Whom can we trust to run the Fed?
Theoretical support for the founders' views

Jon Faust

Aug. 1991
(revised May 19, 1992)

The author is an economist in the International Finance Division of the Federal Reserve Board.

I thank Mark Carey, Neil Ericsson, Joe Gagnon, David Gordon, Dale Henderson, Jaime Marquez and workshop participants in the Division of International Finance for useful comments.

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Stop 24
International Finance Division
Board of Governors of the Federal Reserve System
Washington, D.C. 20551
(202) 452-2328

Abstract

The Federal Reserve Act erected a unique structure of government decisionmaking, independent with elaborate rules balancing internal power. Historical evidence suggests that this outcome was a response to public conflict over inflation's redistributive powers. This paper documents and formalizes this argument: in the face of conflict over redistributive inflation, policy by majority can lead to policy that is worse, even for the majority, than obvious alternatives. The bargaining solution of an independent board with properly balanced interests leads to a better outcome. Technically, this paper extends earlier work in making policy preferences endogenous and in extending the notion of equilibrium policy to such a world. Substantively, this work provides a simple grounding of policy preferences—largely missing heretofore—linking game theoretic models of policy to historical evidence about the formation of an independent monetary authority.

By any standard, the Federal Reserve Act erected a unique structure of governmental decisionmaking—others have preferred the descriptions "uniquely confusing" or "bizarre."[1] It is largely independent from direct government input and administered by people chosen under varied and elaborate rules. In trying to evaluate a formal theory of monetary policymaking, a statistician's intuition tells us that the Fed's unique structure may have great explanatory power: theories that account for this peculiar outcome meet a stringent standard.

In this paper, I rationalize the form of the Fed in a model of conflict over the redistributive effects of inflation. The theory is distilled from arguments by and among the framers of the Federal Reserve System, and is motivated by evidence on the large role inflation politics played in the U.S. prior to the Fed's founding. The basic argument is that, in the face of conflict over redistributive inflation, monetary policy by majority might well lead to policy that is worse—even for the majority—than obvious alternatives. U.S. economic policy under the Articles of Confederation arguably illustrates this result. A better outcome may result from turning monetary policy over to a small group of people chosen to balance the interests for and against inflation. Intuitively, the framers of the Fed hoped that policy chosen in balanced negotiation would dominate more democratic policy.

Three interrelated features of this work bear emphasis. First, the theory is premised on the view that conflict exists in society over proper policy. If this premise is correct, any attempt to explain policy outcomes surely must take account both of the conflict and of the institutions that have arisen to deal with it. In studying conflict, this paper builds on earlier work under the heading of the "partisan theory" of monetary policymaking (for example, Alesina [1987], Alesina and Sachs [1988], Alesina and Tabellini [1987a,b], Havrilesky [1987], Hibbs [1977, 1987]).

Second, the theory treats policy preferences explicitly. Policy preferences arise endogenously as the result of agents' market decisions. The preferences are motivated simply—each group wants to maximize its wealth—and are grounded in

[1] See Kane [1982] and Melton [1985], respectively.

historical evidence. This approach stands in contrast, for example, with a vast literature that relies on an exogenously specified preference for inflation surprises.[2] The source of this preference for surprises is not made explicit and the associated stories often rely on complex accounts of distortions in unmodelled aspects of the economy. Such limitations make it difficult to assess the plausibility of results and impossible to assess how the derivation might change under different economic arrangements and institutional structures.

Third, the theory of this paper emphasizes institutions. Explicit constraints on possible institutional arrangements are examined, and important features of the Fed are rationalized.[3] Since real world economic institutions have arisen endogenously, failure to consider the institutions that have evolved gives rise to serious questions about the relevance of theoretical work on the policy process. In short, if a model cannot rationalize the broad features of institutions that have evolved, one is left to wonder whether some important feature of reality has been missed in the model.

The primary technical innovation in the paper involves the modelling of conflict, which requires extending the notion of competitive equilibrium with endogenously determined policy. Following Chari and Kehoe [1990], who consider a representative agent world, I provide an equilibrium concept that allows policy to be chosen at different times to maximize the welfare of an endogenously changing sub-group of agents. This concept is required, for example, to study policy by majority which involves policy chosen at each point in time to maximize the welfare of the current, endogenously determined, voting majority.

Section 1 provides a historical backdrop for the model. The basic model is presented in section 2. Sections 3 and 4 consider policy by majority and policy by board, respectively, and section 5 concludes.

[2] As the reviews by Rogoff [1987] and Blackburn and Christensen [1989] note, most formal work on monetary policymaking rests on such a formulation.

[3] This approach was also followed by O'Flaherty [1985], who laid out constraints with implications for the optimal office term for policymakers.

1 A selective history of the framing of the Fed

After the banking panic of 1907, most interested groups realized that some legislation would be enacted with the primary purpose of providing an elastic currency. Although this might have seemed a narrow, technical goal, the framing of the legislation involved a political struggle over who could be trusted to exercise the associated money creation powers. The legislative aspects of this struggle were resolved with the passage of the Federal Reserve Act in 1913, and the Banking Acts of 1933 and 1935, which brought the Fed essentially to its current form. This paper focuses on two important features of the structure created to control monetary power: independence from external input and internally balanced interests.

While the nature and extent of Federal Reserve independence has been much discussed, it is the internal power structure that is unique. By the 1930s, it was clear that the key personnel were the governors and the presidents of the Reserve Banks, who together form the Federal Open Market Committee (FOMC).[4] There are 12 votes (an even number) on the FOMC: five presidents vote on a rotating basis; always voting are the president of the New York Fed and either the Chicago or Cleveland Federal Reserve Bank president. The Reserve Bank presidents are nominated by the boards of their respective banks and confirmed by the Federal Reserve Board. The nominating boards are composed of 9 directors, 6 chosen by district bankers (3 representing district bankers and 3 representing general district interests), and 3 chosen by the Federal Reserve Board. The seven governors are nominated by the President of the U.S. with due regard to a fair representation of the financial, agricultural, industrial, and commercial interests. No two governors can come from one Federal Reserve district.

Obviously, Fed legislation pays great attention to balancing voting interests. What follows is a sketch of the evidence indicating that this outcome arose from a need to balance the forces contending for control of inflation's redistributive power.

[4] The FOMC was codified in the Banking Acts of 1933 and 1935. A more complete statement of the relevant regulations can be found in Board of Governors [1990].

The argument for independence is not intended to be novel except, perhaps, in its relative emphasis of redistribution over other issues of policy manipulation.[5] Rather than providing full-blown historical argument, this section gives some highlights of the evidence as motivation for the theoretical work.

1.1 Conflict between nominal debtors and creditors

Ignoring the internal structure of the Fed, it seems reasonable to suppose that the Fed was made independent to insulate policy from electoral manipulation. This danger was certainly understood by the framers.[6] While much recent work has focused on this problem between voters and their political agents, such principal-agent issues cannot explain why the Fed was made largely independent not only of the political agents, but of their principals as well.[7]

The reason the Fed was insulated from direct public as well as governmental input can be understood by noting that many framers were not only concerned about principal-agent problems, they were also concerned that politicians would be *too* responsive to the public. As Paul Warburg [1930, p.780] put it,[8]

> [A] large number of our political leaders might prefer that the Federal Reserve System be subservient rather than independent. They want open doors for patronage and a ready compliance with the wishes of their constituents.

