REPUTATION EFFECTS AS A SOURCE OF DYNAMICALLY UNSTABLE MONETARY AND FISCAL POLICIES

by

Michael B. Loewy*

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Center for Economic Research
Department of Economics
University of Minnesota
Minneapolis, Minnesota 55455

*University of Minnesota

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ABSTRACT

Independent monetary and fiscal policymakers choose between two settings of their single policy variable and have preferences defined over the four resulting outcomes. With incomplete information about each other's preferences, maintaining one value for his policy variable provides credibility for the policymaker and his policy. The incentive for having a credible policy is that it provides the authority with the opportunity to attain his most preferred policy mix. However, when both pursue these benefits, the dynamically unstable policy mix occurs. Since neither wish this to continue, one authority always acquiesces to the wishes of the other.

1. Introduction

The abrupt change in Federal Reserve policy which occurred during 1982 can be explained as a response by the Fed to the numerous forecasts of continued large real federal budget deficits. Had the Fed's previous non-accommodating monetary policy continued in the presence of these deficits, then the Treasury would have been forced to sell even greater quantities of real debt to the private sector than it already has. The dynamic stability of such a policy mix (which is often associated with Friedman's (1960) and (1968) descriptions of monetarism) has been questioned by numerous writers,[1] each of whom conclude that the stock of real debt can become unbounded when these policies are indefinitely continued. If the private sector's demand for this debt does not grow fast enough to absorb it, then such a financing scheme becomes infeasible. Either the net of interest federal deficit must decline over time[2] or the Fed must step in and increase its purchase of debt.[3] The second case seems to correspond to what did in fact occur.

The present paper addresses the question of why would fiscal and monetary policymakers choose deficits and portfolios, respectively, that generate time paths which are dynamically unstable and are Pareto inferior to time paths generated by other policies.[4] To answer this question, a model of reputation developed by Kreps and Wilson (1982) is used. We consider the players of their finitely repeated non-zero-sum game to be the fiscal and monetary policymakers. By assuming there exists incomplete information on the part of each player regarding the preferences of the other, each player finds it beneficial to establish a reputation for having preferences which imply that they will never deviate from their current policy choice. When preferences are properly chosen, we show that the pursuit of a reputation on the part of each policymaker leads to a policy mix that corresponds to the dynamically unstable case. Since we assume that both policymakers are aware of the hazards of continuing this situation, someone eventually changes their policy, thereby alleviating the instability problem. Therefore, the model provides a qualitative description of the recent U.S. events mentioned above.

The primary discussion and analysis of the Kreps and Wilson model as it applies to the present context is contained in Section 3. Section 2 describes how the model and a similar model developed by Blinder (1982) relate to the literature on finitely repeated two-person non-zero-sum games. The paper concludes with some final comments in Section 4.

2. Two Policy Games

In the United States there is virtual independence of decision making by the Federal Reserve from decision making by the legislative and executive branches of the federal government. Combined with the fact that all three groups recognize that their decisions jointly determine economic outcomes suggests that a useful model of this decision making process would be a non-zero-sum, non-cooperative game. To simplify matters we assume that the legislative and executive branches can be combined into a single fiscal policymaker. For two-person non-zero-sum games, perhaps the most common and best understood example is the Prisoner's Dilemma. This is the model Blinder uses to study the effects on monetary and fiscal policy decisions when there exist independent policymakers (1982, pp. 30-34).

To ease comparison with what appears in Section 3, we shall introduce our notation now and apply it to Blinder's example. There are two policymakers, one who determines monetary policy and one who determines fiscal policy. The monetary authority (M) chooses between large (L) and small (S) monetary growth rates while the fiscal authority (F) has the same choices, but concerning the size of the federal budget deficit.[5] Therefore, the space of policy outcomes $\Omega = \{SS, SL, LS, LL\}$ where in ij, i represents the fiscal decision and j the monetary decision. The preferences of each authority are represented by a pair of increasing ordinal functions defined on Ω. Let $f: \Omega \rightarrow R_+$ and $m: \Omega \rightarrow R_+$ be the utilities of F and M respectively. Following Blinder, we assume that preferences satisfy

$$m(SS) > m(SL) > m(LS) > m(LL) \quad (1a)$$

$$f(LL) > f(SL) > f(LS) > f(SS). \quad (1b)$$

As Blinder argues, it is reasonable to assume that the outcome of this game is a Nash equilibrium (assuming one exists). Inspection shows that LS is the unique Nash equilibrium and that it is Pareto inferior to SL, the cooperative outcome. As is well-known, finite repetitions of this game lead to LS occurring at every stage. Thus, with complete information, the unstable time path occurs for the entire length of the game. (This need not be the case in infinitely repeated Prisoner's Dilemmas.) It is interesting to note that experiments with finitely repeated Prisoner's Dilemmas have consistently shown that the cooperative solution usually occurs for at least part of the time. (Axelrod (1981) provides numerous references to these experiments.) Recently, Kreps, et. al (1982) have proved that incomplete information about players' preferences can explain the emergence of the cooperative outcome in a finitely repeated Prisoner's Dilemma. Thus, assuming there exists incomplete information and repeated play in Blinder's model, the equilibrium would be one where SL occurs during the initial stages of the game and is then replaced by LS which continues for the remainder of the game.

