends, it goes back to  $Z^+$ . The Farrell–Maskin criterion argues that this policy path, whose value is  $Z^+$  should not be credible because the central bank would choose to abandon  $Z^-$  in favor of  $Z^+$  once the punishment is called upon. However, such a change in policy announcements could be accepted only if  $Z^+$  were credible. That is, to believe that  $Z^+$  is incredible, it is necessary to believe that  $Z^+$  is credible; but, to believe that  $Z^+$  is credible,  $Z^-$  should be credible, which in turn requires that  $Z^+$  be incredible. In this sense, the Farrell–Maskin criterion, when applied to this class of games, leads to a paradox. One cannot avoid this paradox as long as one considers policy changes only within a given continuation value set.

However, suppose that there exists an alternative SPE (or SE) policy path  $p'$  such that its continuation value set  $C(p')$  differs from  $C(p)$  and that  $\inf[C(p')] > \inf[C(p)]$ . The policy change to  $p'$  is not prone to the same problem with the change to  $Z^+$ . Therefore, one could argue that  $p$  is not credible, without leading to a paradox. Extending this logic further, Pearce (1987) proposes the following credibility criterion. That is, for a SPE (SE) policy path  $p$  to be credible, for any SPE (SE) policy path  $p'$ ,

$$\inf[C(p)] \geq \inf[C(p')]. \quad (\text{IC})$$

In plain English, *credible policy paths are those supported by the least severe punishment*. From now on, I call a SPE (or SE) policy path satisfying IC credible, for the sake of brevity. The implication of this additional reputational constraint on monetary policy is quite substantial.

Let  $R^+$  ( $R^-$ ) be the central bank's highest (lowest) payoff attainable when IC is required and  $V^+$  ( $V^-$ ) be its highest (lowest) payoff attainable when IC is not required. The highest payoff usually discussed in the literature is  $V^+$ . Obviously,

for any credible policy path  $p$ ,  $V^+ \geq R^+ \geq R^- \equiv \inf[C(p)] \geq V^-$ . The following statements are reproductions of Pearce's (1987) main results.

First, any punishment severer than Cournot–Nash reversion would not be adhered to:  $R^- \geq Z(p^*)$ . Second, as long as Cournot–Nash reversion has a deterrence effect without IC, any credible policy  $p$  gives a strictly higher payoff than the myopic one:  $Z(p) \geq \inf[C(p)] \equiv R^- > Z(p^*)$ . In other words, *the announcement that the central bank does not care about its reputation is not credible*. Third, as long as the “severe” punishment mechanisms considered by Abreu (1986) and others have deterrence effects ( $V^+ > V^-$ ), then IC reduces the severity of punishment available:  $R^- > V^-$ . Fourth, when the central bank's discount factor is high, the severest credible punishment becomes less severe:  $R^- = R^-(\beta)$  is nondecreasing in  $\beta$ . Fifth, in an imperfect monitoring case as in Canzoneri's model, IC is a binding constraint for the central bank:  $R^+ < V^+$ . However, when the central bank is very patient, this constraint is negligible and, furthermore, all credible policies guarantee almost the same payoffs:  $\lim_{\beta \rightarrow 1} R^-(\beta) = \lim_{\beta \rightarrow 1} R^+(\beta) = \lim_{\beta \rightarrow 1} V^+(\beta)$ . The last result has a very strong implication. *According to Pearce's criterion, the intertemporal consistency essentially eliminates the multiplicity problem that plagues the existing literature, without reducing the central bank's capacity to achieve its optimal outcome*. In the case of a benevolent central bank, this means that reputational considerations are strong enough to maintain “good” behavior of the central bank.