In particular, a fear of popular demands for redistributive inflation led certain framers to prefer an independent Fed. J. Laurence Laughlin [1933, p.218] argued,[9] "[P]oliticians find it easy to appeal to the underlying prejudice in favor of inflation

[5] This view was distilled from a number of histories of the Fed cited throughout. Notice that this is not an argument about why the Fed was formed; rather, it is an argument about the institutional form chosen, given that monetary power was to be granted to the institution.

[6] Sen. Nelson Aldrich [Kettl, 1986, p.21], for example, argued that the government might use policy to "insure the success of a political party."

[7] For example, Congress could have mandated great openness in the monetary policy process—the U.S. already had history of mandating openness in public decision making. In reality bankers got a direct forum for input into Board decisions, the Federal Advisory Committee, but the public got none.

[8] Warburg was an influential participant in the framing process and an original governor.

[9] Laughlin was a noted monetary economist heavily involved in the framing process.

in order to raise prices, or to lift the burden of debt." Senator Aldrich [Kettl, 1986, p.21] contended, "No government has yet been found strong enough to resist the pressure for enlarged issue in times of real or imagined stress."

While recent discussions of political policymaking have largely ignored inflation's redistributive effect, the popular demand for inflationary debt relief (or relief in some other form) has always been an important part of democracy in America. Murray Wildman [1905, p.65] studied this issue just prior to the founding of the Fed. He drew the following conclusion about U.S. inflation policy under the Articles of Confederation,[10] "[T]aking advantage of a form of government which they were in a measure able to control they sought to accomplish a redistribution of wealth by the convenient and effective resort to a depreciated currency." John Marshall[11] claimed that this "mischief" threatened the existence of credit, and James Madison [*The Federalist*, No. 44] cited this as the basis of certain Article I section 10 restrictions in the U.S. Constitution.[12]

The struggle over inflation was never more evident than in the free silver debates of the late 1800s. Creditors viewed with alarm the free silver argument that by remonetizing silver "[y]ou increase the value of all property by adding to the number of money units in the land. You make it possible for the debtor to pay his debts..."[13] The debtors, for their part, saw the end of free coinage of silver as the "crime of 73," pushed through by the "money power," selling out rural mortgage holders in order to push up the value of outstanding bonds.[14] While the pro-silver forces ultimately failed, Friedman and Schwarz [1963] argue that the fluctuating political prospects of the free silver forces were a major factor disrupting international capital flows during the 1890s.

Some may find it difficult to reconcile this fear of inflation on the part of the Fed's framers with the fact that the U.S. was on a gold standard at the time of founding.

[10] The period between the American Revolution and the adoption of the Constitution.

[11] See, e.g., 12 Wheat. 213 p.354, and Wildman [1905].

[12] e.g., the prohibition of bills of credit and of laws impairing the obligation of contracts.

[13] William Harvey [1963, p.175] wrote this in a popular and influential 1894 tract.

[14] Harvey [1963], for example, makes the argument regarding bond holders. See Friedman [1990] for a richer account of this period.

As the views of Aldrich and Laughlin evidence, however, the gold standard was not seen as an unshakeable anchor. It is not hard to see the reason for this skepticism.[15] The U.S. was off the gold standard from the Civil War until 1879, and the free silver forces nearly took the U.S. off again in the 1890s. Even under the standard, the ratios of monetary gold to money and high powered money varied by a factor of 2 between 1879 and 1914 [Briggs, et. al., 1988]. Between 1914 and 1935, the restraining force of the international gold standard was further eroded by suspension of foreign shipments of gold during World War I and outright suspension of convertibility in 1933.

In the wake of the free silver debates, the Fed was formed with a deliberate emphasis on balancing the pro-inflation and anti-inflation forces. In a summary of proposals extant in 1912 prepared for Carter Glass's Banking committee, Willis [1923, p.125] wrote, "[T]he desirable thing in any such organization is to assure as nearly as possible equality of representation and to prevent the possibility ...of diversion of capital in favor of any interest or section ...." Warburg wrote [1930, p.773] that a "formula had to be found by means of which these two elements [big business and politicians] would be called upon to balance one another." No one claims that all parties to the process fully understood the issues involved and participated in the formulation of an optimal balance. Rather, the contending parties struggled for control, and a mutually acceptable balance was adopted.[16]

1.2 Formalizing the arguments

This paper formalizes these arguments in a model with a nominally wealthy class and a larger working class. Policy by majority is likely to (though does not necessarily) result in excessive inflation, inflation that makes everyone worse off than under obvious alternative policies. The explanation for this parallels that in the time consistency literature [e.g., Barro and Gordon, 1983]. Although inflation is costly,

[15] Briggs, et. al., [1988] survey the role of the gold standard during this period.

[16] Clearly, the framers hoped that Fed policymakers would not simply vote their own interests. Just as clearly, however, they knew that policymakers from different groups would have different views of the best interests of the country.

the working class wants to inflate away the wealth of the rich so long as the marginal benefit from redistribution exceeds the marginal inflation cost. Everyone is aware of this, so the expected rate of inflation in equilibrium is the rate at which the benefit from further inflation to the masses is just offset by the cost. Because this inflation rate is fully expected, the workers get no benefit from redistribution, but everyone suffers the cost associated with equilibrium inflation.

An *ad hoc* solution in this model is to hand policy over to a board with balanced interests, that is, composed of one wealthy person and one worker. In game theoretic terms, the central claim can be put as follows: the outcome of a bargaining process by a board with properly balanced interests is likely to be preferred to that of the anonymous voting game with unbalanced interests.

The claim that the Fed's framers saw the problem as characterized in this game-theoretic framework may seem highly implausible. I believe, however, that some of the framers viewed the essence of the problem very much like the modern game theorist. Paul Warburg probably had the clearest vision in this regard [1930, p.501–502]:

> There are millions of individual enterprises apparently self-centered and independent, but, as a matter of fact, all dependent upon one another.... There is not one which, by exaggerating the single and selfish point of view, might not do harm to others and affect the well-being of the whole. Whenever the fair middle course, essential for the greatest prosperity and comfort of all, cannot be established and adhered to by common understanding between contending parties, the government has to step in as a regulating factor.

This and other writings suggest that Warburg was quite close to the modern statement: when strategically linked, agents' self-interested action can lead to Pareto inefficient outcomes. The agents may have difficulty coordinating a more desirable outcome, suggesting that government action may be desirable.

2 The model

The basic structure is a standard overlapping generations model. This model is chosen because it has many of the textbook features of a monetary economy and because it is one of the few models that has a redistributive role for inflation. The model studied here has two-period people; a single asset, money; and no uncertainty. The agents work when young. They use their earnings to finance consumption when young and to acquire money, which enables them to purchase consumption when old. Thus, the old form a nominally wealthy class and the young a working class.

While in practice the nominally wealthy tend to be older and nominal debtors (e.g., mortgage holders) tend to be younger, I do not want to make too much of the generational aspect of the model or of the fact that money is the only nominal asset. What is crucial is 1) that some form of nominal commitments span the points in time when monetary policy is determined, and 2) that the winners and losers from inflation are not equal in number. The overlapping generations model provides a model with these features that has become well-understood in the three-and-a-half decades since Samuelson's [1958] original contribution.