As a description of why policymakers choose policies resulting in LS, the Prisoner's Dilemma model is lacking in two respects. First, it implies that once LS occurs, it continues until the game's conclusion. That the costs of government insolvency associated with maintaining LS are high suggests instead that the policy mix would soon be changed. Second, the desire for credibility or reputation seems to be a major reason why policymakers continue certain policies. The Prisoner's Dilemma model does not fully capture this aspect of policymaking — policies are maintained simply because they are dominant strategies. Hence, credibility is the effect rather than the cause of continued policies.

A game form which captures these two features is Chicken.[6,7] Unlike Prisoner's Dilemma, there are no dominant strategies. The outcome of the game at each stage is determined by each player weighing the costs and benefits of cooperation and noncooperation. In particular, mutual non-cooperation is viewed by both players to be worse than any other outcome while non-cooperation and a cooperative opponent is considered first best. If a player can gain a strong enough reputation for always being noncooperative, then he will eventually receive his first best outcome because his opponent knows that it is better to cooperate than to continue to receive the least preferred outcome. Since this is true for both players, we would expect each to accept the least preferred outcome for a positive amount of time in the hope that the other player chooses to cooperate first.

By letting the mutually least preferred outcome be LS, we can achieve the unstable policy mix during the period of time in which both policymakers are trying to build a reputation, both with the other policymaker and with the (unseen) public. The interpretation that we wish to give is that reputation building is synonymous with establishing credibility. The latter requires (announced) actions to be carried through while the former continues as long as the (announced) policy is chosen.

3.1 The Chain-Store Paradox

Before proceeding to the discussion of the model, we first provide some background by describing the problem addressed by Kreps and Wilson in their 1982 paper. They provide a resolution (as do Milgrom and Roberts (1982)) to the chain-store paradox, a problem Selten (1978) noticed that standard game-theoretic models have in producing equilibria where past behavior on the part of player A can influence the future behavior of player B. Specifically, Selten dealt with a multi-market monopolist who faces a succession of potential entrants, one in each market. Should entry into a particular market occur, the monopolist decides between sharing or predation. Since he prefers that no entry occurs, it is natural to expect (as Scherer has, (1980, p. 338)) that should entry occur, the monopolist would prey since such actions may convince future entrants to stay out. Selten modeled the chain-store problem as a sequential game where first an entrant chooses between staying out and entering followed by the monopolist choosing between sharing and predation should entry occur. If each entrant knows the monopolist's payoffs and if shared entry is the entrant's most preferred outcome, then shared entry occurs in every market because the monopolist always does better to share once entry has taken place. There are no means by which a current episode of predation can alter the decisions of future entrants even though this seems to be a reasonable possibility.

The solution to the chain-store paradox requires that entrants have incomplete information about the monopolist's payoffs. When the initial entrant assigns a positive probability to the monopolist always following entry with predation, then by behaving accordingly (when challenged), the monopolist will cause future entrants to increase this probability which increases the deterrent to entry. This deterrent will (along the equilibrium path) keep out all but the last "few" entrants who enter because they know that they will not likely meet predation.[8] Kreps and Wilson show that in the presence of this type of uncertainty, there exist strategies such that the game has an equilibrium where the behavior just described occurs.

The chain-store model which we employ again assumes there exists uncertainty on the part of the entrant(s),[9] but adds uncertainty on the monopolist's part as well. The monopolist now assigns a positive probability to the entrant always entering. When the entrant chooses to enter and then the monopolist chooses to prey, both sides revise these probabilities upward, thereby increasing the deterrent each faces towards repeating the same action. Entry followed by predation occurs until someone backs down. Hence, two-sided uncertainty leads to Chicken.

3.2 The Model

The model of policy choice presented below is the continuous time, two-sided uncertainty model of Kreps and Wilson's Section 4 modified to fit the present context. To start, we replace their entrant and monopolist with our fiscal and monetary policymakers respectively. Next, we assume that the following decisions are made sequentially at each point of time in the game's finite horizon: F decides its deficit size, S or L, followed by M choosing the monetary growth rate, S or L. As before, this implies a four element space of outcomes as compared to the three element outcome space of Kreps and Wilson. This additional outcome is trivial;

along the model's equilibrium path, it occurs with probability zero, A quantitative, but non-qualitative modification is caused by our assumption that each policymaker has his own discount rate and perception of the time horizon. These rather innocuous assumptions imply that the equilibrium time path is described by a logarithmic differential equation with a time varying coefficient, a mathematical complexity not found in the original. Nonetheless, the behavior of the equilibrium is not changed. As a convenience, we assume that time runs forward rather than backward. To summarize, our changes are in the model's context but not its content.

