Debt, Inflation and Central Bank Independence

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Abstract

I study the effects central bank independence in an environment where the government faces a tension between maximizing the welfare of agents and maximizing its expenditure. A reform that makes the central bank independent from the fiscal authority consists of reducing the central bank's bias towards expenditure. I show that making the central bank independent implies, for any given level debt, an increase in future debt and reductions in inflation and taxes. However, as debt increases, inflation and taxes revert to their pre-reform levels due to the higher financial burden. In the long-run, only debt varies significantly. That central bank independence has little or no effect on long-run inflation is consistent with previous empirical studies. The results in this paper suggest a plausible explanation for the large debt increase observed in the U.S. and other developed countries during the 1980s.

Keywords: government debt, inflation, central bank independence, time-consistency.

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1 Introduction

What are the effects of central bank independence? Or to be more precise, what are the implications of protecting a monetary authority from the pressures of politicians in the conduct of policy?[1] This question received wide attention after the high inflation episodes experienced by developed economies during the 1970s.

On the theoretical side, Barro and Gordon (1983) formalized the notion that discretion in policymaking may lead to excessive inflation. Subsequently, Rogoff (1985) studied a model where the central bank puts more weight on low inflation than the elected government, which leads to lower inflation. However, this type of analysis presumes the answer to the question posed above.

On the empirical side, a large literature has studied the cross-country relationship between long-run inflation and measures of central bank independence. Early work—see Cukierman (1992) for a survey—suggested a negative correlation in developed countries. More recent papers have criticized this finding. Most notably, Campillo and Miron (1997) find that after controlling for other factors that may determine inflation, central bank independence is relatively unimportant for average inflation rates. Posen (1993) rejects the causality link between inflation and central bank independence, and suggests that both are determined by a strong demand for low inflation. In particular, he argues that increasing central bank independence will not itself lead to lower inflation. Overall, the empirical findings are mixed, although the more recent studies suggest no significant correlation between inflation and central bank independence.

In this paper, I study the effects of a reform that makes the monetary authority independent of the political frictions which affect the fiscal authority. I consider an environment with a government that uses distortionary taxes, money and nominal bonds to finance the provision of a valued public good. The government lacks the ability to commit to policy choices beyond the current period and is further subjected to a political friction: a tension between maximizing the welfare of agents and maximizing its expenditure. I model central bank independence as an institution which shelters—at least partially—the monetary authority from this political friction. An independent central bank will decide monetary policy at the same time as the fiscal authority decides on taxes and expenditure. Both authorities need to take into account how their actions affect current agent behavior and future government policy. Thus, each of the authorities plays a simultaneous game with the other institution and a sequential game with the private sector, its own future-self and the other authority's future-self.

The government's inability to commit implies a trade-off in the conduct of policy that explains the level of debt.[2] On the one hand, there is an incentive to increase debt and delay taxation, so as to reduce current distortions. On the other hand, inflating current prices lowers the real value of nominal debt and so there is a motive to reduce it now. Clearly, the degree of benevolence of government institutions will have an impact in how these two forces balance out. I show that a reform that increases central bank independence results in a shift up of the debt policy functions and a shift down of inflation and tax policy functions. Thus, at any given level of debt, a government with an independent central bank will implement higher debt and lower inflation and taxes than a government without an independent monetary authority. However, in the long-run, only debt is

[1] This definition of central bank independence is due to Walsh (2008).
[2] See Martin (2009).

significantly different. The reason for this is that, with a higher debt policy function, the government with an independent central bank features higher financial liabilities in the future. Thus, as debt increases, so do inflation and taxes. After the reform, the economy ends up with higher debt, but similar inflation, taxes and expenditure. The size of the increase in debt is directly related to the size of the political frictions which afflict the fiscal authority and to the degree of benevolence of the monetary authority after the reform. I show that these results remain if we allow the central bank to move after the fiscal authority (instead of simultaneously).[3]

There is strong evidence to support the notion that the Federal Reserve increased its independence since the late 1970s. The results in this paper suggests that the direct result of this increased independence was the large increase in U.S. public debt observed during the 1980s.

The paper is organized as follows. Section 2 describes the basic economy. Section 3 analyzes government policy under the assumption that there is a single government agency. Section 4 considers the case of separate fiscal and monetary authorities, with potentially different objectives. Section 5 computes the effects of central bank independence and performs several robustness checks. Section 6 concludes with an evaluation of the empirical validity of the theory.