2.1 The basic structure

The following assumptions define the basic model. With the exception of endogenous policy determination, the only nonstandard assumption is the inflation cost, A7, discussed below.

A 1 *Events take place at discrete time intervals,* $t = 0, 1, 2, \ldots$

A 2 *Each agent lives two periods. Each member of the generation born at* t *seeks to maximize:*

$$U = \ln(c_{y,t}) + \delta \ln(c_{o,t+1}) \quad 0 < \delta < 1$$

where c *is consumption with indices indicating whether the consumption is by a (y)oung or (o)ld person and the date at which consumption occurs.*[17]

While logarithmic utility is expositionally convenient, the basic character of the results requires only mild restrictions on preferences.

[17] For the generation old at time zero, c_y is given exogenously.

A 3 *Each young person supplies labor inelastically for a fixed commodity wage, w, that cannot be stored.* [18]

A 4 *The population of agents old at t is given by*

$$N_t = (1+x)^t N_0 \qquad N_0 > 0, \ -1 < x, \quad x \neq 0$$

Unless otherwise noted, the discussion of the model assumes the leading case of positive population growth. In this case, the working class is larger than the wealthy class and dominates elections. The formal results, however, cover both positive and negative growth.

A 5 *Money is a durable substance that cannot be consumed. The total stock of money at any time is M_t; the money stock grows between t and $t+1$ at rate z_t. Any addition to the money stock between period t and $t+1$ is distributed in equal shares to the old at $t+1$ before any trading occurs.*[19]

Per capita real and nominal money stock variables will be measured after any transfers and trades in the indexed period and *per member of the old generation.* The per capita nominal money stock, $m_t = M_t/N_t$, is such a variable.

A 6 *At $t = 0$, each old person holds $m_0 = M_0/N_0 > 0$ units of money.*

A 7 *The young and old at t each pay $\Phi(z_t) = \phi z_t^2$, $\phi > 0$, in real terms for the growth in the money stock. The money growth rate, z_t, satisfies the resource constraint $(2+x)/(1+x)\Phi(z_t) \leq w$, and the minimum feasible z is greater than -1.*

The most narrow interpretation of this assumption is as a cost of money creation and distribution (or collection and destruction). A more general interpretation is as a real cost of inflation and deflation. While formally generating such a cost in a rich way is difficult, I believe any sensible model would involve such a cost at some finite level of growth. In this model, the cost can be arbitrarily small over a large range of money growth near zero without affecting the results.[20]

[18] If the wage were paid in nominal terms, then the results of the paper would require that the agents trade off the benefits of redistribution against any loss in the value of wages.

[19] In a model with richer inter-temporal contracting, one would have to motivate the existence of nominal contracts—an ambitious task avoided here.

[20] The proofs minimally require only that $\Phi(0) = \Phi'(0) = 0$, that $\Phi(z)$ and $\Phi'(z)$ rise with $|z|$, and that there is a minimum and maximum feasible growth rate.

2.2 Exogenous constant money growth equilibria

The goal of the paper is to illustrate the likely outcomes of a number of monetary policy formation structures. Thus, I do not catalog all possible equilibria of the model, instead focussing on stationary equilibria.[21] The equilibria discussed are probably the simplest ones illustrating the issues at hand, and, while any remaining equilibria are probably less plausible, I believe many would show the essential features discussed here.

Defining p_t as the money price for exchange between the young and old at t, competitive equilibrium is,

Definition 1 *An equilibrium is a sequence of consumption pairs $\{c_{y,t}, c_{o,t+1}\}$; money stocks, $\{m_t\}$; and prices, $\{p_t\}$ that are all non-negative and that together are solutions for each $t = 0, 1, 2, \ldots$ osf*[22]

$$\max_{m_t^d, c_{y,t}, c_{o,t+1}} \ln(c_{y,t}) + \delta \ln(c_{o,t+1}) \tag{1}$$

subject to

$$\begin{aligned} w &= c_{y,t} + \frac{m_t^d}{p_t} + \Phi(z_t) & (2) \\ \frac{m_t^d}{p_{t+1}} + \frac{z_t M_t}{N_{t+1} p_{t+1}} &= c_{o,t+1} + \Phi(z_{t+1}) & (3) \end{aligned}$$

and that also satisfy the aggregate resource and money supply constraints:

$$\begin{aligned} w &= c_{y,t} + \Phi(z_t) + \frac{c_{o,t} + \Phi(z_t)}{1+x} & (4) \\ m_t^d &= m_t/(1+x) \end{aligned}$$

I characterize the stationary, constant money growth equilibria using an expression for equilibrium real balances in terms of current and future (but not past) variables. This function exploits the forward looking nature of the model: past inflation does not affect money's attractiveness.

[21] Thus, I ignore any sunspot or nonstationary equilibria of the model. This is not too tight a restriction in that all of the policy formation structures studied can achieve a Pareto optimal outcome. Thus, while I do not catalog all possible outcomes, the mechanisms could not achieve any outcomes that are unambiguously better.

[22] This formulation imposes symmetry and exploits sufficient conditions for an interior solution.

Start with the first order condition from (1),

$$p_{t+1}/p_t = \delta c_{y,t}/c_{o,t+1} \tag{5}$$

Define per capita real balances, $r_t = m_t/p_t$, and define the function giving equilibrium per capita real balances in terms of current and future variables, $R(z_t, z_{t+1}, r_{t+1})$. Substituting for consumption in (5) using the budget constraints and rearranging gives,

$$R(z_t, z_{t+1}, r_{t+1}) = \frac{\delta(1+x)(w - \Phi(z_t))}{(1+z_t)(1-\Phi(z_{t+1})r_{t+1}^{-1}) + \delta} \tag{6}$$

which reveals how real balances must evolve in any interior equilibrium of the model.[23] The unique constant level of real balances, $\bar{R}(z^*)$, associated with constant money growth, z^*, is then,

$$\bar{R}(z^*) = \frac{\delta(1+x)(w - \Phi(z^*)) + (1+z^*)\Phi(z^*)}{1+z^*+\delta} \tag{7}$$

This equation has some expected properties, noting that real balances are savings for the future. More rapid discounting of the future lowers real balances; higher population (and, hence, output) growth raises real balances. The effect of money growth, however, is ambiguous:

$$\frac{\partial \bar{R}(z^*)}{\partial z} = \frac{(1+z^* - \delta(1+x))\Phi'(z^*) - (\bar{R}(z^*) - \Phi(z^*))}{1+z^*+\delta}$$

where $\Phi'(z) = 2\phi z$. When money growth is costless, raising money growth lowers real balances—money is less attractive in an inflationary environment. With a money growth cost, the result is ambiguous: raising money growth may raise real balances, since the old need more balances with which to pay for money growth. The only sensible specification of the model has a cost of money production that, at low rates of money growth, does not dominate the decision problem. The specification here satisfies this restriction, since $\Phi(0) = 0$ and $\Phi'(0) = 0$.

[23] The qualifier *interior* is used because this function need not satisfy $R(z_t, ., .) > \Phi(z_t)$ which is required if the consumption of the old is to be non-negative. This condition is met in all the equilibria discussed in this paper.

