The Dynamic (In)efficiency of Monetary Policy by Committee

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Abstract

This paper constructs a model where the value of the monetary policy instrument is selected by a heterogenous committee engaged in a dynamic voting game. Committee members differ in their institutional power and, in certain states of nature, they also differ in their preferred instrument value. Preference heterogeneity and concern for the future interact to produce decisions that are dynamically inefficient and inertial around the previously-agreed instrument value. This model provides an explanation for the empirical observation that the nominal interest rate under the central bank's control is infrequently adjusted.

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1 Introduction

This paper studies the dynamic implications of monetary policy-making by committee. The subject matter is important because, in many countries, monetary policy decisions are made by committees, rather than by one individual alone. For example, Fry *et al.* (2000) report that in a sample of 88 central banks, 79 use some form of committee structure to formulate monetary policy.

In particular, this paper focuses on a two-person committee where heterogenous agents must select the value of the policy instrument (say, the nominal interest rate) but face exogenous uncertainty regarding their preferred policies in the future. The committee members differ in two ways. First, agents have different state-dependent preferences over policy. There are states of nature where agents do not agree in their preferred instrument value, and states where they agree. Second, agents differ in their institutional role. More concretely, one agent, the chairman or agenda setter, makes a take-it-or-leave-it proposal to the other agent in every period. This assumption captures the idea that chairmen have usually more power and influence than their peers as a result of additional legal responsibilities, statutory prerogatives, or prestige. The identity of the chairman and the composition of the committee are assumed to be fixed over time. An important and plausible feature of the voting game is that the instrument value decided in the previous meeting is the default option in case the proposal is rejected in the current meeting. Hence, the status quo is a state variable.[1]

In this setup, heterogeneity and concern for the future interact to affect the conduct of monetary policy. Committee decisions are inertial in that the chairman's optimal proposal is often the status quo, even when the state of nature has changed. This result is primarily due to the heterogeneity in policy preferences and the role of the status quo as default option in the voting game. Since the default policy may not necessarily be bad for a committee member, in many instances policy changes are not passed (or proposed).

Furthermore, there are circumstances where policy changes that would benefit both members are not undertaken. This form of "political failure" (to borrow the term proposed by Besley and Coate, 1998) may imply more muted responses to changing economic conditions and introduces a source of inefficiency into policy-making. In states of nature where both policy makers agree, it may be possible to raise the utilities of all agents with a policy change. However, the implementation of this program requires commitment to keep future policies

[1] The theoretical literature on bargaining with evolving defaults is scant. Among the few contribution, see Baron (1996), Baron and Herron (2003), and Bernheim *et al.* (2005). To the best of our knowledge, this paper is the first one to incorporate uncertainty in a model with dynamic reversion of the status quo.

constant. Absent commitment, policy makers do not engage in Pareto-improving policy changes that affect the status quo. The reason is that changes in the status quo would alter the negotiation power of each committee member in the next meeting and, consequently, affect the voting outcome in case agents disagree in their desired instrument value.

The result that committee decision-making may induce policy conservatism has been previously derived by Waller (2000) in a model with partisan central bank appointments and exogenous electoral outcomes *à la* Alesina (1987). In our model, policy conservatism is not sustained by the strategic appointment of moderate committee members (as in Waller's model) or by trigger punishments (as in Alesina's model), but it is due to the voting game played by the committee. Moreover, in the above literature, policy smoothing is regarded as welfare increasing because it reduces the uncertainty associated with elections. Thus, a constant policy rule, irrespective of the identity of the winning party, is beneficial to both parties. In our model, preferred policies are not constant but, instead, they vary over time as the state of nature changes. As a result, a constant policy rule is not optimal and policy conservatism moves the economy away from the efficient frontier.

The inertia in committee decision-making implied by this model is a plausible explanation for the empirical observation that the interest rate under the central bank's control is infrequently adjusted despite the arrival of new information. Figure 1 plots the histogram of the changes in the target value of the key interest rate in four central banks, namely the U.S. Federal Reserve, the European Central Bank, the Bank of England, and the Bank of Canada.[2] Note that, by far, the most frequent policy decision is to leave the interest-rate target unchanged. In the voting model, inertia is local around previously-agreed decisions: for small changes in the state of nature the committee maintains the status quo, but for large changes a new instrument value is selected. Thus, the change in the instrument value is a nonlinear function of the change in economic conditions. Moreover, since the status quo is a state variable, the current instrument value is a function of its previous value. Hence, the voting model endogenously generates the (positive) autocorrelation observed in key interest rates. In contrast, the standard model with a single central banker, which underlies the derivation of Taylor-type rules, predicts that the interest rate is always adjusted and in a proportional manner whenever inflation or unemployment change. Also, the standard model

[2] The interest rates are the Federal Funds Rate, the Rate for Main Refinancing Operations, the Repo Rate, and the Overnight Rate, respectively. The samples used to construct these histograms start in August 1987, January 1999, June 1997, and June 1997, respectively, and end in March 2005 in all cases. For the Federal Reserve, the sample starts with the first meeting under Alan Greenspan chairmanship, and the data sources are Chappell *et al.* (2005) and the Federal Reserve Bank of New York. For the other central banks, the sample starts (roughly) at the time when committee decision making was instituted, and the data were collected by the authors using official press releases.

does not predict that interest rates are autocorrelated and, consequently, the empirical analysis of Taylor rules usually involves the *ad-hoc* introduction of the lagged interest rate in the estimated relation.

The paper is organized as follows. Section 2 describes the committee and solves a simple two-state model that illustrates the main implications of the voting game. Section 3 solves and simulates a more general multi-state model. Section 4 compares the voting model with endogenous and fixed default. Section 5 concludes.

2 Two-State Model

This section describes the committee and examines a version of the dynamic voting game with two states of nature. The two-state model is solved for three horizons, namely $T = 1, 2$ and ∞. The finite horizon cases ($T = 1, 2$) are solved analytically by backward induction and the infinite horizon case ($T = \infty$) is solved numerically. Studying first the two-state model is instructive because this special case illustrates the main results of this paper in the simplest possible setup.

The committee is composed of two agents with heterogenous preferences: C and P, with C the fixed chairman.[3] In every period, the committee is concerned with selecting the policy variable x that takes values in the interval $X = [a, c]$, with $a < c$. For concreteness, think of the policy variable as the target value of a key nominal interest rate. In each period, the payoff of policy maker j, for $j = C, P$, is

$$U_j(x, \varepsilon_i) = -(x - r_j(\varepsilon_i))^2,$$

where $r_j(\varepsilon_i)$ is j's state-dependent preferred policy and ε is an exogenous shock. For analytical convenience, it is assumed that the probability distribution of ε is discrete. In this section, it is also assumed that ε can take only two values, ε_1 and ε_2. The shock follows a Markov chain and its transition matrix has elements $p_{ki} = prob(\varepsilon_k \mid \varepsilon_i) \in (0, 1)$ with $i, k = 1, 2$ and $\sum_{k=1}^{2} p_{ki} = 1$. Two states of nature are defined by the possible realizations of ε. When $\varepsilon = \varepsilon_1$, agents C and P disagree in their preferred instrument values, with c and a their respective preferred points.[4] When $\varepsilon = \varepsilon_2$, C and P agree and $b \in (a, c)$ is their

[3]The assumption of a fixed agenda setter is made for realism. For example, in the case of the United States, the chairman of the Federal Open Market Committee is (by tradition) the chairman of the Board of Governors, who in turn is appointed by the President for a renewable four-year term. For models of legislative bargaining where the the agenda setter is randomly selected, see Baron (1996) and Baron and Ferjohn (1989).

[4]The converse assumption – that C and P's preferred points are a and c, respectively – leads to decision rules that are mirror images of the ones derived here. Hence, the main theoretical implications of the model are robust to using either version of this assumption.

preferred point. Note that C is more "conservative" than P in the sense that, on average, he prefers a higher nominal interest rate than P does. Without loss of generality, it is assumed that the bliss points are evenly spaced, meaning that $b - a = c - b$.

Note that preferences depend on the policy instrument rather than on policy outcomes (say, inflation and unemployment). This approach has two advantages. First, it makes the voting game more tractable because otherwise the private sector's expectations would be a state variable that has to be validated in a rational expectations equilibrium.[5] Second, it means that the particular economic model that the policy maker believes to be true needs not be specified. This is important because anecdotal evidence suggests that policy makers may have different views about how the economy works depending on their background and intellectual environment. For example, Hetzel (1998) argues that Arthur Burns, the chairman of the U.S. Federal Reserve from February 1970 to January 1978, attached significant importance to nonmonetary factors (*e.g.,* business optimism and wage demands by unions) in the determination of inflation, and did not consider monetary policy to be the driving force behind the rise in U.S. inflation in the 1970s. The actions of Paul Volcker as chairman from August 1979 to August 1987 suggests that he did not completely share Burns' views on the causes of inflation. Furthermore, committee members serving under the same chairman may disagree on the "correct" economic model. For example, Chappell *et al.* (2005, ch. 6.3) document the division within the Federal Open Market Committee (FOMC) between Keynesian and Monetarists members during Burns' chairmanship.