Using the notation introduced earlier, we assume that the preferences of the two policymakers are as follows:

$$m(SS) > m(SL) > m(LL) > m(LS) \qquad (2a)$$

$$f(LL) > f(SL) > f(SS) > f(LS). \qquad (2b)$$

Though they are little different from those of Blinder's Prisoner's Dilemma, these are an example of Chicken. Justification for such preferences is admittedly somewhat difficult since they represent the attitudes of ill-defined "authorities".[10] Nonetheless, they do seem plausible and reflect that each policymaker would prefer to avoid LS. In order to apply Kreps and Wilson's model, we must reinterpret these preferences to be cardinal rather than ordinal. Hence, the policy authorities' utility functions can and will be thought of as payoff functions. Cardinal numbers are necessary because each policymaker's behavior is determined by the size of the payoffs he receives.

Under complete information, the Nash equilibrium of the sequential game governed by equations (2) is seen to be LL. Since M prefers to accommodate a large deficit ex post and F knows this, F picks L in order to maximize his payoff. To generate Chicken, we assume there exists uncertainty of the following form: M believes that F may have L as a dominant strategy while F believes that M may have S as a dominant strategy. Henceforth, we shall refer to possession of a dominant strategy as being strong.

The problem each policy authority faces is to choose between L and S so as to maximize the present value of their payoffs subject to their beliefs about the behavior of the other policy authority. Since we find a perfect equilibrium, these beliefs are rational. We represent beliefs as probabilities over strong behavior; let p_t = P(M is strong at t) and q_t = P(F is strong at t). (p_t, q_t) describes the "state" of the system so that the closed unit square in R^2 is that "state space". A related pair of probabilities is the conditional probability of acquiescence given that each policymaker does not have a dominant strategy (i.e. payoffs are as in (2), a situation we shall refer to as being weak). Define π_t and ρ_t by $\pi_t = P(M \text{ acquiesces at } t \mid M \text{ is weak})$ and $\rho_t = P(F \text{ acquiesces at } t \mid F \text{ is weak})$.

Optimal behavior for each policymaker requires that if strong play is to be continued, then the marginal benefits be at least as large as the marginal costs. The benefits are the stream of large payoffs received should the other policymaker give in first,[11] while the cost is the difference in payoffs between acquiescing and playing strong. Formally, we have over the interval (t - h, t)

$$[(1-q_t)\rho_t h]\, m(SS) \int_t^{T_M} \exp(-r_M\tau)\, d\tau = [m(LL) - m(LS)] \cdot \int_{t-h}^{t} \exp(-r_M\tau)\, d\tau + o(h) \tag{3a}$$

$$[(1-p_t)\rho_t h]\, f(LL) \int_t^{T_F} \exp(-r_F\tau)\, d\tau = [f(SS) - f(LS)] \cdot \int_{t-h}^{t} \exp(-r_F\tau)\, d\tau + o(h) \tag{3b}$$

where r_Z and T_Z, Z = F,M are the discount rate and the preceived time horizon for the two policymakers.

To solve for p_t and q_t, we first integrate (3), divide by h and then let h go to zero. Solving these expressions for ρ_t and π_t give

$$\rho_t = \frac{r_M\, y}{(1-q_t)\ \{1-\exp[-r_M(T_M-t)]\}} \tag{4a}$$

$$\pi_t = \frac{r_F\, x}{(1-p_t)\{1-\exp[-r_F(T_F-t)]\}} \tag{4b}$$

where we have defined y and x by

$$y = [m(LL) - m(LS)]/m(SS)$$

$$x = [f(SS) - f(LS)]/f(LL).$$

x and y are measures of F and M's ability to play strong.

Next, we construct the joint probability table describing F's behavior at time t-h. This is given by Table 1. (The table for M is symmetric.)

Table 1[12]

	F weak	F strong	
F gives in (small deficit)	$(1-q_{t-h})\ \rho_{t-h}\, h$	0	$(1-q_{t-h})\ \rho_{t-h}\, h$
F fights (large deficit)	$(1-q_{t-h})\ (1-\rho_{t-h})\, h$	q_{t-h}	$1-(1-q_{t-h})\rho_{t-h}\, h$
	$1-q_{t-h}$	q_{t-h}	