Given the real balance function, the budget constraints imply that,

$$\bar{c}_y(z^*) = w - \frac{\bar{R}(z^*)}{1+x} - \Phi(z^*) \tag{8}$$

$$\bar{c}_o(z^*) = \bar{R}(z^*) - \Phi(z^*) \tag{9}$$

The constant growth equilibria, then, are summarized in

Proposition 1 *For every feasible rate of money growth, z^*, there is a constant money growth equilibrium characterized by real balances as defined in (7) and consumption given by (8) and (9).*

Proof: By construction, the solution satisfies the constraints and the first order condition. The second order condition is easily verified in this case. Q.E.D.

As a benchmark for assessing endogenously selected policy outcomes, it is useful to ask which exogenous rate of money growth would be chosen by a benevolent policymaker. That is, what policy would be chosen by a policymaker who could commit to a sequence of money growth rates at the beginning of time? The answer can be seen in,

Proposition 2 *In constant money growth equilibria,*

i) For all but the initial old, equilibrium utility falls monotonically as money growth rises or falls from zero.

ii) For the initial old, utility falls monotonically as money growth rises from zero. Utility initially rises and ultimately falls as money growth is lowered from zero.

Proof: See Appendix.

An informal argument for the proposition goes as follows. The $z^* = 0$ equilibrium equates the real return on money, minus the inflation rate, with the rate of output growth in the economy. This is best for all but the initial old, who face no intertemporal decision. Any increase or decrease in inflation both raises money growth costs and worsens the intertemporal allocation. In contrast, the initial old would, but for the money growth cost, uniformly prefer greater deflation, which raises real balances. At some point, however, the money growth cost overwhelms the benefit of higher real balances, making more deflation unattractive.[24]

[24] Note that only the zero money growth equilibrium is Pareto optimal. Given the fact that the money growth cost is pure loss, any allocation involving $z \neq 0$ can be improved by creating no money. Such allocations cannot be achieved through the market.

Assuming that the benevolent policymaker's options are limited to setting z^*, the policymaker would choose a policy under which it impossible to improve everyone's utility. She would pick money growth rate somewhere between zero and the negative rate that maximizes utility of the initial old.

3 Equilibria with endogenous policy by majority vote

This section describes which constant inflation equilibria can be supported by majority vote. The central result is that the workers may choose positive money growth, making everyone worse off than under zero money growth. As noted above, this is because the expected rate of inflation must be high enough that the marginal benefit to the workers of surprise inflation is offset by the marginal money growth cost.

Some aspects of the problem studied below have been explored before. Loewy, for example, has considered policy in an overlapping generations model chosen by either the old [1988a] or the young [1988b]. Loewy's work differs from mine in two respects: first, I add a money growth cost, which confronts voters with a much richer tradeoff, keeping the young from preferring the unrealistic policy of infinite inflation. Second, dynamic expectational linkages across generations, a crucial issue below, were not part of Loewy's work.

The work here shares much with Chari and Kehoe's [1990] work on sustainable plans. In both, policy is chosen endogenously to maximize the welfare of certain agents. The optimal policy in both approaches is subject to a similar perfect equilibrium interpretation. Further, both approaches assume that policy is determined in a strategic game while market decisions proceed in a competitive manner taking the expected sequence of policies as given. The primary difference in the approaches is that in their model policy is chosen to maximize welfare of a representative agent, while policy here is chosen at each point in time to maximize the welfare of an endogenously chosen sub-group—a voting majority or board. This generalization is central to the study of policy conflict.

3.1 Definition of a voting equilibrium

Democratic policy is chosen according to

A 8 *Before any trading takes place in period t, the agents vote on the money growth rate z_t. The growth rate receiving the most votes is implemented.*

The primary difficulty in defining a voting equilibrium is that future votes might be affected by the votes taken today. For example, if one young generation votes for high inflation, leading to very low consumption for the old, there are a number of reasons to expect that the next young generation might also vote for high inflation—the societal consensus for low inflation or for treating the old *fairly* might have broken down. Thus, analyzing what it is rational for voters to do today will require an explicit treatment of their expectations regarding future voting behavior.

For the results to be of interest, it is necessary that the expectations attributed to people be reasonable. I impose the rational expectations assumption that the expectations be right on average, which in this non-stochastic model implies they are always right. A stronger restriction is needed since equilibrium choices will be affected by voters' beliefs about what nasty thing might happen if some non-equilibrium choice were made. To rule out equilibrium behavior being determined by bizarre expectations about what might happen off the equilibrium path, I require that the behavior expected of future agents faced with earlier non-equilibrium decisions be consistent with rationality of those agents. This restriction falls under the heading of a *perfect equilibrium* constraint.[25]

Expectations regarding future voters are captured by two functions in this model. First are voting strategy functions that reveal what rates of money growth the young and old are expected to vote for at t given any sequence of votes that might have preceded. Defining the history of votes up to t as $Z_{t-1} = \{z_0, \ldots, z_{t-1}\}$, these

[25] For a discussion of sub-game perfection and other game theoretic solutions, as well as the associated limitations, see Kreps, 1990. The information structure here (the fact that voters do not know how each prior voter voted) as well as the maintained assumption of perfectly competitive behavior in markets complicates a simple perfect equilibrium interpretation in this model. Chari and Kehoe [1990] provide a detailed construction of the perfect equilibrium interpretation in a context similar to that here.

functions can be written, $z_{kt} = v_k(Z_{t-1})$, $k \in \{y, o\}$.[26] The need for a second function arises because the overlapping generations model has multiple equilibria, implying that voting behavior may not uniquely pick out an equilibrium. I assume that given the history, Z_{t-1}, and the selection of rate z_t at t, $E = V(Z_{t-1}, z_t)$ is the equilibrium that all agents expect to ensue from time t onward. A young majority at t is expected to enact the rate $v_y(Z_{t-1})$ and the economy is expected to follow the equilibrium $V(Z_{t-1}, v_y(Z_{t-1}))$ from t onward.

Finally, I assume agents optimize in the competitive market just as they did under exogenous policy. Since the act of voting does not directly enter the market decision problem of the agents, it is sensible to assume that people's behavior in the competitive market proceeds just as before, taking the expected sequence of policy as given. Thus, voting equilibrium must satisfy the requirements of any competitive equilibrium, and the voting equilibria are a subset of the competitive equilibria.

Now specify $W_y(E)$ to be the lifetime utility of the first full generation in competitive equilibrium E. $W_o(E)$ is the utility of the initial old in the same equilibrium. We can now state,

Definition 2 *A voting equilibrium is given by a competitive equilibrium E^*, with constant growth z^*, and voting and expectation functions v_k^* and V^* that satisfy*
i) for all t

$$E^* = V(Z_{t-1}^*, v_k^*(Z_{t-1}^*)) \tag{10}$$

where Z_{t-1}^* is a history of strictly z^* growth rates, and that satisfy
ii) for all t and Z_{t-1}

$$W_k(V^*(Z_{t-1}, v_k(z^*))) = \max_{z_t} W_k(V^*(Z_{t-1}, z_t)) \tag{11}$$

where W_k and v_k are the welfare and voting functions for the young if $x > 0$, and for the old if $x < 0$.

The first condition requires that the z^* equilibrium be expected so long as no majority has deviated from z^*, and the second requires that the majority generation gets higher utility voting as expected (consistent with v_k^*) than by voting for any other rate.