Policies are decided sequentially taking as given the initial status quo, that is the value of the policy variable at the end of the previous period. The timing is the following. First, the current realization of the shock ε is observed. Then, the chairman makes a take-it-or-leave-it proposal $x \in [a, c]$. If the proposal is rejected by P, then the status quo persists till next period. If the proposal is accepted, then x is implemented and becomes the new status quo for the voting game in the next period. The assumption that the chairman makes take-it-or-leave-it proposals to the committee is not meant to be a literal description of how monetary policy committees actually work. Instead, it is a modeling device that captures the idea that chairmen have usually more power and influence than their peers.[6]

[5] This is a non-trivial fixed point to solve for. The strategy of the private sector depends on the expected voting outcome, but the outcome of the voting game depends on the expectations of the private sector in two ways. Directly, since expected inflation affects the policy makers' utilities, and indirectly by changing the default payoff, since the real interest rate in case of disagreement is the difference between the nominal status quo policy and expected inflation. For now, we leave this extension to future research.

[6] On the account of his experience as Board governor from 1996 to 2002, Laurence Meyer (Meyer, 2004) remarks on "the chairman's disproportionate influence on FOMC decisions" and on "his efforts to build consensus around his policy recommendations" (p. 50). However, Mayer also notes that the chairman "does not necessarily always get his way" (p. 52). Sherman Maisel, who was member of the Board during Burns'

Mathematically, the problem of the chairman can be formulated recursively with state given by the initial status quo and the current shock. The Markov strategies of the two agents are defined as follows. The proposal strategy of the chairman is

$$G_{C,t} : [a, c] \times \{\varepsilon_1, \varepsilon_2\} \to [a, c] .$$

The voting rule followed by P depends on both the state and the proposal made by C,

$$G_{P,t} : [a, c] \times \{\varepsilon_1, \varepsilon_2\} \times [a, c] \to \{yes, no\} .$$

In the infinite-horizon game, player's strategies will be stationary. The voting rule is assumed to be sequentially rational. That is, P votes in favor of the proposal whenever the current utility from the proposal plus the continuation value of moving to the next period with a new status quo is higher than or equal to keeping the status quo and moving to the next period with the current status quo. Define the acceptance set A_t as the set of policies that are accepted by P at time t, for a given default policy and a given realization of the state of nature. More formally,

$$A_t(q, \varepsilon_i) = \left\{ x \in X : U_P(x, \varepsilon_i) + \delta \sum_{k=1}^{2} p_{ki} V_{P,t+1}(x, \varepsilon_k) \geq U_P(q, \varepsilon_i) + \delta \sum_{k=1}^{2} p_{ki} V_{P,t+1}(q, \varepsilon_k) \right\} .$$

Note that unanimity is required for a policy change only because we consider a two-person committee. The appendix shows that our set up is equivalent to a committee with $n + 1$ representatives where P occupies the role of the median and simple majority is required to pass a proposal.

Let $q \in [a, c]$ denote the initial status quo. For all t the proposal strategy $G_{C,t}(q, \varepsilon_i)$ solves the dynamic programming problem

$$V_{C,t}(q, \varepsilon_i) = \max_{x \in A_t(q, \varepsilon_i)} U_C(x, \varepsilon_i) + \delta \sum_{k=1}^{2} p_{ki} V_{C,t+1}(x, \varepsilon_k),$$

where the last term is the conditional expectation of $V_{C,t+1}(x, \varepsilon)$ as of time t, and $\delta \in (0, 1)$ is the discount factor. In words, C proposes the policy x that maximizes his utility from among those that are acceptable to P. In the noncooperative bargaining environment studied here, the chairman's proposals are never rejected in equilibrium.[7] The latter implication is in line with historical records from the FOMC which show that a chairman's recommendation has never been voted down by the committee (see, Chappell *et al.,* 2005).

chairmanship also points out that "while the influence of the Chairman is indeed great, he does not make policy alone" (Maisel, 1973, p. 124).

[7]Note that proposing a policy outside the acceptance set is equivalent to proposing the status quo, which is always accepted.

The solution concept is Markov perfection. A Markov perfect equilibrium is a set of policy rules $\{G_{C,t}, G_{P,t}\}_{t=1}^{T}$, such that 1) for all $q \in [a, c]$ and for all t, the voting rule $G_{P,t}$ is sequentially rational given $\{G_{P,s}\}_{s=t+1}^{T}$ and $\{G_{C,s}\}_{s=t}^{T}$, and 2) for all $q \in [a, c]$ and for all t, the proposal rule $G_{C,t}$ solves the problem of the agenda setter at time t, given $\{G_{C,s}\}_{s=t+1}^{T}$ and $\{G_{P,s}\}_{s=t}^{T}$.

2.1 Finite Horizon with T=1

Consider the voting game described above with finite horizon $T = 1$. Absent any dynamics, the solution is similar to that of the agenda-setting game studied by Romer and Rosenthal (1978). The chairman's proposal strategy is depicted in the first column of Figure 2 as a function of the status quo q for each possible realization of ε. Proposals on the 45 degree line are the status quo

First, suppose that ε_1 occurs. In this case, the chairman proposes the status quo for any $q \in [a, c]$. The reason is that P would not accept any proposal $x \in (q, c]$ that gives C higher utility than q, and C would not propose any $x \in [a, q)$ that gives him lower utility than q. Since the proposal strategy is independent of the values of δ, p_{11} and p_{22}, it follows that policy inertia arises in this case only as result of the heterogeneity among committee members. Now, suppose that ε_2 occurs and both members agree that b is the optimal value of the policy instrument. In this case, the chairman proposes b starting from any status quo.

2.2 Finite Horizon with T=2

Suppose now that the horizon is $T = 2$. The model is solved backwards for $t = T, T-1$. The proposal strategies at time $t = T$ are the ones derived in Section 2.1. The proposal strategies at time $T-1$ are derived in Proposition 1 below. In order to develop the reader's intuition, these strategies are depicted in the second column of Figure 2 in the special case where $\delta = 0.5$, $p_{11} = 0.8$ and $p_{22} = 0.5$. These probabilities correspond approximately to those computed using the voting records of the Monetary Policy Committee (MPC) of the Bank of England from June 1997 to January 2005.[8]

[8] The voting records contain information on the date of the meeting, the policy decision, the name of the members in favor of the decision, and the name of dissenting members with their preferred policy option. The probabilities are computed as follows. A meeting where the policy decision is adopted unanimously is treated as one where all committee members agree in their preferred instrument value, meaning that in terms of our model $\varepsilon = \varepsilon_2$. A meeting with at least one dissenting individual is treated as one where committee members disagree in their preferred instrument value, meaning that $\varepsilon = \varepsilon_1$. Then, p_{11} (p_{22}) is computed as the number of observations where members disagree (agree) in two consecutive meetings divided by the number of observations where members disagree (agree) in the first of these two meetings.

Proposition 1. *Let $T = 2$. For all $q \in [a, c]$ the proposal rules when ε_1 and ε_2 occur are, respectively, $G_{C,T-1}(q, \varepsilon_1) = q$ and*

$$G_{C,T-1}(q,\varepsilon_2) = \begin{cases} y, & \text{for } q \in [a, 2z-y], \text{ where } y = (b + c\delta p_{12})/(1+\delta p_{12}), \\ 2z - q, & \text{for } q \in (2z-y, z), \text{ where } z = (b + a\delta p_{12})/(1+\delta p_{12}), \\ q, & \text{for } q \in [z, y], \\ y, & \text{for } q \in (y, c]. \end{cases}.$$

Proof: We start by showing that $G_{C,T-1}(q, \varepsilon_1) = q$ is the optimal proposal rule. Suppose that the current shock is ε_1. The chairman's proposal strategy at time $t = T - 1$ is found by exploiting the fact that the successful proposal in T will be given by the proposal rules in Section 2.1. The chairman chooses the proposal x that maximizes his two-period payoff within the acceptance set, $A_{T-1}(q, \varepsilon_1)$. That is, he solves the following problem:

$$\max_{x \in A_{T-1}(q,\varepsilon_1)} -(1 + \delta p_{11})(x - c)^2,$$

where the acceptance set is defined as

$$A_{T-1}(q, \varepsilon_1) = \left\{x \in [a, c] : -(1 + \delta p_{11})(x - a)^2 \geq -(1 + \delta p_{11})(q - a)^2\right\}.$$

It is easy to see that the acceptance set is $[a, q]$ for any $q \in [a, c]$. Since C's two-period payoff is increasing in the current proposal, the chairman always proposes $x = q$.