By writing q_t as $q_t = P(F \text{ is strong} \mid F \text{ plays strong during } (t-h,\, t))$, Table 1 implies that $q_t = \dfrac{q_{t-h}}{1-(1-q_{t-h})\rho_{t-h}\, h}$ which upon solving for $\dot{q}_t$ gives $\dot{q}_t = q_t(1-q_t)\rho_t$. A similar procedure gives $\dot{p}_t = p_t(1-p_t)\pi_t$. Finally, substituting for ρ_t and π_t from (4) and integrating gives

$$q_t = k_1 \exp[-r_M(T_M-t)y]\{1-\exp[-r_M(T_M-t)]\}^{-y} \quad (5a)$$

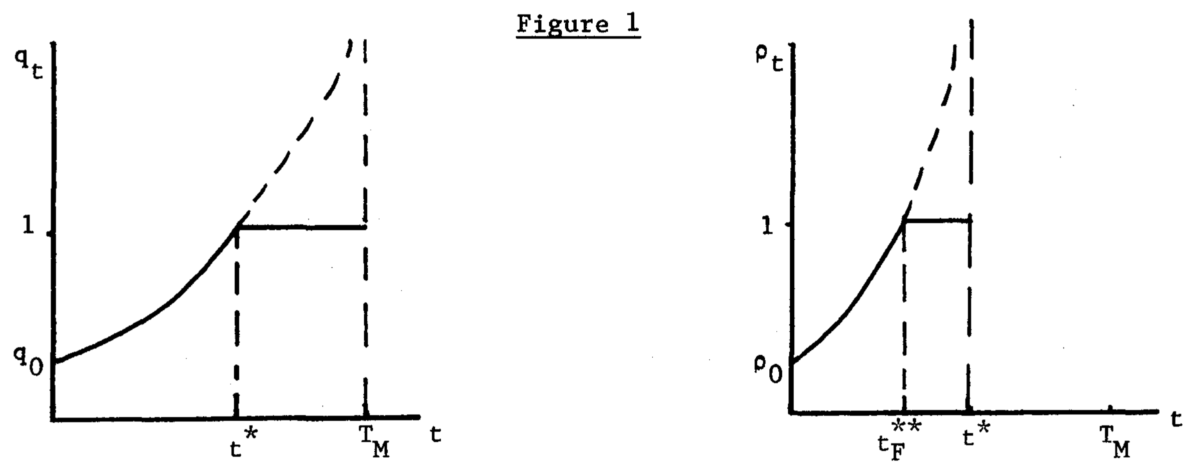
$$p_t = k_2 \exp[-r_F(T_F-t)x]\{1-\exp[-r_F(T_F-t)]\}^{-x} \quad (5b)$$

where k_1 and k_2 are integration constants.

Since p_t and q_t are probabilities, k_1 and k_2 are positive. Therefore, considered as functions with unrestricted ranges, both p_t and q_t are continuous and strictly increasing in t becoming unbounded as t approaches T_F and T_M respectively. This implies that for each function, there exists a unique $t \in [0, T_Z]$ $Z = F,M$ at which q and p equal one. By a normalization to be imposed below, p_t and q_t simultaneously reach one at a value of t denoted by t^*. For Chicken to occur, it is necessary for $t^* > 0$.

The behavior of π_t and ρ_t are now easily deduced. By the properties of p_t and q_t (and by momentarily ignoring the fact that π and ρ are probabilities) both π_t and ρ_t are seen to be continuous, strictly increasing functions of time which become unbounded at t^*. Therefore, if $\rho_0 < 1$, there exists a unique $t_F^{**} < t^*$ such that $\rho_{t_F^{**}} = 1$. Similarly, if $\pi_0 < 1$, then there exists a unique $t_M^{**} < t^*$ such that $\pi_{t_M^{**}} = 1$. Since t_M^{**} and t_F^{**} are upper bounds to the length of strong play, they are in the spirit of stopping times. Unlike p_t and q_t, there is no restriction to force t_M^{**} and t_F^{**} to be equal. An example of typical q_t and ρ_t (or p_t and π_t) functions is given in Figure 1.

Figure 1



The procedure determining p_t and q_t utilized the fact that along the equilibrium path, p and q satisfy Bayes' rule. This allows us to represent the evolution of the game (as of time t) as the location in the unit square of the Bayesian posterior resulting from the randomization(s) occurring at t. The location is determined by a curve, $\phi(p, q, t) = 0$, which passes through (0,0) and (1,1). This definition implies that at $t = 0$, given priors on (p_o, q_o), $\phi(p_o, q_o, 0)$ determines which policymaker randomizes first. Letting the prior on p_o be δ, that on q_o be γ and viewing ϕ as a locus in (p, q)-space, we have the following. If (δ, γ) lies above ϕ, then F plays L and M randomizes. Should M choose S, then the game moves from (δ, γ) to ϕ where the process continues by F randomizing. If M picked L, then LL occurs for the entire game. Similarly, if (δ, γ) lies below ϕ, F randomizes and if L occurs, the game moves to ϕ followed by M randomizing. If F chooses S, then SS occurs for the entire game. Assuming that the game moves to $\phi(p_o, q_o, 0)$ rather than to either boundary, both players "continuously" randomize moving along ϕ until one player's randomization leads him to give in. Once this occurs, the outcome jumps from LS to either LL or SS.