2 Basic Economy

The environment is a version of the Lagos and Wright (2005) framework. There is a continuum of infinitely lived agents. Each period, two perfectly competitive markets open in sequence: a day and a night market. In each stage a perishable good is produced and consumed. Before each day market opens, agents receive an idiosyncratic shock that determines whether they can produce or consume the day-good, x. With equal probability an agent can either consume but not produce, or can produce but not consume. A *consumer* derives utility $u(x)$ from consuming the good, where u is twice continuously differentiable, with $u_x > 0$ and $u_{xx} < 0$, and satisfies Inada conditions. A *producer* incurs in utility cost $f(x)$, where f is twice continuously differentiable with $f_x > 0$, $f_{xx} \geq 0$ and $2f_{xx} + f_{xxx}x \geq 0$.[4] Further assume there exists a $\hat{x} \in (0, \infty)$ such that $u_x(\hat{x}) = f_x(\hat{x})$.

During the day market, agents are anonymous, in the sense that their trading histories are unknown. Thus, no private credit is possible. The day market is characterized by both anonymity and lack of double coincidence of wants. Thus, some medium of exchange is essential for trade to occur.

At night, all agents can produce and consume the night-good, c. The production technology is assumed to be linear in hours worked. Utility from consumption is given by $U(c)$, where U is twice continuously differentiable with $U_c > 0$ and $U_{cc} < 0$. Disutility from labor is given by αn, where n is hours worked and $\alpha > 0$. Assume there exists a $\hat{c} \in (0, \infty)$ such that $U_c(\hat{c}) = \alpha$.

There is a government that supplies a valued public good g. To finance its expenditure, the government may use proportional labor taxes τ, print fiat money at rate μ and issue one-period nominal bonds, which are redeemable in fiat money. The public good is transformed one-to-one from the night-good. Agents derive utility from the public good according to $v(g)$, where v is twice

[3]This variant captures the idea that central banks make policy decisions at a higher frequency than fiscal authorities.

[4]This last requirement is satisfied by any convex CES function.

continuously differentiable with $v_g > 0$, $v_{gg} < 0$ and such that there exits a $\hat{g}$ for which $v_g(\hat{g}) = \alpha$. The government can commit to policies within the period, but lacks the ability to commit to future policy choices. Assume the government announces its policy for the period at the beginning of the day, before agents' preference shocks are realized. Given the anonymity friction in the day market, the government only actively participates in the night-market, i.e., taxes are levied on hours worked at night and open market operations are conducted in the night market.

All nominal variables—except for bond prices—are normalized by the aggregate money stock. Thus, today's aggregate money supply is equal to 1 and tomorrow's is $1 + \mu$. The government budget constraint is

$$\frac{(1+B)}{p} + g = \tau n + \frac{(1+\mu)(1+qB')}{p}, \tag{1}$$

where B is the aggregate bond-money ratio, p is the—normalized—market price of the night-good c, and q is the price of a bond that earns one unit of fiat money in the following night market.

In principle, both fiat money and government bonds could play the role of a medium of exchange. A standard assumption in the literature[5] is that money is the only asset that is recognizable in the day market. Thus, government bonds are illiquid, in the sense that they cannot be used to purchase goods in the day market. One could think of this restriction in two ways. First, bonds could be just book entries in the government's record. Thus, unless the government participates in a given market, exchange of bonds is not possible. Another possibility is to assume that bonds—but not money—can be costlessly counterfeited and only the government can provide third-party verification. Again, bonds will only be traded in markets where the government participates.

2.1 The night market

An agent arrives to the night market with individual money balances m and government bonds b. Since bonds are redeemed in fiat money at par, the initial composition of an agent's nominal portfolio is irrelevant. Let $z \equiv m + b$, i.e., total—normalized—nominal assets holding. The budget constraint of an agent at night is

$$c + \frac{(1+\mu)(m' + qb')}{p} = (1-\tau)n + \frac{z}{p}.$$

Notice that the composition of the nominal portfolio the agent decides to carry over to the next period matters, as only fiat money can be used to buy goods in the day market.