Now we prove that the posited $G_{C,T-1}(q, \varepsilon_2)$ is optimal. When ε_2 occurs at time $T - 1$, the chairman's problem becomes:

$$\max_{x \in A_{T-1}(q,\varepsilon_2)} -(x - b)^2 - \delta p_{12}(x - c)^2,$$

where

$$A_{T-1}(q, \varepsilon_2) = \left\{x \in [a, c] : -(x - b)^2 - \delta p_{12}(x - a)^2 \geq -(q - b)^2 - \delta p_{12}(q - a)^2\right\}.$$

In finding $G_{C,T-1}(q, \varepsilon_2)$, it is useful to first derive P's voting rules. P's two-period utility is concave in x, with a maximum at

$$z = \frac{b + a\delta p_{12}}{1 + \delta p_{12}}.$$

Note that $a < z < b$. Because the payoff is symmetric around z, the acceptance set is easy to derive. For any $q \in [a, z]$, $A_{T-1}(q, \varepsilon_2) = [q, 2z - q]$, and for any $q \in [z, c]$, $A_{T-1}(q, \varepsilon_2) = [2z - q, q]$. Now consider C's proposal strategy. C's objective function is concave and has a global maximum at

$$y = \frac{b + c\delta p_{12}}{1 + \delta p_{12}}.$$

Since the mapping from the voting records to the model is clearly imperfect, the policy rules in Figure 2 are best interpreted as illustrative only.

Note that $b < y < c$. When $q \in [y, c]$ C is not constrained and will propose y. When $q \in (2z - y, y)$, C is constrained and proposes his preferred policy in the acceptance set. We distinguish two cases: when $q \in [z, y)$, the proposal is $x = q$, and when $q \in (2z - y, z)$, the proposal is $x = 2z - q$. Finally, when $q \in [a, 2z - y]$, the acceptance set includes C's bliss point y and, consequently, P proposes $x = y$. ■

Note that the decision rules in period $T - 1$ converge to those in period T as $\delta \to 0$ (committee members attach no weight to future payoffs) or $p_{11}, p_{22} \to 1$ (the states of nature are absorbing): in either case $y, z \to b$.

We now comment on the policy rules just derived. When ε_1 occurs and committee members disagree on the optimal instrument value, inertia originates from the opposite agents' preferences. In this case, there is no Pareto-improving policy change and the political equilibrium is efficient according to the standard economic definition. To see this, pick any $q \in [a, c]$ and note that any policy choice to the right (left) of q would reduce P's (C's) utility.

When ε_2 occurs and committee members agree that b is the optimal instrument value today, the possibility of disagreement in the next period affects current policy choices. For example, when $q \in [y, c]$, C adjusts the current policy only to y, which is larger than b. The reason is that the chairman trades off the benefit of moving towards the ideal point b and the cost of worsening his bargaining power should $\varepsilon = \varepsilon_1$ in the next period. This outcome is clearly dynamically inefficient. To make the notion of inefficiency more precise, we use the following definition of political failure (Besley and Coate, 1998). A given politico-economic equilibrium displays a political failure if, keeping future policies unchanged, there exist values of the choice variable that can increase the utility of all agents in the current period.

To verify the existence of a political failure in our equilibrium, consider, for instance, the case where $q = y$. Rather than staying in y, as established in Proposition 1, a Pareto-improving choice would be moving to b today and going back to y next period. However, this policy requires commitment. Absent commitment, after the default policy has changed to b, it is not sequentially rational for P to allow C to return to y. Consequently, a policy change to b will not be implemented by the committee. Similar polices that Pareto-improve upon those in Proposition 1 can be constructed for all status quo in $[a, c]$ except for $\{b, 2z - b\}$. In these two cases, committee decision making is not dynamically inefficient because the proposal coincides with b. Hence, this simple two-state, two-period model illustrates the fact that, in some circumstances, committee decision making with an endogenous status quo is dynamically inefficient and leads to more muted responses to shocks compared to a single central banker. Since y is increasing in p_{12} and δ, the chairman is more cautious as the conditional probability of future disagreement increases and as the future is discounted less heavily by committee members.

While it is difficult to obtain a closed-form solution for an arbitrary period $T-s$, where $s=0,...,T-1$ denotes the number of remaining periods until T, it possible to show that the above result carries over as the horizon increases. Suppose the initial status quo is equal to c at time $T-s$. We can show that the committee does not move when ε_1 occurs and moves to v_{T-s} when ε_2 occurs, where v_{T-s} is defined as:

$$v_{T-s}=\frac{b+c\delta p_{12}\sum\limits_{j=1}^{s}\left(\delta p_{11}\right)^{j-1}}{1+\delta p_{12}\sum\limits_{j=i}^{s}\left(\delta p_{11}\right)^{j-1}},\qquad 1\leq s\leq T-1.$$

Note that $v_{T-1}=y$ in the special case where $T=2$ and $s=1$. If repeated realizations of $\varepsilon=\varepsilon_2$ take place, we can show that the committee moves gradually towards $y>b$. To see this, note that the sequence $\{v_{T-s}\}_{s=1}^{T-1}$ is decreasing in t and converges to y as the economy approaches the previous-to-last period. Intuitively, at time $T-s-1$, the chairman is more cautious in moving towards y than at $T-s$ because he is more likely to be constrained as a result of today's choice when more periods are left before the end of the game. Note that today's decision has an effect on future outcomes only when ε_1 occurs in the next period, two periods in a row, three periods in a row, etc.[9] However, when more periods are left, the sum of the probabilities associated with these events is quantitatively larger.

2.3 Infinite Horizon

Consider now the voting game in the case where the horizon is infinite. Because finding the analytical solution of the infinite-horizon game is not trivial, we employ instead a numerical algorithm to find the stationary decision rules. The procedure builds on the projection method employed by Judd (1998) to study the Bellman equation of the stochastic growth model, and it works by backward induction exploiting the observation that the chairman's problem is a constrained maximization which can be solved numerically using standard hill-climbing methods.

Algorithm:
Step 1. Starting at time $t=T$, solve the chairman's optimization problem for a set of discrete nodes n_j, for $j=1,2,\ldots,N$ in $[a,c]$, given the shock $\varepsilon=\varepsilon_i$, for $i=1,2$. The nodes

[9] For example, if ε_1 occurs next period and ε_2 in two periods from now, the payoff two periods from now is not affected by today's decision because two periods from now the chairman will not be constrained and can move to his bliss point.

n_j may be interpreted as possible status quo at the beginning of period T. Given n_j and ε_i, the chairman's problem at time $t = T$ is

$$V_{C,T}(n_j, \varepsilon_i) = \max_{x \in [a,c]} U_C(x, \varepsilon_i),$$

subject to the nonlinear constraint $U_P(x, \varepsilon_i) \geq U_P(n_j, \varepsilon_i)$. This maximization problem is solved numerically for each n_j and ε_i using a hill-climbing method. The result is a collection of $2N$ optimal proposal values $G_{C,T}(n_j, \varepsilon_i)$. Using these optimal values, compute $V_{C,T}(n_j, \varepsilon_i) = U_C(G_{C,T}(n_j, \varepsilon_i), \varepsilon_i)$ and $V_{P,T}(n_j, \varepsilon_i) = U_P(G_{C,T}(n_j, \varepsilon_i), \varepsilon_i)$ for all n_j and ε_i.
Step 2. For each ε_i, approximate the continuous value function $V_{C,T}(q, \varepsilon_i)$ using a Chebyshev polynomial of order $N-1$. The polynomial coefficients are obtained from the Least Squares projection of $V_{C,T}(n_j, \varepsilon_i)$ on a constant and the first $N-1$ members of the Chebyshev polynomial family. At the N nodes $q = n_j$, the Chebyshev polynomial fits $V_{C,T}(q, \varepsilon_i)$ exactly. For a points $q \neq n_j$, the value of $V_{C,T}(q, \varepsilon_i)$ is computed by interpolation ($i.e$, by evaluating the Chebyshev polynomial at q). For each ε_i, the value function $V_{P,T}(q, \varepsilon_i)$ is approximated likewise.
Step 3. Move backwards one period. For each possible status quo n_j and each possible shock realization ε_i, solve numerically the chairman's problem

$$V_{C,t}(n_j, \varepsilon_i) = \max_{x \in [a,c]} U_C(x, \varepsilon_i) + \delta \sum_{k=1}^{2} p_{ki} V_{C,t+1}(x, \varepsilon_k),$$

subject to

$$U_P(x, \varepsilon_i) + \delta \sum_{k=1}^{2} p_{ki} V_{P,t+1}(x, \varepsilon_k) \geq U_P(n_j, \varepsilon_i) + \delta \sum_{k=1}^{2} p_{ki} V_{C,t+1}(n_j, \varepsilon_k),$$

where the value functions are replaced by their respective approximating polynomials. The result is a collection of $2N$ optimal proposal values $G_{C,t}(n_j, \varepsilon_i)$. Using these optimal values, compute $V_{C,t}(n_j, \varepsilon_i)$ and $V_{P,t}(n_j, \varepsilon_i)$ for all n_j and ε_i.
Step 4. Repeat Steps 2 and 3 backwards until the chairman's decision rules converge. ■