[26] For simplicity, I only consider non-random strategies in which voters condition only on past monetary growth rates. Given the equilibrium function $V(.)$, Z_{t-1} is a summary statistic for all observable variables except the distribution of votes.

3.2 Unconditional voting: the majority picks bad policy

The simplest equilibrium is one in which no strategic behavior takes place: each majority unconditionally votes for the same growth rate, z^*. Thus for the majority, $v_k^*(Z_{t-1}) = z^*$ for all Z_{t-1}. The associated equilibrium is the constant money growth equilibrium if $z_t = z^*$. The only remaining thing to be defined is what equilibrium is expected to ensue if some majority votes for a non-z^* growth rate.

Suppose the current majority votes for $z_t \neq z^*$ at t. Since future generations are expected to choose z^*, the only stationary equilibrium involves all real variables returning to z^* equilibrium values at $t+1$. Thus, the only real effect of voting for z_t instead of z^* operates through time t money growth costs and real balances. Equation (6) reveals that time t real balances are

$$R(z_t, z^*, \bar{R}(z^*)) = \frac{\delta(1+x)(w - \Phi(z_t))}{(1+z_t)(1 - \Phi(z^*)\bar{R}(z^*)^{-1}) + \delta} \tag{12}$$

For any $z_t \neq z^*$, then, the expected equilibrium involves real balances given by (12) at t and $\bar{R}(z^*)$ thereafter.

To isolate what constant growth rate represents a voting equilibrium for the specified expectation functions, consider the utility of the young from choosing any growth rate, z_t at t,

$$\begin{aligned} W_l(V^*(Z_{t-1}, z_t)) &= \ln(c_y) + \delta \ln(\bar{c}_o(z^*)) \\ c_y &= w - \frac{R(z_t, z^*, \bar{R}(z^*))}{1+x} - \Phi(z_t) \end{aligned} \tag{13}$$

From (11), the equilibrium growth rate will be a z^* that maximizes this expression with respect to z_t. The first order condition for this problem is straightforward to interpret:

$$-(1+x)^{-1}\frac{\partial R(z_t, z^*, \bar{R}(z^*))}{\partial z_t}\Big|_{z_t=z^*} = \Phi'(z^*) \tag{14}$$

For the young at t, marginal benefit of shrinking the wealth (real balances) of the old at t must be just offset by the marginal cost of raising money growth. Notice that raising money growth from zero shrinks real balances of the old: $\partial R(z_t, 0, \bar{R}(0))/\partial z_t < 0$ for $z_t = z^* = 0$. This increases consumption for the young and has a money growth cost of $\Phi'(0) = 0$. At zero money growth, the young have an incentive to use surprise inflation. Thus,

Proposition 3 *For any population growth rate, there is a constant money growth voting equilibrium with unconditional voting strategies.*

i) With positive population growth, any unconditional equilibrium has higher money growth and lower lifetime utility for all generations than the zero money growth equilibrium.

ii) With negative population growth, any unconditional equilibrium has lower money growth and lower lifetime utility for all generations but the initial old than the zero money growth equilibrium.

Proof: See appendix.

The workers want to choose positive money growth in order to deflate the asset values of the financially wealthy. Because this incentive of the workers is fully recognized, the anticipated and actual rates of inflation are driven to a level where everyone is worse off than under the zero money growth equilibrium.

The fact that the young vote to make themselves worse off may seem to stem from the fact that every young majority ultimately suffers as an old minority. This is not a crucial feature. Quite to the contrary, the overlapping structure actually gives rise to the possibility of further good and bad equilibria: because the current young majority is ultimately an old minority, its inflationary tendencies can be tempered by the possibility of future inflation.[27]

3.3 A plethora of good and bad voting equilibria

Under positive population growth, any range of constant money growth between a negative lower bound and the positive rate preferred by the young in the previous section can be supported as a voting equilibrium. These equilibria require that future majorities be expected to condition their votes on past votes in a particular way. Call the growth rate chosen by the young in unconditional voting z^v, and consider some other constant rate, z^*. Suppose future workers are expected to behave in the

[27] Of course, under negative population growth, there is no way for the old majority's behavior to be affected by future votes: they die and are unaffected. Thus, the sort of equilibria examined in the next section is possible only under positive population growth.

following manner: if z^* has won the previous election, vote for z^*, otherwise, vote for z^v.[28]

Consider whether any generation would want to choose a different growth rate than z^*, given that no previous one has. The majority expects that majorities thereafter will vote for z^v, and the previous section showed that the current majority does best with z^v if all future majorities vote for z^v.[29] Thus, the young who do not vote for z^* can do no better than they do under the z^v equilibrium. By prop. 2, utility to the young falls monotonically in constant money growth equilibria as growth deviates from zero. Thus, there must be a range of constant growth equilibria with z^* between some $\tilde{z}^v < 0$ and z^v such that the young do better sticking with z^* than by precipitating a change to z^v. These results are summarized in

Proposition 4 *Under positive population growth, there exists a $\tilde{z}^v < 0$ such that any growth rate, $z^* \in [\tilde{z}^v, z^v]$ can be supported as a voting equilibrium.*

The equilibria with growth above zero are clearly bad equilibria in that there are exogenous policy outcomes in which everyone is better off. The equilibria with z^* less than zero are among the good equilibria in the sense that they are not Pareto dominated by any market solution.

3.4 Which equilibrium is likely to prevail?

Of all these voting equilibria, which ones involve expectations and strategies that are likely to surface in an economy populated with rational actors? I believe that society might have difficulty converging on one of the good equilibria. Providing a plausible account of how agents converge on one among many equilibria is always difficult. Explaining how agents in an anonymous voting game played over long periods of time with changing participants might converge on a good equilibrium is even more difficult. Achieving a good equilibrium requires that a majority of current

[28] To be explicit about V^* in this case, if all previous elections have gone for z^*, the constant z^* equilibrium prevails. If $z_t \neq z^*$, the stationary z^v equilibrium is expected to prevail from $t+1$ onward and real balances are $R(z_t, z^v, \bar{R}(z^v))$ in t.

[29] It is clear that future generations would find it rational to switch to z^v since an unconditional vote for z^v is an equilibrium.

voters somehow come to *correctly* believe that all future majorities have settled on the strategies leading to the same good equilibrium.

While such factors as communication, morals, conventions, and learned behavior might increase the chance of coordination on a good equilibrium, the strength of these factors in the case at hand are likely to be weak. For example, while social mores such as "do not make your parents miserable or you will be made miserable as parents," might help, the power of such principles in actual societies clearly fluctuates.[30] The forces to maintain the low inflation equilibrium are weak at best.

The problem with majority-determined policy, then, is not that good outcomes are impossible; rather, they require sufficiently sophisticated and coordinated voter behavior as to be unlikely. Unless such coordination came to pass, an economy might be expected to have periodic struggles resisting the redistributive urges, which is precisely what was common in the U.S. before the founding of the Fed. In such a situation, it is natural for the society to seek a better alternative.