Let $W(z)$ be the value of entering the night market with nominal balances z and let $V(m, b)$ be the value of entering next period's day market with money and bond balances equal to m and b, respectively. The problem of an agent in the night market is

$$W(z) = \max_{c, m', b'} U(c) - \frac{\alpha c}{1-\tau} + \frac{\alpha(z - (1+\mu)(m' + qb'))}{p(1-\tau)} + v(g) + \beta V(m', b').$$

[5] See Aruoba, Waller and Wright (2006), Aruoba and Chugh (2008) and Telyukova and Wright (2008).

The first-order conditions are

$$\begin{aligned} U_c - \frac{\alpha}{1-\tau} &= 0 \\ -\frac{\alpha(1+\mu)}{p(1-\tau)} + \beta V'_m &= 0 \\ -\frac{\alpha q(1+\mu)}{p(1-\tau)} + \beta V'_b &= 0. \end{aligned}$$

Following the arguments of Lagos and Wright (2005) one can show that the last two equations above imply all agents exit the night market with the same money and bond balances. Furthermore, the value function W is linear:

$$W_z = \frac{\alpha}{p(1-\tau)}.$$

Both results follow from labor entering linearly in the objective function and the budget constraint. The linearity of W allows us to write $W(z+\Delta) = W(z) + \frac{\alpha\Delta}{p(1-\tau)}$, for any $\Delta \geq -z$.

The first-order conditions also imply

$$q = \frac{V'_b}{V'_m}.$$

Thus, if $V'_b < V'_m$, i.e., the value of entering tomorrow's day market with a unit of bonds is less than with a unit of money, then agents need to be compensated to acquire bonds, i.e., $q < 1$.

2.2 The day market

The ex-ante value for an agent that enters the day market is

$$V(m,b) = \frac{1}{2}V^c(m,b) + \frac{1}{2}V^p(m,b),$$

where V^c and V^p are the values of being a consumer and a producer in the day market, respectively.

The frictions in the day market—lack of double coincidence of wants, anonymity, lack of commitment and illiquid government bonds—allow fiat money to serve as a medium of exchange and provides a rationale for its demand.

A consumer faces a day-budget constraint, $\tilde{p}x \leq m$, where $\tilde{p}$ is the—normalized—market price of good x. Using ξ as the Lagrange multiplier associated with this constraint, the problem of a consumer can be written as

$$V^c(m,b) = \max_x u(x) + W(m+b) - \frac{\alpha \tilde{p} x}{p(1-\tau)} + \xi(m - \tilde{p}x).$$

The first-order condition is

$$u_x - \frac{\alpha\tilde{p}}{p(1-\tau)} - \xi\tilde{p} = 0,$$

which implies

$$\xi = \frac{u_x}{\tilde{p}} - \frac{\alpha}{p(1-\tau)}.$$

From the envelope condition we get

$$\begin{aligned} V_m^c &= \frac{u_x}{\tilde{p}} \\ V_b^c &= \frac{\alpha}{p(1-\tau)}. \end{aligned}$$

The problem of a producer is

$$V^p(m,b) = \max_x -f(x) + W(m+b) + \frac{\alpha \tilde{p} x}{p(1-\tau)}.$$

The first-order condition is

$$-f_x + \frac{\alpha \tilde{p}}{p(1-\tau)} = 0. \tag{2}$$

Note that because of the quasi-linear preferences in the night stage, a producer's actions during the day are unaffected by the amount of money he brings into the period. The envelope condition implies

$$\begin{aligned} V_m^p &= \frac{\alpha}{p(1-\tau)} \\ V_b^p &= \frac{\alpha}{p(1-\tau)}. \end{aligned}$$

A standard result is that consumers spend all their money in the day market, i.e., $m = \tilde{p}x$. The market clearing condition is then $1 = \tilde{p}x$, which implies

$$\tilde{p} = \frac{1}{x}.$$

Substitute this expression in the first-order condition of the producer (2) and we get that x solves

$$f_x x = \frac{\alpha}{p(1-\tau)}.$$

Then,

$$\begin{aligned} V_m &= \frac{x(u_x + f_x)}{2} \\ V_b &= f_x x \\ \xi &= x(u_x - f_x). \end{aligned}$$