The chairman's stationary decision rules are plotted in the third column of Figure 2. When $\varepsilon = \varepsilon_1$ and both members disagree, the chairman simply proposes the status quo. When $\varepsilon = \varepsilon_2$, the proposal strategy is qualitatively similar to that derived analytically in Proposition 1 for the horizon $T = 2$, but the difference between the proposed policy and the current bliss point is larger. This result follows from the observation that v_{T-s} decreases as $s \to \infty$. In particular,

$$\lim_{s \to \infty} v_{T-s} = v = \frac{b + c\delta p_{12}/(1 - \delta p_{11})}{1 + \delta p_{12}/(1 - \delta p_{11})} > \frac{b + c\delta p_{12}}{1 + \delta p_{12}} = y > b.$$

Finally, since $v - w > y - z$, the set of status quo for which the chairman does not propose a policy change is larger in the infinite horizon case.

3 Multi-State Model

This section solves the dynamic voting game in the more general case where the number of possible shock realizations is larger than two. This extension is important because the two-state model features a strong form of policy inertia in the form of the absorbing region $[w, v]$ and, consequently, does not permit the derivation of time series implications.[10] In what follows, the chairman's proposal strategies are computed, and then policy decisions by the committee are simulated for a sample of sequential meetings.

3.1 Proposal Strategies

Assume that the shock ε can take I discrete values, ε_i for $i = 1, 2, \ldots, I$. Define $S = \{\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_I\}$. As before, the shock follows a Markov chain and its $I \times I$ transition matrix has elements $p_{ki} = prob(\varepsilon_k \mid \varepsilon_i) \in (0, 1)$ that satisfy $\sum_{k=1}^{I} p_{ki} = 1$. The shock ε shifts the agents' preferred policies over an evenly-spaced policy set denoted by Q. The timing and other features of the model are as described in Section 2. For this more general specification, the Markov strategies of the two agents are defined by

$$\begin{aligned} G_{C,t} &: Q \times S \to Q, \\ G_{P,t} &: Q \times S \times Q \to \{yes, no\}. \end{aligned}$$

The chairman's proposal strategy $G_{C,t}(q, \varepsilon_i)$ solves the dynamic programming problem

$$V_{C,t}(q, \varepsilon_i) = \max_{x \in A_t(q, \varepsilon_i)} U_C(x, \varepsilon_i) + \delta E_t V_{C,t+1}(x, \varepsilon),$$

where E_t denotes the conditional expectation at time t and the acceptance set is defined as

$$A_t(q, \varepsilon_i) = \{x \in X : U_P(x, \varepsilon_i) + \delta E_t V_{P,t+1}(x, \varepsilon) \geq U_P(q, \varepsilon_i) + \delta E_t V_{P,t+1}(q, \varepsilon)\}.$$

For concreteness, we focus on the case where $I = 6$ and maintain the convention that committee members agree in the even states and disagree in the odd states of nature. The bliss points of P (C) in states 1 through 6 are, respectively, $a(c)$, $b(b)$, $b(d)$, $c(c)$, $c(e)$, and $d(d)$, where $a < b < c < d < e$ and are equally spaced. Stationary decision rules are solved for using the algorithm described in Section 2.3.

[10] To see this, note that as soon as ε_2 occurs, the successful proposal will be $x \in [w, v]$ with $x = q \in [w, v]$ thereafter.

Since the chairman's proposal strategies depend on the matrix of transition probabilities, we conducted extensive experiments with various parameter configurations and report below results for $\delta = 0.5$ and the transition matrices[11]

$$A = \begin{bmatrix} 3/5 & 1/5 & 0 & 0 & 0 & 0 \\ 1/5 & 3/5 & 1/5 & 0 & 0 & 0 \\ 1/5 & 1/5 & 3/5 & 1/5 & 0 & 0 \\ 0 & 0 & 1/5 & 3/5 & 1/5 & 1/5 \\ 0 & 0 & 0 & 1/5 & 3/5 & 1/5 \\ 0 & 0 & 0 & 0 & 1/5 & 3/5 \end{bmatrix} \text{ and } B = \begin{bmatrix} 1/6 & 1/6 & 1/6 & 1/6 & 1/6 & 1/6 \\ 1/6 & 1/6 & 1/6 & 1/6 & 1/6 & 1/6 \\ 1/6 & 1/6 & 1/6 & 1/6 & 1/6 & 1/6 \\ 1/6 & 1/6 & 1/6 & 1/6 & 1/6 & 1/6 \\ 1/6 & 1/6 & 1/6 & 1/6 & 1/6 & 1/6 \\ 1/6 & 1/6 & 1/6 & 1/6 & 1/6 & 1/6 \end{bmatrix}.$$

Matrix A was deliberately designed to represent the idea that preferred policies evolve slowly over time as new information about business cycle and inflation variables becomes available. Matrix B is used to show that overshooting may be an outcome of the voting model when drastic changes in preferred policies are allowed (see below). Decision rules are respectively plotted in the first and second column of Figure 3. Proposals on the 45 degree line are the status quo (that is, $x = q$).

The following implications for committee decision-making can be drawn from Figure 3. First, there is dynamic inefficiency. That is, the chairman proposes values different from b, c and d in states $2, 4$ and 6, respectively, even though both members agree that these are their current preferred policy options. As in the two-state model, dynamic inefficiency arises because the probability of future disagreement effects current policy choices. Although Pareto-improving policy choices are available, they are not implemented in the politico-economic equilibrium due to the absence of a commitment mechanism.

Second, there is local policy inertia around previously-agreed decisions. To see this, consider the following example. Starting from state $\varepsilon = \varepsilon_2$ and instrument value b, suppose there is a "small" change in the state of nature, meaning to either of the adjacent states $\varepsilon = \varepsilon_1$ or ε_3. In these states, members disagree on their preferred instrument value but the chairman's decision rule still implies $x = b$. Now, suppose there is a "large" change in the state of nature, meaning to $\varepsilon = \varepsilon_4, \varepsilon_5$ or ε_6. Note that in these cases the proposal will be different from the status quo regardless of whether members agree in their desired instrument value or not.

An implication of local inertia is that the relation between changes in the state of nature and in policy is nonlinear. In particular, small changes in the state of nature are less likely to produce policy changes compared with larger ones. Empirically, this would mean, for

[11] The relatively-low value of δ is used to show that dynamic inefficiency arises in the multi-state version of the model even when the future is heavily discounted. Alesina (1987) argues that policy makers' effective discount rates may be low because reappointment probabilities are less than one. Results from unreported experiments are available from the corresponding author upon request.

example, that small variations in the rates of inflation and unemployment are less likely to result in a change in the key nominal interest rate, compared with large movements in these variables.[12] In contrast, the standard model with a single central banker, which underlies the derivation of the linear Taylor rule, predicts a proportional change in the policy instrument for any change in inflation and unemployment regardless of their size.

Third, in certain circumstances, there may be overshooting. By overshooting, we refer to the situation where the committee changes the instrument value by more than a single central banker would. An example of overshooting under the transition matrix B is the following. Starting in state $\varepsilon = \varepsilon_2$ and with a status quo larger than b, note that the chairman proposes a policy less than b, while the single central banker would have adopted b. The reason why we observe overshooting with matrix B, but not with matrix A, is the following. The rationale for overshooting and proposing a policy less than b is to have more leverage should $\varepsilon = \varepsilon_5$ occur and get closer to the ideal point e. The cost of overshooting is that the chairman is worse off if shock ε_1 occurs, because the agenda setter is stuck with a policy lower than b, when his ideal instrument value is c. Since $p_{52} = 0$ in matrix A, the expected cost of overshooting is larger, and, consequently, overshooting does not occur in equilibrium. The above example illustrates the more general proposition that overshooting may arise when drastic changes in the preferred policies are allowed. Note that overshooting is also a form of political failure because, conditional on keeping future policies constant, both member would increase their current payoff by choosing the instrument value they both currently prefer.