## 6. DISCUSSIONS

Pearce's credibility criterion, relative to the Farrell–Maskin criterion, is more compelling in the context of dominant-player games than two-person games, in which they proposed these criteria. The main concern of Farrell and Maskin (1987) is the deterrence power of asymmetric punishments in which each player can be punished in such a way that the other player actually benefits. If such asymmetric punishments are always Pareto-efficient, we do not need to worry about the threat of renegotiation. Section 5 of their paper shows necessary and sufficient conditions under which this is the case. On the other hand, Pearce's results are most elegant when equilibria are restricted to the symmetric ones. However, there are no compelling justifications for this restriction. Furthermore, it could be potentially serious because Pearce considers renegotiation *across* continuation value sets, unlike Farrell and Maskin, who consider renegotiation *within* a continuation value set. (That is, Renegotiation-Proof equilibria in Section 3 of Pearce's paper may be renegotiated away by some asymmetric equilibria.)

The dominant-player games discussed in the macroeconomic literature provide quite a different setting in which the plausibility of these two criteria can be tested. This is because of the presence of the benevolent government. First, it has the unilateral power to select an equilibrium: No renegotiation process is necessary to move from one equilibrium to another. Second, asymmetric punishment is not available because there is no conflict of interest between the public and the benevolent

government. Without asymmetric punishments, the Farrell–Maskin criterion leads to a paradox, as discussed in Section 5. On the other hand, this fully justifies the application of Pearce’s powerful results on symmetric equilibria.

Most monetary games studied in the literature presume that the nominal wage is determined in a competitive way. If the wage setting is done by one large labor union, as in Tabellini (1988), a monetary policy game could be considered as a two-person game. Furthermore, because the labor union generally pursues the welfare of its members only, it is natural to specify that the benevolent central bank and the wage setter have a conflict of interest. This creates the possibility of asymmetric punishments. In this environment, the Farrell–Maskin criterion would be more compelling and Pearce’s less compelling.

## 7. CONCLUDING REMARKS

The recent literature on strategic models of macroeconomic policy assumes that the government cannot make a commitment to pursue the previously announced policy path once the public has formed its expectations. It is implicitly assumed, however, that the government can make a commitment not to change policy announcements right *before* the public forms its expectations in future periods. I find these two assumptions inconsistent. If we assume that neither types of commitments can be made, then the government needs to satisfy additional credibility constraints. To capture this issue, I discuss two criteria, recently proposed by Farrell and Maskin (1989) and Pearce (1987). They lead to completely different conclusions. According to the Farrell–Maskin criterion, reputational forces cannot deter the government from attempting to surprise the public. On the other hand, Pearce’s criterion essentially eliminates the multiplicity problem that plagues the existing literature, without reducing the government’s capacity to achieve its optimal outcome, when the government is very patient. Reputational considerations are strong enough to maintain good behavior of the government. Although monetary policy games are used to illustrate the points, the same argument can be applied to other macroeconomic policy games, where the benevolent government plays with the atomistic private agents.

## NOTES

1. Matsuyama (1990) and Pearce and Stacchetti (1997) have applied Renegotiation-Proof to policy games.
2. The underlying assumption here is that the labor market consists of atomistic wage setters, and that they do not set nominal wages strategically.
3. I merely regard period 1 as a period when the analyst looks at the issue, not the period when the new member of the central bank is installed. Once a change in the member is allowed in period 1, it is hard to exclude the possibility of a future change, a proper treatment of which requires a departure from the infinite-horizon framework.
4. Mention should be made of my choice of terminology. In a standard game, a preplay negotiation often is considered as a way of explaining how the players know which equilibrium is to be played. Hence, a profile of strategies from which the players *collectively* have no incentive to deviate

is called *Renegotiation-Proof*. On the other hand, in the dominant player games usually discussed in the macroeconomic literature, only one player (the government) behaves strategically, and infinitely many other players (the public) simply respond to the dominant player by forming expectations rationally. In such circumstances, the only way of coordinating to an equilibrium is the dominant player's announcements on its strategy. No negotiation process will be necessary. For this reason, I use the term "intertemporal consistency of policy announcements" instead of "Renegotiation-Proof." In any event, the opportunity to communicate during the course of the play is essential, which is not the case with subgame perfection.

5. The following discussion is very informal, and any technical assumptions are not stated. See the original articles for the detail.

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