4 Endogenous policy by independent, balanced board

The framers of the Fed attempted to improve upon policy by majority by creating an independent, balanced board. The essence of this solution can be formally illustrated in this model by considering policy by a board made up of one worker and one wealthy person. The resulting bargaining solution has two distinct advantages over policy by majority. First, the parties involved can negotiate (make offers and counter offers, for example) in a way that voting populations cannot. Second, because the interests have been balanced, it seems likely that the two policymakers will choose a money growth rate that splits the benefits to the old of deflation and the benefits to the young of inflation.

At a very general level, there is a strong presumption that the bargaining solution must be (weakly) better than majority policy. The wealthy member of the board could simply let the worker set policy, which would result in the preferred

[30] The 1960s come to mind.

policy of the workers being chosen, just as in the previous section. On the other hand, if the democratic equilibrium has positive money growth, any power exercised by the wealthy board member should pull the growth rate down. More formal demonstration of this result will require some added structure.

4.1 The constraints on available options

Initially, I specify a set of constraints on the legislative options available to society. Explicit consideration of these constraints is important in arguing that the independent board solution is of interest in the face of other possible solutions. For example, a zero money growth law in this model would solve the demonstrated problem. Indeed, in this and all other simple models of the policy process, optimal policies and any number of legislative solutions that—if feasible—would reach them are painfully obvious. To shed light on real world outcomes, the challenge is to characterize the general nature of constraints that might have generated those outcomes.

First, I assume that the society chooses only from among structures in which policymakers have discretion. In a richer (necessarily unsolvable) model, such a result might arise naturally if the complexity of the economic environment made codification of a satisfactory monetary rule too costly.

A 9 *Policymaking structures that determine money growth directly or that offer direct incentives for policymakers to choose particular growth rates are ruled out.*

It may seem that this discretion assumption simply rules out the most natural solution, some automatic rule for money growth. Indeed, at the time the Federal Reserve Act was passed many analysts probably favored some automatic policy rule anchored by the gold standard and the real bills doctrine. As noted in Section 1, however, these were not unshakable anchors. Further, during the 1920s and early 1930s, when important rules governing the Fed were formulated, the desirability of these anchors was widely questioned, and many key players came to view monetary policy as a discretionary art.[31] In this light, a board with discretion, and with due

[31] This view was by no means unanimous. For example, see Kettl [1986] on the debate between Henry Simon (rules) and Marriner Eccles (discretion).

representation of all views, appeared a more natural and a more politically viable option than some rule.

Next are two very general assumptions about how discretion can be granted:

A 10 *Control of money growth can be assigned to any subset of living agents chosen based on observable features.*

A 11 *Private side-payments among agents in the governing subset and from the general population to these agents can effectively be prohibited.*

The assumption that the people can, if they choose, cede policymaking power to a board should be uncontroversial.[32] While we may in practice be able to rule out explicit side payments (bribes), however, it may be difficult to rule out the effect of non-pecuniary payments (hate mail).

4.2 The equilibrium concept

The equilibrium concept in this case relies, as did the voting equilibrium, on the assumption that competitive behavior prevails in the market independent of how policy is chosen:

Definition 3 *An equilibrium with policy by board is given by a competitive equilibrium E^* with money growth z^* and*

i) membership rules for the board,

ii) bargaining rules for the board,

iii) expectations $V^*(Z_{t-1}, z_t)$, giving what competitive equilibrium is expected to be associated with any sequence of policies, and satisfying $E^* = V(Z^*_{t-1}, z^*)$,

iv) Equilibrium strategies for board selection, and

v) Equilibrium strategies for potential board members, v^*_k, $k \in \{y, o\}$, that make z^* an equilibrium bargain at t whenever all past growth rates have been z^*.[33]

It is worth noting that this equilibrium concept encompasses a great variety of endogenous policy generation mechanisms. For example, the voting equilibrium of the previous section is a special case where the board includes the whole living

[32] The *if they choose* is important here, but I leave aside the issue of how Fed legislation was passed in the first place.

[33] This precise sense of equilibrium in (*iv*) and (*v*) depends on the specification of rules and is taken up below.

population and the "bargaining rules" involve policy by majority vote. Indeed, the definition seems to subsume most sensible forms of endogenous policy: it allows some endogenously chosen sub-group to set policy subject to specified rules.

The membership rule I examine is a board of one old and one young agent selected each period.[34] The board follows the bargaining rules examined by Rubinstein [1982] in which the members alternate in making offers until an offer is accepted.[35] The bargainers are impatient, resulting in immediate agreement. These bargaining rules are convenient because they allow an obvious implementation of a balanced board and yield a tractable solution. In general, under this form of bargaining, the first mover has an advantage that is limited by the cost to the bargainers of proceeding to the next round of bargaining. In context of this paper, this cost is surely miniscule;[36] thus, I interpret balanced power as the case of a vanishingly small bargaining cost.

4.3 Balanced board equilibria

Parallel to the previous section, I seek to determine which constant inflation competitive equilibria can be supported as equilibria with endogenous policy by board. For concreteness, I assume that the young agent offers first. The welfare functions of the previous section must be supplemented with a bargaining cost. Utility to bargainers who agree in round b, leading to equilibrium E, is

$$W_k^B(E, b) = W_k(E) - d(b-1) \tag{15}$$

where $d > 0$ is the bargaining cost, and $k \in \{y, o\}$.[37]

Since the young offer first, their strategy function, v_y, in odd numbered bargaining rounds gives their growth rate offer (as a function of previous actual growth

[34] The mode of selection beyond this is irrelevant; participation is mandatory; in equilibrium, participation is costless.

[35] Only the outcome of the bargain is public knowledge.

[36] Having heard one money growth offer, "5 percent", the second mover could respond, "-3 percent", in a fraction of a second, and at virtually no cost.

[37] Given log utility, this formulation implies that preferences are a monotonic transform of (for the young) $\exp(d)^{-(b-1)} c_y c_o^{\delta}$. This is similar to Rubinstein's constant discounting case.

rates, Z_{t-1}, and the proposals in earlier bargaining rounds). In even numbered rounds, the function dictates acceptance or rejection of the old's offer (as a function of the offer, earlier offers, and Z_{t-1}). The old's strategy function is analogously defined. For strategies to form a perfect equilibrium, it must be the case that each bargainer in round i at time t expects to do better following the strategy than by deviating. This must hold for all t, i, Z_{t-1}, and history of offers in rounds prior to i.

Consider unconditional strategies. No matter what the history of policy, the young bargainer offers some z^*, and accepts any offer at least as good as getting z^* in the following period. The old bargainer offers some $\tilde{z}$ and accepts only offers as good as getting $\tilde{z}$ in the next period.[38] Given the structure of the bargaining problem here, z^* will be accepted in the initial bargaining round if $\tilde{z}$ is such that the young bargainer is indifferent between $\tilde{z}$ immediately and z^* in next round, and conversely, the old bargainer is indifferent between z^* immediately and $\tilde{z}$ next round. Formally,

$$W_y^B(V^*(Z_{t-1}, z^*), 1) = W_y^B(V^*(Z_{t-1}, \tilde{z}), 0) \tag{16}$$

$$W_o^B(V^*(Z_{t-1}, \tilde{z}), 1) = W_o^B(V^*(Z_{t-1}, z^*), 0) \tag{17}$$

The young agent knows the old would not accept any worse offer than z^*, and knows that the old will never offer anything the young prefer to getting z^* immediately. Thus, the young offer z^*. Similarly, the old agent knows the young will not accept any worse offer than $\tilde{z}$ in the next round. The old person is thus willing to accept z^* immediately, which is as good as $\tilde{z}$ next round. Thus, the perfection requirement is met for the agents at t, conditional on the expected future behavior. The expected behavior of the future agents is also rational by the same argument.