Finally, P allows a policy change in the (odd) states of nature where there is disagreement, even when the current default coincides with his preferred policy. For example, when $q = a$ and $\varepsilon = \varepsilon_1$ occurs, the committee chooses an instrument value closer to c. The intuition for this result is the same that underlies all the previous features. In our dynamic game, committee members smooth their bargaining power across periods. When the default coincides with P's preferred policy and, consequently, his negotiation power is large, P is willing to accept a different policy to increase his bargaining power in future meetings. Returning to the previous example, were policy a remain the default and should $\varepsilon = \varepsilon_5$ occur next period, P would enter the next meeting with a low negotiation power. Hence, in order to smooth his bargaining power, P accepts to move away from his preferred point a when $\varepsilon = \varepsilon_1$ occurs.

[12] Eijffinger, Schaling and Verhagen (1999) construct a model for a single central banket that generates a similar prediction in the form an inaction range around the previous policy choice, but inertia is the result of an unspecified fixed cost for policy changes.

3.2 Simulations

This section simulates committee decision making using an artificial sample of sequential meetings under the multi-state voting model examined above. This exercise is important because it reveals the proposal strategies that are implemented in practice and allows the derivation of time series implications.

A series of 200 realizations of the shock ε were generated using each transition probability matrix (whether A or B). Then, the outcome of the voting game was found using the chairman's proposal strategies in Figure 3. The simulated series of ε and x are plotted in Figure 4. Notice that there is policy smoothing in the sense that the policy variable changes less often than the state of nature. That is, there are many instances where nature changes but the value of the policy variable remains the same. Earlier research by Alesina (1987) and Waller (2000) also finds that policy may display less variance when decisions are made through committees than when they are made by a single individual. However, in this model, policy smoothing is not sustained by the strategic appointment of moderate committee members (as in Waller's model) or by trigger punishments (as in Alesina's model), but by the voting game played by the heterogenous committee. Also, notice that the ergodic process of the policy variable involves a finite number of realizations but they do not correspond to the agreement values (b, c, and d) because of dynamic inefficiency.

From the simulated series, it is possible to construct the frequency histograms for Δx in Figure 5.[13] From this Figure, it is clear that the most common policy decision by the committee is to set $\Delta x = 0$ despite the fact that the state of nature has changed.[14] This result is due to the local inertia implied by the optimal decision rules of committee members which was discussed above. Thus, the voting model can provide an explanation for the observation in Figure 1 whereby the interest rate under the central bank's control is infrequently adjusted, despite the fact that there is new information.

It is important to compare this implication with the one obtained when monetary policy is determined by a single individual, say C. Absent a committee, C's decision rule involves changing the policy variable to his preferred value whenever there is a change in the state of nature. The histograms for this case are plotted in the bottom panel of Figure 5 and show that, in contrast with the data, the outcome $\Delta x = 0$ is relatively infrequent.

[13] In order to get a more accurate picture of the distribution, these histograms were constructed using simulations of 10000 observations.

[14] Because the transition matrix has a built-in inertia when the diagonal elements are non-zero and in order not to overstate the policy inertia predicted by the voting game, the histograms are plotted using only observations where there is a change in the state of nature.

4 Comparing Monetary Policy Institutions

5 Discussion

This paper shows the existence of a political failure in policy-making by committee. In some circumstances, committee decision-making may exacerbate policy inertia. Up to the extent that activist monetary policy is socially welfare-improving, inertia may bring the economy away from the efficient frontier. However, as Besley and Coate (1998) point out: "It is insufficient to demonstrate a political failure by showing that there exist some technologically feasible policy choices that produce a Pareto-superior utility allocation. It behooves the analyst to specify an alternative institutional arrangement which actually selects such policy choices." In our model, policy makers choose sub-optimal policies to strategically influence their future bargaining power. If this is so, we should ask ourselves why an institutional arrangement that exhibits an endogenous default policy is observed so often in practice.[15] An alternative arrangement would be to have a default policy that is independent from previous decisions: i.e., the default option may be fixed or decided in the current period within the committee.

In order to understand, from a quantitative point of view, the importance of the concern for the future on policy making, we simulate a model with a fixed status quo. By doing so, we shut down the dynamic link between periods and, consequently, make the committee members' problem static. Notice that, when the default is fixed, the location of the fixed status quo crucially affects the results. Results reported in Table 1 show that the chairman is better off when the default option is endogenous. The intuition for this result is that, when the default is endogenous, the chairman is able to get approval for policy changes in the (odd) states of nature where there is disagreement, even if the status quo coincides with the preferred policy of the other committee member. In contrast, when the status quo is fixed, the committee never changes the instrument value if the default is a member's preferred policy. The preferences of the chairman are such that he prefers being allowed to move closer to his ideal point in states of disagreement than implementing his preferred policy in the states of nature when both agents agree. The stylized nature of the model developed here prevent us from assessing more in detail the potential social welfare implications of committee decision-making and the empirical relevance of dynamic inefficiency, but we intend to take up these issues in future work.

We stress that this paper does not intend to play down the advantages of policy making

[15] On this point, see Tsebelis (2002, p. 8). Rasch (2000) identifies countries where this provision is part of the formal rules in legislative decision-making.

by committees. We recognize that committee decision making has many desirable attributes. First, previous works show that committees can help overcome credibility problems. Sibert (2003) studies the conditions under which committees have more incentives to gain reputation than individual central bankers. In Dal Bó (2005), committee decision making under a supermajority voting rule is able to deliver the ideal mix between commitment and flexibility. Riboni (2004) shows that making policies through committees playing a voting game with an evolving default makes time inconsistency less severe. Second, another body of literature sees information sharing as the main rationale for committee decision making. This argument goes back to the celebrated Condorcet jury theorem. For example, Gerlach-Kristen (2003) shows that in presence of uncertainty about potential output, voting by committees leads to more efficient signal extraction. Experimental studies by Blinder and Morgan (2000) and Lombardelli *et al.* (2005) provide some support for this conclusion..

Table 1. Comparison of Voting Models with Endogenous and Fixed Default

Variable	Endogenous	Fixed					Single
		a	b	c	d	e	Banker
				Matrix A			
C's mean payoff	−0.85	−0.59	−1.23	−0.92	−0.17	0	0
P's mean payoff	−0.51	−0.92	−0.26	−0.59	−1.48	−1.99	−1.99
$Var(x)$	0.58	1.13	0.83	0.50	0.75	0.96	0.96
$Var(\Delta x)$	0.27	0.78	0.45	0.44	0.77	0.95	0.95
$\Delta x = 0$ (in %)	75	25	49	51	13	0	0
				Matrix B			
C's mean payoff	−0.68	−0.82	−1.00	−0.83	−0.17	0	0
P's mean payoff	−1.05	−0.83	−0.33	−0.82	−1.49	−1.99	−1.99
$Var(x)$	0.75	1.29	0.90	0.58	0.75	0.96	.96
$Var(\Delta x)$	0.88	1.82	1.27	0.82	1.05	1.35	1.35
$\Delta x = 0$ (in %)	48	7	26	40	27	14	14

Notes: The numbers in this Table were computed using 10000 simulations. The percentage of observations where $\Delta x = 0$ were computed using only observations for which there was a change in the state of nature.

A Appendix

Consider a committee composed of $n+1$ members. Let n be odd and $X = [\underline{x}, \overline{x}]$ denote the policy space where policies take value. For a policy change, the chairman needs $(n+1)/2$ favorable votes besides his own. Each member other than the chairman is indexed by j, with $j \in N = \{1, ..., n\}$. When $\varepsilon = \varepsilon_1$, members disagree in their preferred instrument values, $r_j(\varepsilon_1)$. We order the n members other than the chairman so that member 1 (n) is the one with the smallest (largest) preferred value under shock ε_1, and $r_1(\varepsilon_1) \leq r_2(\varepsilon_1) \leq ... \leq r_n(\varepsilon_1)$. The median is the one with index $(n+1)/2$. When $\varepsilon = \varepsilon_2$, all members agree and $b \in (\underline{x}, \overline{x})$ is their preferred point. We assume that c and a are, respectively, the preferred values of the chairman and the median, with $\underline{x} \leq a < b < c \leq \overline{x}$. As before, we assume that the voting representative i accepts proposal x if and only if

$$U_i(x, \varepsilon_i) + \delta \sum_{k=1}^{2} p_{ki} V_{i,t+1}(x, \varepsilon_k) \geq U_i(q, \varepsilon_i) + \delta \sum_{k=1}^{2} p_{ki} V_{i,t+1}(q, \varepsilon_k).$$

This requirement, which is stricter than sequential rationality when $n > 2$, rules out equilibria where players accept a proposal they do not like, for the simple reason that a single rejection does not affect the voting outcome (see Baron and Kalai, 1993). The acceptance set is then defined as

$$A_t(q, \varepsilon_i) = \{x \in X : |\{i \text{ accepts } x\}| \geq (n+1)/2\}.$$

Denote by r_t^i a policy at time t under the shock ε_i. Note that the proposal made by the agenda setter concerns only the current period. However, in order to accept or reject the proposal, members implicitly compare two sequences of policies, where future policies are derived by using the proposal rule.