To determine ϕ, we first find its slope. Using the expressions for q_t and p_t we have

$$dq_t/dp_t = \dot{q}_t/\dot{p}_t = \frac{r_M y \{1-\exp[-r_F(T_F-t)]\}q_t}{r_F x \{1-\exp[-r_M(T_M-t)]\}p_t} . \qquad (6)$$

Writing this as $\dot{q}_t/q_t = f(t)\,\dot{p}_t/p_t$ we see that the assumption of different discount rates and time horizons implies that the slope of ϕ and therefore ϕ itself, are direct functions of time.[13] In Appendix A we show that there exists a function H(t) with

$$H(t) = \frac{y}{x}\left[\frac{r_M\ (T_M\text{-}t) + \ln\{1\text{-}\exp[-r_M\ (T_M\text{-}t)]\}}{r_F\ (T_F\text{-}t) + \ln\{1\text{-}\exp[-r_F\ (T_F\text{-}t)]\}}\right] \tag{7}$$

such that

$$\phi(p,\ q,\ t) \equiv q_t - (k_2)^{H(t^*)}\ (p_t / k_2)^{H(t)} = 0. \tag{8}$$

Despite the fact that H can take on any value of the extended real line, as well as appear in the "undefined" form 0 / 0, (8) is always well-defined. This rather surprising fact is easily explained. Defining q_t/k_1 as α_t and p_t/k_2 as β_t, (8) is equivalent to $k_1\alpha_t = k_2^{\ln k_1/\ln k_2} \circ \beta_t^{\ln\alpha_t/\ln\beta_t}$. But for any numbers u and v, $v^{\ln u/\ln v} = u$ so that even if $\beta_t = 1$, the right-hand side and therefore the left-hand side remain well-defined.

3.3 Behavior of Stopping Times

The primary content of the model is captured by the two stopping times t_M^{**} and t_F^{**}. Not only do they give estimates of the lengths of time that policy will be LS, but they suggest which policymaker is the most likely to acquiesce first. Therefore, it is of interest to ask how these values change as the parameters of the model change.

Intuition suggests that any change which improves a policymaker's willingness to continue pursuit of a reputation should increase his stopping time. In fact, this is only partly true, holding for the first policymaker to randomize, but not for the second. Rather, the stopping time for the second randomizer depends only on the parameters of the first randomizer's problem, with the former increasing (decreasing) whenever the latter increases (decreases). If policymaker A randomizes first, it is because he is in a weaker position to play strong than is policymaker B. Therefore, even if A's position improves (but is still weaker than B's), it pays B to hold out longer in order to continue attempting to take advantage of his superior position.

To illustrate the results of the preceeding paragraph, we focus on the case where F plays L followed by M randomizing. This assumption is not restrictive since the other case can easily be determined by symmetry. When F simply chooses L, M learns nothing new so that $q_0 = \gamma$. Therefore, $k_1 = \gamma \exp(r_M T_M y)\, [1-\exp(-r_M T_M)]^y$ so that q_t is determined. Solving $q_{t^*} = 1$ gives

$$t^* = -(r_M)^{-1}\, \ell n\{\gamma^{1/y}[1-\exp(-r_M T_M)] + \exp(-r_M T_M)\}. \tag{9}$$

Given t^*, we use $p_{t^*} = 1$ to get $k_2 = \exp[r_F(T_F - t^*)x]\ \{1-\exp[-r_F(T_F - t^*)]\}^x$ so that p_t is determined. With both q_t and p_t known, equations (4) are set equal to one and solved for t_F^{**} and t_M^{**}.

There are four pairs of parameters to investigate: discount rates, time horizons, measures of ability to play strong and initial priors. Implicit differentiation of (4) with respect to t_F^{**} or t_M^{**} and these eight parameters implies the derivative signs appearing in Table 2. Explicit formulae are found in Appendix B.

Table 2

	t_F^{**}	t_M^{**}
r_M	-	-
r_F	0	?
T_M	+	+
T_F	0	?
y	-	-
x	0	?
γ	-	-
δ	0	0

Beginning with t_M^{**}, the signs for r_M, T_M, y and γ are as we would expect. Increases in the discount rate and a shorter time horizon both lessen the perceived amount of time available for obtaining any gains from strong play and so act to decrease t_M^{**}. An increase in y implies that M will be less willing to continue playing strong because his payoffs have moved in a direction more favorable to acquiescence. This too lowers t_M^{**}. If γ increases, then q_t increases providing M with an incentive to acquiesce sooner which causes t_M^{**} to fall. The zero derivative for δ reflects the fact that this prior becomes irrelevant as soon as M makes his initial randomization. p_0 either equals zero or is determined by (8). The three ambiguous signs reflect the countervailing incentives associated with r_F, T_F and x. For the same reasons as given above, increases in r_F and x or a decrease in T_F lower F's willingness to play strong. This acts to increase t_M^{**} in order for M to take advantage of his improved position. But since LS is a costly outcome, there is also an incentive to adjust t_M^{**} downward for F is now more likely to give in first.