A revealing characterization of the equilibrium can be derived by considering the balanced power case in which the bargaining cost is small. Substituting (15) in

[38] The expected equilibrium associated with any bargain, given by $V^*(.,.)$, is just as in the unconditional voting case: the z^* equilibrium prevails if no generation has deviated, and the economy returns to z^* immediately following any deviation.

(16) and (17), solving for d, and equating gives,

$$W_y(E(z^*)) - W_y(E(\tilde{z})) = W_o(E(\tilde{z})) - W_o(E(z^*))$$

where $E(z) = V^*(Z^*_{t-1}, z)$. As d vanishes, $W_k(E(z^*)) \approx W_k(E(\tilde{z}))$ for both young and old. Taking a first order approximation of $W_k(E(\tilde{z}))$ around $W_k(E(z^*))$ and substituting gives,

$$\lim_{d\to 0} \frac{\partial W_y(E(z^*))}{\partial z_t} + \frac{\partial W_o(E(z^*))}{\partial z_t} = 0 \tag{18}$$

This expression clarifies the sense of balanced negotiating power at work: the workers can only push the growth rate up if the marginal benefit to them is greater than the marginal cost to the wealthy. It turns out that this sense of fairness guarantees that the bargaining equilibria must be in the range preferred by the benevolent policymaker in prop. (2. These equilibria are efficient in the sense that they are not Pareto dominated by any market solution. Compare this result to the analogous relation in the unconditional voting case. The first order condition from (11) requires that inflation be pushed up until no benefit remains to the workers of further increases. In the bargaining case, the growth rate is pushed up only so long as the benefits to the young exceed the costs to the old.

Proposition 5 *For any population growth rate, there is a constant money growth equilibrium with policy by board with unconditional bargaining strategies. The equilibrium is not Pareto dominated by any market outcome.*

Proof: see Appendix.

The Appendix also notes that any equilibria with conditional strategies are efficient, if, for example, higher inflation today leads to inflation tomorrow. Thus, for a broad range of reasonable assumptions about the reactions of future bargainers, policy set by an independent board is efficient relative to market solutions. I believe this result is illustrative of the general principle relied upon by the framers of the Fed: a balanced board is likely to select a policy somewhere in between the policy preferred by the individual constituents. While seriously modelling the actual bargaining process of the FOMC would be impossible, this model captures the essence of why such a policymaking structure might be adopted.

5 Discussion

Whom can we trust to run the Fed? The Fed's framers answered this question in light of a history of conflict over the redistributive powers of inflation. Some hesitated to trust anyone who might be swayed by populist forces for inflationary debt relief. Many also distrusted the "money power," which might act at the expense of the society at large. The solution the framers chose was to insulate the policymakers from the external pressures, and to balance the internal pressures for and against inflation.

The model in this paper formally rationalizes these arguments. The incentive of nominal debtors to use policy to re-distribute wealth in their favor leads to an inflationary bias under policy by majority: expected and actual inflation may reach a level sufficiently high to remove any benefit to debtors of surprise inflation. Whereas the majority-rule solution could be dominated by the debtors, monetary policy by a board with balanced interests leads to a more moderate policy, balancing the inflation interests of both groups.

5.1 Relevance of these results for modern institutions and inflation outcomes

Even if this paper provides a correct account of the formation of an independent Fed, there remains a question as to whether issues of independence and balance still have relevance today. Several bits of information suggest that the forces in this paper have not died. For example, proposed political reform of the Fed often focuses on re-balancing the internal interests. The Fed's refusal to inflate to enhance the stimulative effect of the Kennedy tax cuts of 1964 led to a major reform proposal intended to make the Fed more responsive to the pro-inflation political forces in the 1960s.[39] Key features of the plan involved removing voting rights of the Reserve Bank presidents on the FOMC and removing the statutory requirement that governors be chosen to fairly represent the various interests cited in Section 1.

[39] U.S. Congress, 1964

In 1991, a bill was once again put forward to vest policymaking exclusively in the Board. While one major argument for the bill is based in political philosophy,[40] several supporters of the bill also emphasized their view that the presidents have historically been more concerned with inflation than the governors.[41] In formalizing the rationale of the framers of the Fed, I have not argued that the framers *correctly* balanced interests on the Board; thus, I am not arguing about the merits of rebalancing power. Rather, I cite this legislation as clear evidence that issues of balance remain of interest today.

The actual behavior of inflation provides some further evidence regarding the relevance of the story given here. A number of economists have contended that the inflation of the 1960s and 1970s was in part supported by the large group of mortgage holders who fared well during the period [e.g., Hetzel [1990]. Similar arguments have been made for Argentina [Hirshman, 1985].

These contentions about the cause of inflation not only indicate that debtor-creditor tension is still important, they raise questions as to the success of the Fed as an institutional response to these tensions. Such issues cannot be formally addressed in the context of the model at hand, since inflation does not fluctuate. There are two obvious directions for extending the model to analyze such issues. The first would make the *proportion preferring inflation* (or the strength of the preference) both endogenous and stochastic. Average inflation might then be high enough to prevent surprise inflation by the typical constituency favoring inflation, but inflationary bursts might occur when a majority strongly preferring inflation emerged. The second approach would have the monetary authority's ability or incentive to resist this pressure vary through time.

[40] The argument is that it is inappropriate for public policy to be made by people who are neither selected nor ratified by a political body. Of course, this paper does not deal with issues regarding the legitimization of government power.

[41] Some formal evidence regarding this claim by, e.g., Hamilton and Sarbanes [1991], Tobin [1991], Martin [1991] is presented in Belden [1989] and Havrilesky and Gildea [1991].

5.2 A postscript about democracy

Some economists have argued against policy by an independent board simply on the grounds that it is not democratic [e.g., Milton Friedman, 1962; and James Tobin, 1991]. While such a system of policymaking is clearly not democratic in the simplest sense of the term, neither are many of the most important institutions in the U.S.

As noted above, some of the Constitution's Article I Section 10 restrictions provide an interesting case. These restrictions were put in place to keep democratic forces from using their state legislatures to redistribute wealth from creditors to debtors. While these restrictions are directly intended to thwart the majority will, few economists would suggest that capitalism would be well-served by leaving the enforcement of contracts open to majority vote. Just as the majority may be better off by giving up its general rights to alter contracts, it may also improve its welfare by giving up some of its power to alter the terms of nominal contracts through monetary policy. Thus, while the particular form of independence chosen by Congress may be open to question, it is difficult to support a generic "pro-democracy" argument against monetary authority independence.