Lemma 1. *Suppose $T \leq \infty$. Let $\{\widetilde{r}_s^1, \widetilde{r}_s^2\}_{s=t}^T$ and $\{\widehat{r}_s^1, \widehat{r}_s^2\}_{s=t}^T$ be two arbitrary policy sequences starting from an arbitrary t . The difference between the utilities associated with these two sequences is a monotone function of $r_i(\varepsilon_1)$.*

Proof: Without any loss of generality, suppose that the current shock is ε_1. Write the utility associated with the sequence $\{\widetilde{r}_s^1, \widetilde{r}_s^2\}_{s=t}^\infty$,

$$\begin{aligned} & U_i(\widetilde{r}_s^1, \varepsilon_1) + \delta p_{11} U_i(\widetilde{r}_{s+1}^1, \varepsilon_1) + \delta p_{21} U_i(\widetilde{r}_{s+1}^2, \varepsilon_2) + \dots \\ = \quad & -(\widetilde{r}_s^1 - r_i(\varepsilon_1))^2 + \delta p_{11}(\widetilde{r}_{s+1}^1 - r_i(\varepsilon_1))^2 + \delta p_{21}(\widetilde{r}_{s+1}^2 - b)^2 + \dots, \end{aligned}$$

and with the alternative sequence $\{\widehat{r}_s^1, \widehat{r}_s^2\}_{s=t}^\infty$,

$$\begin{aligned} & U_i(\widehat{r}_s^1, \varepsilon_1) + \delta p_{11} U_i(\widehat{r}_{s+1}^1, \varepsilon_1) + \delta p_{21} U_i(\widehat{r}_{s+1}^2, \varepsilon_2) + \dots \\ = \quad & -(\widehat{r}_s^1 - r_i(\varepsilon_1))^2 + \delta p_{11}(\widehat{r}_{s+1}^1 - r_i(\varepsilon_1))^2 + \delta p_{21}(\widehat{r}_{s+1}^2 - b)^2 + \dots. \end{aligned}$$

Compute the derivative of the difference of these two utilities with respect to $r_i(\varepsilon_1)$, which is given by

$$2\left(\widehat{r}_s^1 - \widetilde{r}_s^1\right) + 2\delta p_{11}(\widehat{r}_{s+1}^1 - \widetilde{r}_{s+1}^1) + \ldots.$$

Since the derivative does not depend on $r_i(\varepsilon_1)$, the difference in utility among any two sequences is monotone in $r_i(\varepsilon_1)$. ■

The useful corollary follows.

Corollary 1. *A proposal is accepted if and only if it is accepted by the median.*

Since the chairman only needs the approval of the median to pass a proposal and the preferences of the other members do not matter, then a committee with $n+1$ members is equivalent to a two-person committee with the chairman and the median as the only policy makers.

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Figure 1: Monetary Policy Decisions