Turning next to t_F^{**}, the signs for r_M, T_M, y and γ are explained by the argument made earlier. With F being in a superior position, he should simply adjust his stopping time to account for any changes in M's behavior. The independence of t_F^{**} from δ is due to the same reason that t_M^{**} is. The remaining three derivatives, all zero, reflect the importance the first randomization has on the model's behavior. Since M determines whether Chicken can occur, F need only be concerned with M's ability to pursue a reputation when deciding how long to do likewise.

Table 3 provides a series of examples where M is the first to randomize. Equalities of t_F^{**} and t_M^{**} in examples 3 - 5 are caused by rounding.

TABLE 3

	1	2	3	4	5	
r_F	.05	.05	.05	.05	.05	
r_M	.05	.1	.1	.05	.05	
T_F	100	100	100	100	100	
T_M	100	100	100	200	100	
x	.5	.5	.5	.5	.5	
y	.5	.5	.6	.5	.5	
γ	$.\bar{3}$	$.\bar{3}$	$.\bar{3}$	$.\bar{3}$	$.\bar{6}$	
δ	.25	.25	.25	.25	.25	
t^*	42.9	22	18.3	43.9	16.1	
t_F^{**}	41.9	20.9	17.3	42.9	15	
t_M^{**}	41.9	21	17.3	42.9	15	
q_0	$.\bar{3}$	$.\bar{3}$	$.\bar{3}$	$.\bar{3}$	$.\bar{6}$	
p_0	$.\bar{3}$	.573	.63	.325	$.\bar{6}$	
ρ_0	.0378	.0750	.0900	.0375	.0755	*
π_0	.0378	.0589	.0680	.0373	.0755	

* Because F always plays L at $t = 0$, ρ_0 in fact equals 0. The values given are provided for comparison with π_0 (which are correct).

4. Concluding Remarks

We have provided a model where the expected gains from establishing a reputation can lead independent fiscal and monetary policymakers to follow policies that have been shown elsewhere as potentially placing an economy on a dynamically unstable time path. This undesirable outcome causes one of the policymakers to change his policy. Recent U.S. experience is described quite well by this scenario.

The importance of the particular payoff structure, (2), in generating the behavior we seek cannot be overlooked. It is clear that by changing (2), we can completely alter the model's solution. In fact, there are relatively few pairs of payoffs which generate Chicken. Of these, even less provide LS as the reputational outcome. However, this is not problematic because there is no reason to expect that policymakers always disagree and even when they do, that they disagree in just the right way for our results to be valid. Quite often, there may be general agreement about the first best outcome. The infrequent examples of government policies that can be described as LS support this contention.[14] Nonetheless, we must ask how payoffs that lead to Chicken might come about.

On obvious possibility is for payoffs, discount rates, etc. to be randomly chosen. Depending upon the payoffs which are realized, there may or may not be agreement on the policy mix and there may or may not exist a situation in which establishing a reputation will help someone to achieve a more preferred outcome. Assuming that a new draw of payoffs and parameter values occurs as the current time period (minimum of the current T_F and T_M) ends, we would have a sequence of various policy mixes occurring for different lengths of time, one after the other. This does not sound entirely implausible.

A second, more institutional means to determine payoffs and other parameters is to assume that these values reflect the preferences of the agents of the economy expressed through the vote. If we allow for a diversity of agents, it seems quite possible that agents might vote into office policymakers who will attempt to implement policies that may not be feasible for extended periods of time. As an example, suppose that agents vote for both a fiscal and monetary policymaker. Let these agents typically have preferences and endowments that lead them to save. Then because agents are made worse off by tax increases, they might choose to vote into office policymakers who will implement lower taxes and therefore (assuming no compensating change in spending) higher deficits. Furthermore, because greater money creation reduces the real return to saving, these agents might also vote for a monetary policymaker who will reduce (or at least not increase) money growth. Combining things, we see that agents may vote for policy that is incompatible. If the policymakers, after pursuing the wishes of the electorate, find that the desires of the voters cannot be maintained without precipitating a fiscal collapse, we might expect them (or one of them) to change policy. Eventually, the policymakers are either reelected or voted out of office.

A final comment before concluding. Throughout the paper, we have assumed that the fiscal authority chooses his strategy and then the monetary authority reacts. Nothing substantive would be changed were we to reverse the order. That we chose the order that we did is in deference to the manner in which such decisions seem to be made in the U.S. An improvement might be to assume that the fiscal authority makes decisions discretely while the monetary authority continuously reacts during the intervals between successive fiscal actions.

Appendix A

In this appendix we briefly show how (8) is found to be the solution to (6) with H(t) given by (7). We recall that (6) is of the form $\mathring{q}_t/q_t = f(t)\,\mathring{p}_t/p_t$. Clearly, when f(t) is a constant, $\ln q_t = f \ln p_t + c$ where c is an integration constant. This suggests examining the relationship between $\ln q_t$ and $\ln p_t$ in a case where f varies with t.