Appendix

Proof of Prop. 2. Part *i*: The proof follows the logic in the text, showing that both the intertemporal allocation and the total quantity of resources consumed are worsened monotonically by any deviation from zero money growth. Define $Q(z^*) = w - (2+x)/(1+x)\Phi(z^*)$ as the total edible resources, and $k(z^*) = \bar{c}_y(z^*)/Q(z^*)$ as the equilibrium proportion eaten by the young. Differentiating equilibrium utility with respect to a constant growth rate gives,

$$\partial U/\partial z = Q(z^*)[\bar{c}_y^{-1} - \delta(1+x)/\bar{c}_o]k'(z^*) + [\bar{c}_y^{-1}k(z^*) + \delta\bar{c}_o^{-1}(1-k(z^*))(1-x)]Q'(z^*)$$

The proof is complete if this derivative has the opposite sign of z^*. In the first term, $Q(z^*) > 0$, and the term in brackets has the opposite sign of z^* (which can be seen by manipulating (5)). To see that $k'(z^*) > 0$, write $k(z^*) = \bar{c}_y/(\bar{c}_y + \bar{c}_o/(1+x)) = (1+z^*)/(1+z^*+\delta)$ revealing $k'(z^*) = \delta/(1+z^*+\delta)^2 > 0$. The second term has the opposite sign of z^*, since, $Q'(z^*)$ does and the term multiplying it is positive.

Part *ii*: For the initial old, $U_o = \ln((1-x)(1-k(z^*))Q(z^*))$, and

$$\partial U_o/\partial z = \bar{c}_o^{-1}(1+x)((1-k(z^*))Q'(z^*) - Q(z^*)k'(z^*)))$$

From the signs of derivatives established above, this expression is negative for $z^* > 0$. The same applies for small negative z^*. The derivative must turn positive as z^* falls to its lower bound under A7 at which consumption falls to zero. Q.E.D.

Proof of Prop. 3. Part *i*: $x > 0$. Given a fixed z^* expected of future agents, young utility from choosing z_t is a monotonic transform of young consumption: $c_y(z_t, z^*) = w - R(z_t, z^*, \bar{R}(z^*))/(1+x) - \Phi(z_t)$. Thus,

$$c_y'(z_t, z^*) \equiv \frac{\partial c_y(z_t, z^*)}{\partial z_t} = \frac{K(z^*)(\delta(w - \Phi(z_t)) - ((1+z_t)K(z^*) + \delta)(1+z_t)\Phi'(z_t)}{((1+z_t)K(z^*)+\delta))^2}$$

where $K(z^*) = 1 - \Phi(z^*)/\bar{R}(z^*)$. The following properties follow directly: $c_y'(z,z)$ is continuous in z, positive for $z \leq 0$, and negative as z approaches its upper bound. Thus, there is a $z^* > 0$ such that $c_y'(z^*, z^*) = 0$, implying the first order condition (14) holds. Fix this z^*. $c_y'(z_t, z^*) > 0$ for $z_t < z^*$ and negative for $z_t > z^*$, implying

$z_t = z^*$ uniquely maximizes expected consumption given z^*. The part i claims regarding utility follow from prop. 2.

Part ii: $x > 0$. The old's utility from choosing z_t, given a fixed z^*, is a monotonic transform of $c_o(z_t, z^*) = R(z_t, z^*, \bar{R}(z^*)) - \Phi(z_t)$. The existence proof can be completed by forming $c_o'(z_t, z^*)$ analogously to the proof of part (i).

Utility of the young is lower than in the zero money growth equilibrium by prop. 2. Utility of the initial old is higher than at $z^* = 0$ if the unconditional voting rate of deflation is smaller (in absolute terms) than the rate of exogenous deflation that maximizes welfare under prop. 2. The utility maximizing rate of exogenous growth rate satisfies $\partial \bar{R}(z^*)/\partial z = \Phi'(z^*)$, whereas the rate under unconditional voting strategies will satisfy, (14). Thus, the proof is done if $\partial \bar{R}(z^*)/\partial z < \partial R(z_t, z^*, \bar{R}(z^*))/\partial z_t|_{z^*}$ for $z^* < 0$. This condition, which can be verified directly, implies that the gain in real balances to the old from raising the steady-state deflation rate exceeds the gain from one-shot cheating. Thus, the unconditional voting rate of deflation will be less than the best exogenous rate of deflation. Q.E.D.

Proof of Prop. 5. Initially, the existence proof is sketched, then the welfare claim is proven. Following the logic and notation of the previous proof, one can see that for any fixed z^*, there is a $z_y > 0$ such that $c_y'(z_t, z^*) > 0$ for $z_t < z_y$, and $c_y'(z_t, z^*) < 0$ for $z_t > z_y$; likewise there is a $z_o < 0$ such that $c_o'(z_t, z^*) > 0$ for $z_t < z_o$, and $c_o'(z_t, z^*) < 0$ for $z_t > z_o$. These functions are continuous and differentiable in z_t, implying that for any z^* the Pareto frontier of the imputed utility set (attainable by choosing z_t) is smooth, downward sloping, and involves $z_t \in [z_o, z_y]$. Given these results, there is a z_t in the optimal range such that the first order condition, (18), holds when z^* replaced by z_t. Thus, for any z^*, there is an equilibrium bargain, z_t^*, today. What we need is a z^* such (18) holds at z^*, implying $z_t^* = z^*$.

Define the function,

$$f(z_t, z^*) = \partial W_y(E(z_t))/\partial z_t + \partial W_o(E(z_t))/\partial z_t$$

and note the $\partial W_k(E(z_t))/\partial z_t$ is continuous and differentiable in z_t, just as $c_k'(z_t, z^*)$

is. Note that $f(z,z)$ is continuous in z, $f(z_o,z_o) > 0$, and $f(z_y,z_y) < 0$. Thus, there is a z^* such that $f(z^*,z^*) = 0$, implying (18) holds.

Now show that any z^* satisfying (18) is in the efficient range relative to market outcomes. Any bargaining equilibrium with vanishing bargaining cost must satisfy (18), which can be expanded to

$$c_y'(z^*,z^*)/\bar{c}_y + c_o'(z^*,z^*)/\bar{c}_o = 0 \tag{19}$$

Re-arranging gives, $\bar{c}_o/\bar{c}_y + c_o'/c_y' = 0$. From the first order condition (5) and the definition of p_t, the first term is $\delta(1+x)/(1+z^*)$. Differentiating the resource constraint allows us to write $c_y'(z^*,z^*) + c_o'(z^*,z^*) + (2+x)/(1+x)\Phi'(z^*) = 0$. Substituting and re-arranging gives,

$$c_y'(z^*,z^*) = \frac{(1+z^*)(2+x)\Phi'(z^*)}{(1+x)(\delta-(1+z^*))} \tag{20}$$

Along the Pareto frontier, $c_y'(z_t,z^*) > 0$. The right-hand side of (20) can be positive only for negative z^*: for positive z^* the numerator is positive, but the denominator is negative. Thus, the unconditional equilibrium must involve negative money growth. Further, since $c_o'(z^*,z^*) < 0$, z^* is in the Pareto optimal range relative to market outcomes by the same argument as used in the proof of prop. 3, part (*ii*). Q.E.D.

Remark: The same efficiency argument goes through for conditional strategies of the sort that led to good equilibria under voting. If inflation today leads to inflation next period, decreasing the consumption when old of today's young, then any constant money growth bargaining equilibrium must be efficient. Call the marginal change in consumption of next period's old from a small change in z_t, $c_{o,t+1}'(z_t,z^*)$. The conditional strategy merely adds the negative term $\delta c_{o,t+1}'(z^*,z^*)/\bar{c}_o$ to the lefthand side of (19), which does not change the efficiency result.

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