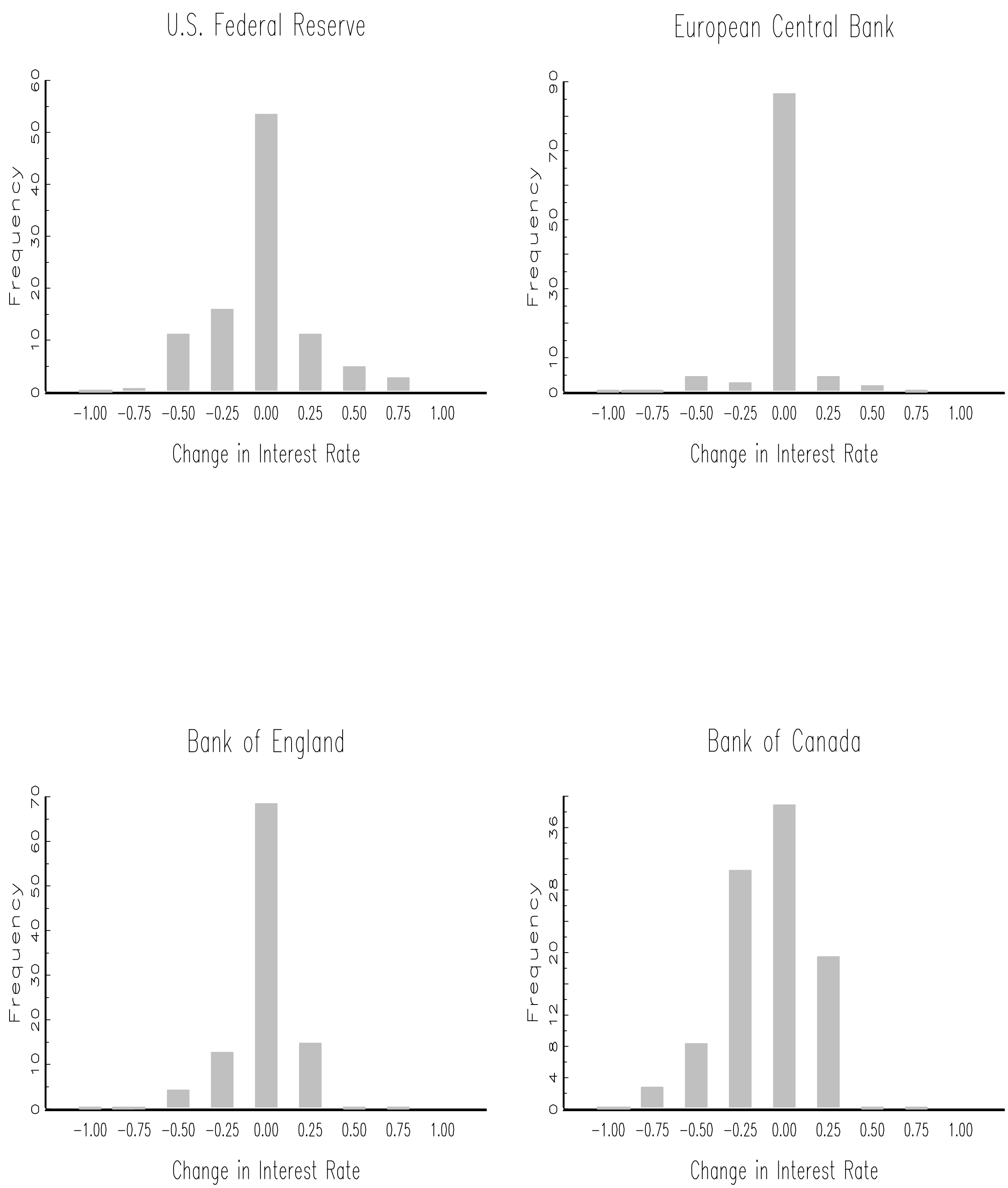

Figure 2: Policy Rules for Two-State Model

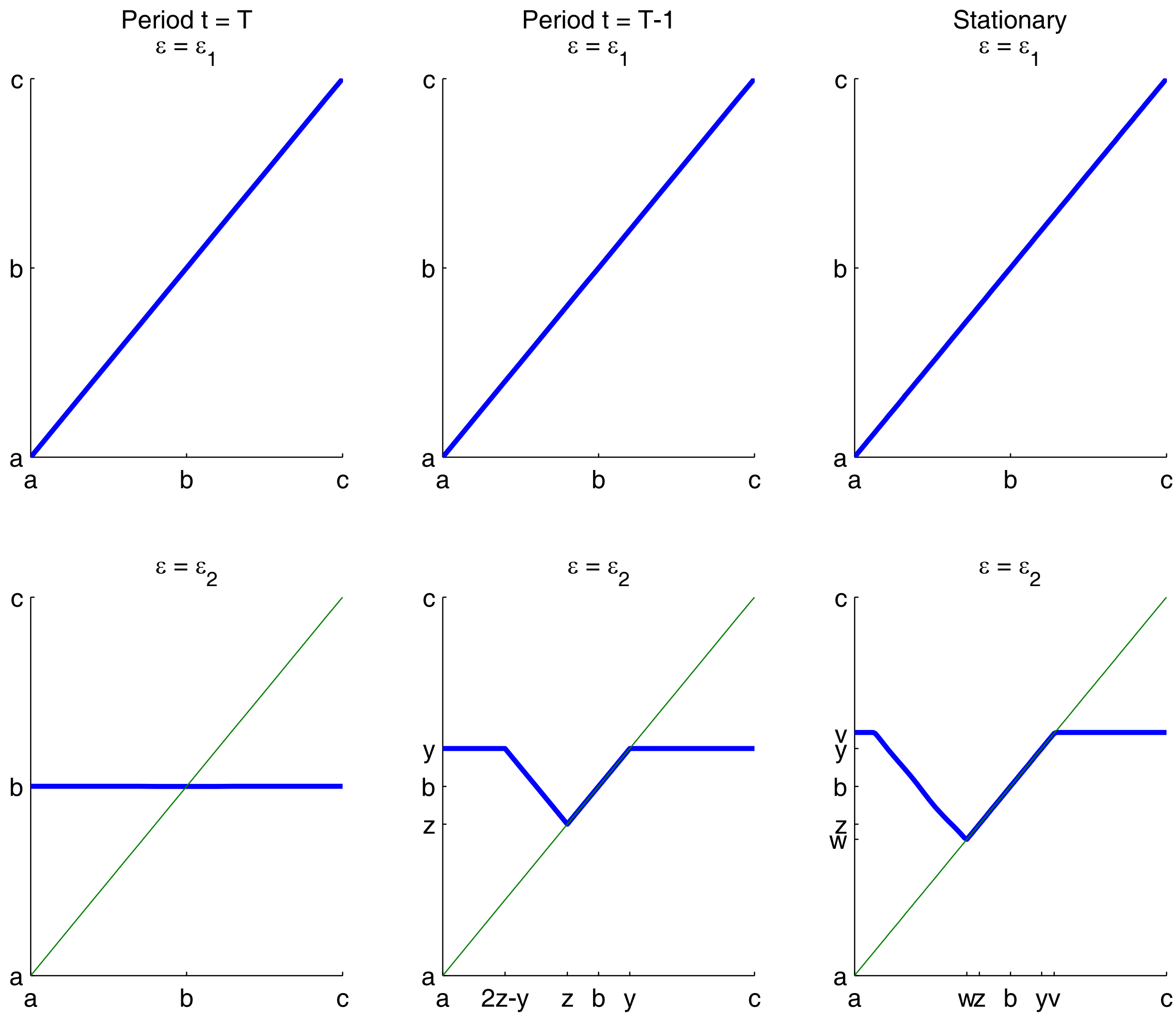

Figure 3: Stationary Policy Rules for Six-State Model

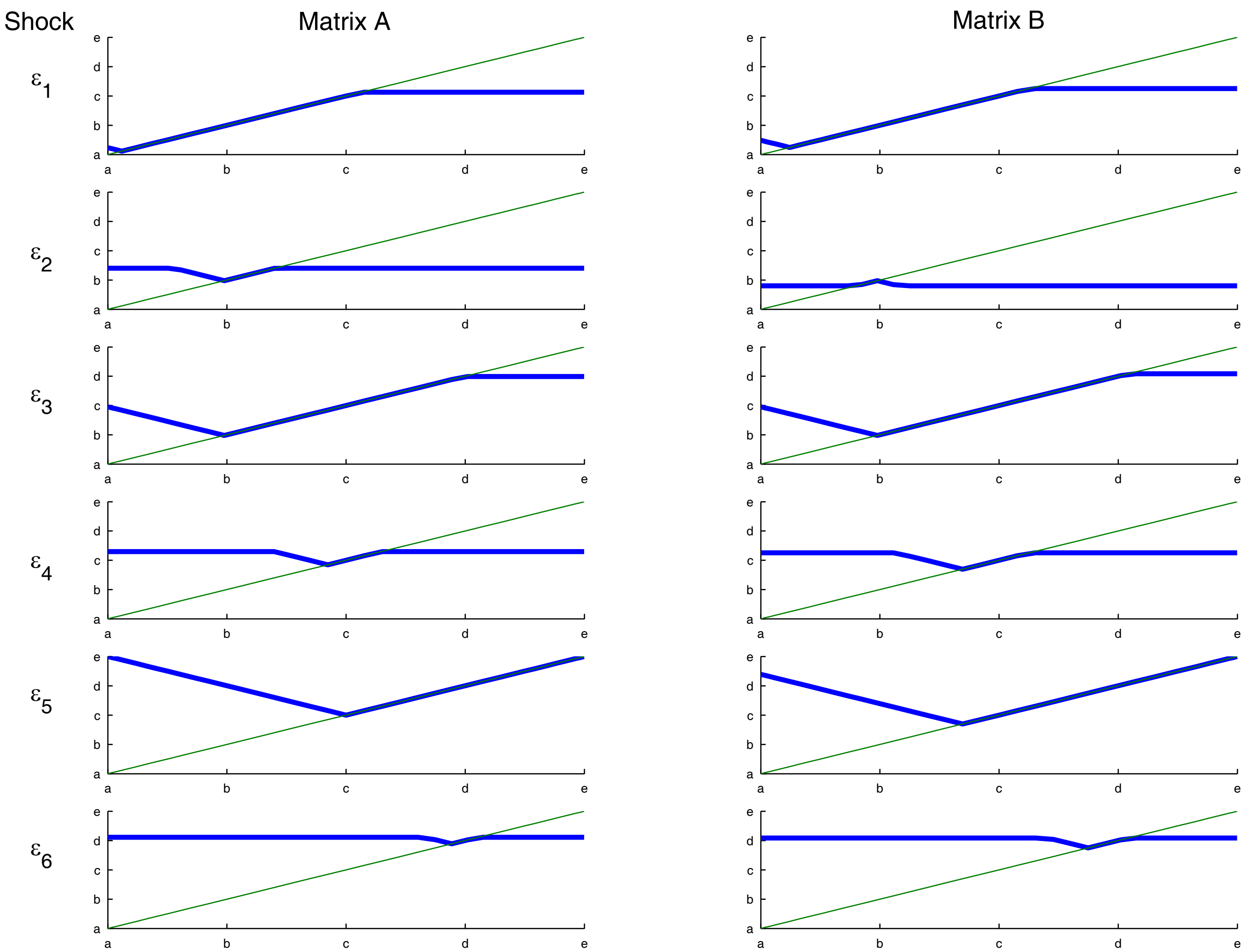

Figure 4: Simulations