From (5) we obtain

$$\ln q_t - \ln k_1 = -y[r_M(T_M - t) + \ln\{1 - \exp[-r_M(T_M - t)]\}] \qquad \text{(A-1a)}$$

$$\ln p_t - \ln k_2 = -x[r_F(T_F - t) + \ln\{1 - \exp[-r_F(T_F - t)]\}] \qquad \text{(A-1b)}$$

Defining H(t) to be the ratio of the right-hand sides of (A-1), we immediately obtain $\ln q_t - \ln k_1 = H(t)[\ln p_t - \ln k_2]$. To be a solution of (6), we need only add an integration constant. Doing so and taking the exponential gives

$$q_t/k_1 = k(p_t/k_2)^{H(t)}. \qquad \text{(A-2)}$$

Evaluating (A-2) at t^* and recalling that we require $q_{t^*} = p_{t^*} = 1$ implies that $k = k_1^{-1} k_2^{H(t^*)}$. Substitution into (A-2) gives (8).

APPENDIX B

To ease what would otherwise be some cumbersome expressions, the following notation will be used:

$$\alpha(t;\ r,\ T,\ z) = z(T - t)[1-e^{-r(T-t)}]^{-1} \tag{B-1}$$

$$\beta(t;\ r,\ T) = r(T-t) + \ln(1-e^{-r(T-t)}) \tag{B-2}$$

$$\zeta(t;\ r,\ T,z) = rz[1-e^{-r(T-t)}]^{-1} \tag{B-3}$$

Differentiation of α, β and ζ with respect to time implies that $\mathring{\alpha} < 0$, $\dot{\beta} < 0$ and $\dot{\zeta} > 0$.

Recalling the definition of t_F^{**} and using (4a), implicit differentiation and a large amount of algebra lead to

$$\frac{dt_F^{**}}{dr_M} = \{(1-q_{t_F^{**}})^{-1}\ q_{t_F^{**}}[\alpha(t_F^{**};\ r_M,\ T_M,\ y) - \alpha(0;\ r_M,\ T_M,\ y)] + \zeta(t_F^{**};\ r_M,\ T_M,y)^{-1}\ \dot{\alpha}\ (t_F^{**};\ r_M,\ T_M,\ y)\}\ /\ \{q_{t_F^{**}} + r_M \exp[-\beta(t_F^{**};\ r_M,\ T_M)]\} < 0 \tag{B-4}$$

$$\frac{dt_F^{**}}{dT_M} = \{(1-q_{t_F^{**}})^{-1}\ q_{t_F^{**}}[\zeta(t_F^{**};\ r_M,\ T_M,\ y) - \zeta(0;\ r_M,T_M,\ y)] + r_M \exp[-\beta(t_F^{**};\ r_M,\ T_M)]\}\ /\ \{q_{t_F^{**}} + r_M \exp[-\beta(t_F^{**};\ r_M,\ T_M)]\} > 0 \tag{B-5}$$

$$\frac{dt_F^{**}}{dy} = \frac{(1-q_{t_F^{**}})^{-1}\ q_{t_F^{**}}[\beta(t_F^{**};\ r_M,\ T_M) - \beta(0;\ r_M,\ T_M)] - y^{-1}}{q_{t_F^{**}} + r_M \exp[-\beta(t_F^{**};\ r_M,\ T_M)]} < 0 \tag{B-6}$$

$$\frac{dt_F^{**}}{d\gamma} = \frac{-(1-q_{t_F^{**}})^{-1}\ q_{t_F^{**}}\ \gamma^{-1}}{q_{t_F^{**}} + r_M \exp[-\beta(t_F^{**};\ r_M,\ T_M)]} < 0 \tag{B-7}$$

The independence of q_t from r_F, T_F, x and δ implies the same properties for ρ_t.

To find the derivatives of t_M^{**}, we need an intermediate step. From (4b), we see that π_t is a function of p_t which depends upon t^* via k_2. But t^* is a function of r_M, T_M, y and γ (see (9)). Therefore, π_t and t_M^{**} are functions of these parameters as well, the latter implicitly. Differentiation of (9) can be shown to imply $dt^*/dr_M < 0$, $dt^*/dT_M > 0$, $dt^*/dy < 0$, $dt^*/d\gamma < 0$. Implicit differentiation of $\pi_{t_F^{**}} = 1$, a lot of algebra and the above derivatives for t^* imply

$$\frac{dt_M^{**}}{dr_M} = \frac{(1-p_{t_M^{**}})^{-1}\ p_{t_M^{**}}\ \zeta(t^*;\ r_F,\ T_F,\ x)\ dt^*/dr_M}{p_{t_M^{**}} + r_F\ \exp[-\beta(t_M^{**};\ r_F,\ T_F)]} < 0 \qquad \text{(B-8)}$$