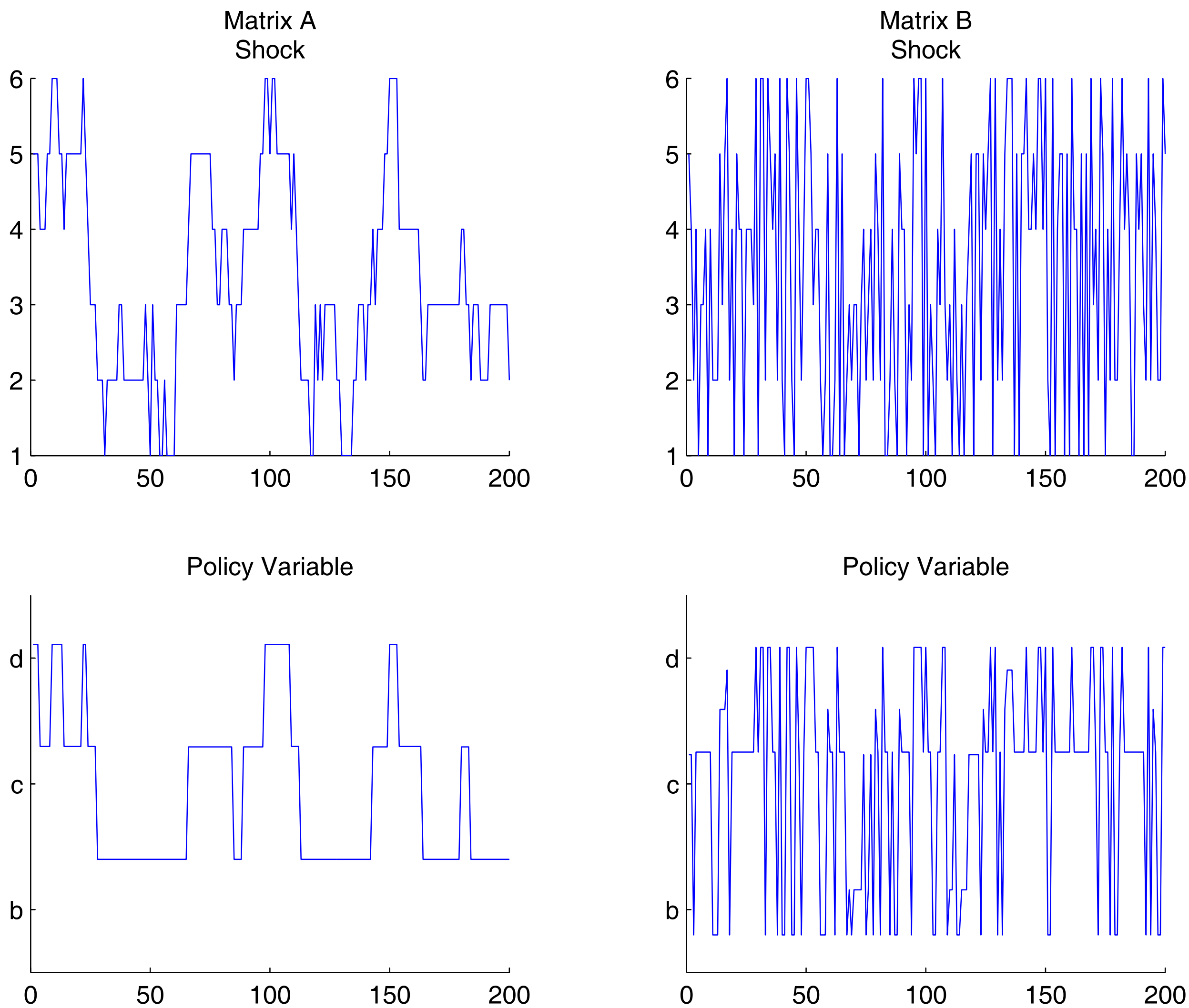

Figure 5: Histograms

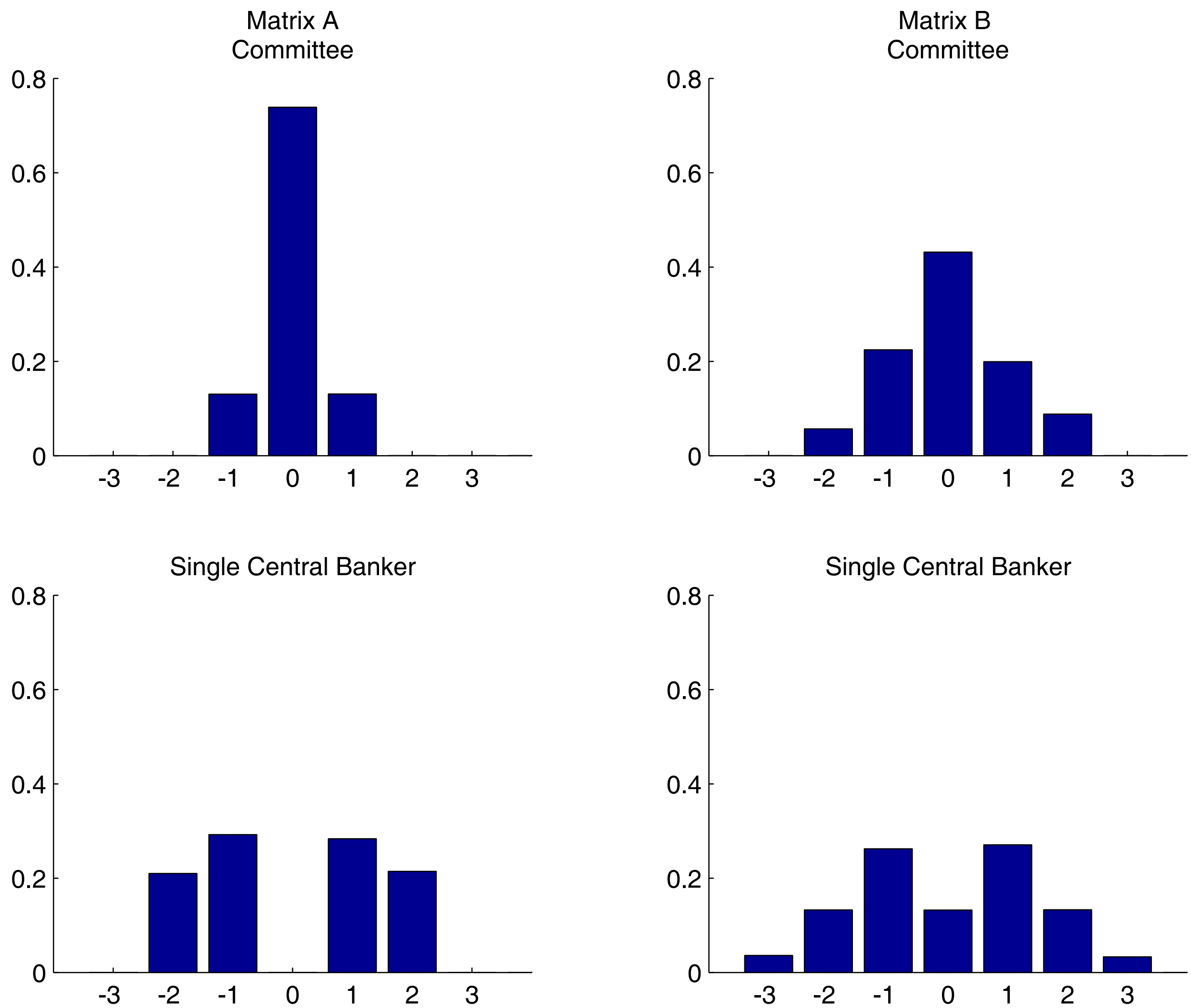

Figure 6: Autocorrelation Functions

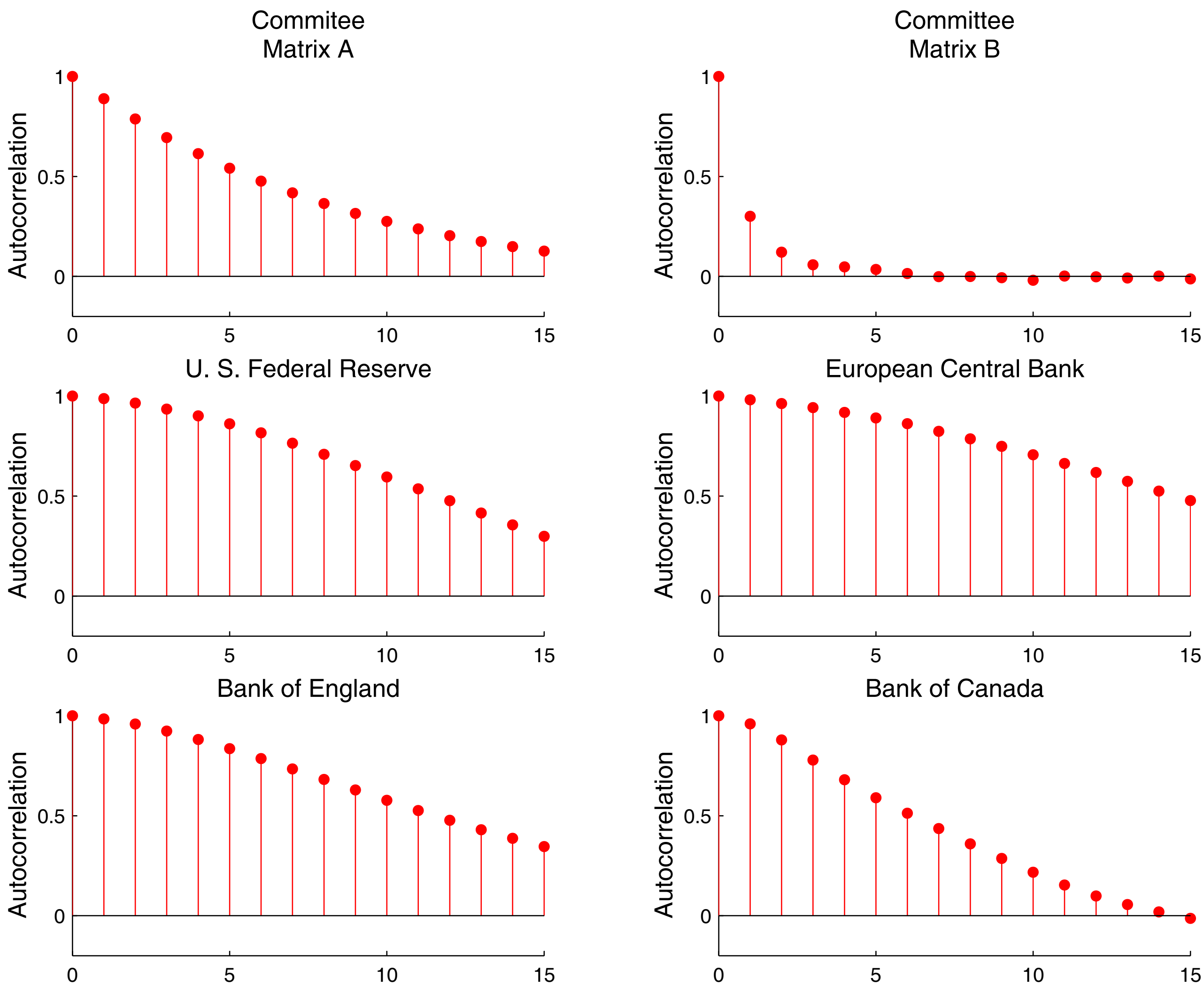

Figure 7: Stationary Policy Rules when Default is Fixed