$$\begin{aligned}\frac{dt_M^{**}}{dr_F} = &\ \{(1-p_{t_M^{**}})^{-1}\ p_{t_M^{**}}\ [\alpha(t_M^{**};\ r_F,\ T_F,\ x) - \alpha(t^*;\ r_F,\ T_F,\ x)] \\ &+ \zeta(t_M^{**};\ r_F,\ T_F,\ x)^{-1}\ \dot{\alpha}(t_M;\ r_F,\ T_F,\ x)\} / \{p_{t_M^{**}} + \\ &\ r_F\ \exp[-\beta(t_M^{**};\ r_F,\ T_F)]\} \gtrless 0\end{aligned} \qquad \text{(B-9)}$$

$$\frac{dt_M^{**}}{dT_M} = \frac{(1-p_{t_M^{**}})^{-1}\ p_{t_M^{**}}\ \zeta(t^*;\ r_F,\ T_F,\ x)\ dt^*/dT_M}{p_{t_M^{**}} + r_F\ \exp[-\beta(t_M^{**};\ r_F,\ T_F)]} > 0 \qquad \text{(B-10)}$$

$$\begin{aligned}\frac{dt_M^{**}}{dT_F} = &\ \{(1-p_{t_M^{**}})^{-1}\ p_{t_M^{**}}\ [\zeta(t_M^{**};\ r_F,\ T_F,\ x) - \zeta(t^*;\ r_F,\ T_F,\ x)] \\ &+ r_F\ \exp[-\beta(t_M^{**};\ r_F,\ T_F)]\} / \{p_{t_M^{**}} + \\ &\ r_F\ \exp\ [-\beta(t_M^{**};\ r_F,\ T_F)]\} \gtrless 0\end{aligned} \qquad \text{(B-11)}$$

$$\frac{dt_M^{**}}{dy} = \frac{(1-p_{t_M^{**}})^{-1}\ p_{t_M^{**}}\ \zeta(t^*;\ r_F,\ T_F,\ x)\ dt^*/dy}{p_{t_M^{**}} + r_F\ \exp[-\beta(t_M^{**};\ r_F,\ T_F)]} < 0 \qquad \text{(B-12)}$$

$$\frac{dt_M^{**}}{dx} = \frac{(1-p_{t_M^{**}})^{-1}\, p_{t_M^{**}}\,[\beta(t_M^{**};\ r_F,\ T_F) - \beta(t^*;\ r_F,\ T_F)] - x^{-1}}{p_{t_M^{**}} + r_F \exp[-\beta(t_M^{**};\ r_F,\ T_F)]} \gtrless 0 \qquad \text{(B-13)}$$

$$\frac{dt_M^{**}}{d\gamma} = \frac{(1-p_{t_M^{**}})^{-1}\, p_{t_M^{**}}\, \zeta(t^*;\ r_F,\ T_F,\ x)\ {dt^*}/{d\gamma}}{p_{t_M^{**}} + r_F \exp[-\beta(t_M^{**};\ r_F,\ T_F)]} < 0 \qquad \text{(B-14)}$$

$$\frac{dt_M^{**}}{d\delta} = 0 \qquad \text{(B-15)}$$

FOOTNOTES

1. See Blinder and Solow (1973, 1976), Turnovsky (1977), Christ (1979), Sargent and Wallace (1981), McCallum (1982), Scarth (1982) and Smith (1982).

2. This corresponds to McCallum's example (1982, Section III) of dynamic stability when the deficit defined as including interest payments is held constant. He does not, however, make explicit this important assumption.

3. The consequences of this outcome on the welfare of private agents is explored in Sargent and Wallace (1981).

4. See Sargent and Wallace (1981, p. 6) for an example.

5. The two decisions determine the quantity of federal debt sold to the private sector.

6. An example of a pair of preferences corresponding to Chicken is given by equation (2). As will be seen in Section 3, Kreps and Wilson's model (1982, Section 4) essentially formalizes the following discussion.

7. A useful discussion of the differences between the Prisoner's Dilemma and Chicken is provided by Snyder (1971).

8. As the number of stages remaining declines, the return from predation falls thereby lessening the probability that the monopolist preys following entry. This increases the incentive to enter.

9. Kreps and Wilson comment that the most interesting version of this game has the monopolist repeatedly facing the same entrant (p. 266). Since this interpretation exactly matches our policy choice game, we will assume just two players in all that follows.

10. We will say more about the determination of the public authorities' preferences in Section 4.

11. Recall that one of the features of Chicken is that the victor receives his most preferred choice.

12. This table is taken from Kreps and Wilson (1982, p. 272). I have simply relabelled the rows and columns to fit the present context.

13. This is the complication referred to earlier.

14. On the other hand, there may be disagreement about the first best outcome, but one policymaker finds pursuit of his first best impossible to undertake and so goes along with the wishes of the other policymaker from the beginning. In terms of our notation, either $\rho_0 = 1$ or $\pi_0 = 1$.

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