2.3 Monetary equilibrium

As analyzed above, all agents choose the same c, m' and b' in the night market. Thus, $m' = 1$ and $b' = B'$. The only difference between agents is their role in the day stage and their labor effort in the night stage. The aggregate resource constraint in the night market is

$$c + g = n. \tag{3}$$

We can now collect the remaining equations that summarize agents' behavior in any given period. After some rearrangement we get

$$\begin{aligned} \mu &= \frac{\beta x'(u'_x + f'_x)}{2f_x x} - 1 && (4) \\ \tau &= 1 - \frac{\alpha}{U_c} && (5) \\ p &= \frac{U_c}{f_x x} && (6) \\ q &= \frac{2f'_x}{u'_x + f'_x} && (7) \\ u_x - f_x &\geq 0. && (8) \end{aligned}$$

Equation (8) comes from the requirement that the Lagrange multiplier in the day-consumer's problem, ξ be non-negative. From the equations above we can see that allocations and prices in any given period depend on tomorrow's consumption of the day-good, i.e., x'. In equilibrium, x' is a function of the policies implemented by tomorrow's government.

3 Government Policy with Political Frictions

3.1 The problem of the government

Assume the government lacks the ability to commit to policy choices in future periods. Thus, the problem of the current government is to make policy choices for the period, subject to agents behaving competitively, future government behavior and the government budget constraint. Further assume that the government faces a tension between maximizing agents welfare and maximizing expenditure. Let $\omega \in (0, 1]$ be a measure of government "benevolence", which is exogenous and constant over time.

We can use the equilibrium conditions (3) to (7) to write the government budget constraint in terms of current and future allocations only

$$(U_c - \alpha)c - \alpha g + \frac{\beta x'(u'_x + f'_x)}{2} + \beta f'_x x' B' - f_x x(1 + B) = 0. \tag{9}$$

The equation above is a function of x, x', c, g, B and B'. Let $x' = \mathcal{X}(B')$, where $\mathcal{X}$ is the policy that is perceived to be implemented by the government tomorrow. We can write the government budget constraint compactly as

$$\varepsilon(B, B', x, \mathcal{X}(B'), c, g) = 0.$$

The other constraint in the government's problem is (8). That is, the current government is constrained to implement policy such that a monetary equilibrium in the day market exists.

Given the perception that future governments implement $\mathcal{X}(B)$, the problem of the current government is

$$\mathcal{V}(B) = \max_{B',x,c,g} \omega \left\{ \frac{1}{2}u(x) - \frac{1}{2}f(x) + U(c) - \alpha(c + g) + v(g) \right\} + (1 - \omega)g + \beta\mathcal{V}(B')$$

subject to

$$\begin{aligned} \varepsilon(B, B', x, \mathcal{X}(B'), c, g) &= 0 \\ u_x - f_x &\geq 0. \end{aligned}$$

Definition 1 *A Markov-Perfect Monetary Equilibrium (MPME) is a set of functions* $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}, \mathcal{V}\} : \mathbb{R} \to \mathbb{R}^5$*, such that for all B:*

$$(i)\ \{\mathcal{B}(B), \mathcal{X}(B), \mathcal{C}(B), \mathcal{G}(B)\} = \underset{B',x,c,g}{\operatorname{argmax}}\ \omega \left\{ \frac{1}{2}u(x) - \frac{1}{2}f(x) + U(c) - \alpha(c+g) + v(g) \right\} + (1-\omega)g + \beta\mathcal{V}(B')$$

subject to

$$\begin{aligned} \varepsilon(B, B', x, \mathcal{X}(B'), c, g) &= 0 \\ u_x - f_x &\geq 0; \end{aligned}$$

and

$$(ii)\ \mathcal{V}(B) = \omega \left\{ \frac{1}{2}u(\mathcal{X}(B)) - \frac{1}{2}f(\mathcal{X}(B)) + U(\mathcal{C}(B)) - \alpha(\mathcal{C}(B) + \mathcal{G}(B)) + v(\mathcal{G}(B)) \right\} + (1-\omega)\mathcal{G}(B) + \beta\mathcal{V}(\mathcal{B}(B))$$

Note that this not a typical dynamic programming problem since the problem of the current government takes $\mathcal{X}(B)$, i.e., policy of future governments, as given. Solving for a MPME involves finding the fixed point of both $\mathcal{V}(B)$ and $\mathcal{X}(B)$.

Using λ and ζ as the Lagrange multipliers associated with the constraints above, the first-order conditions are

$$\begin{aligned} \lambda(\varepsilon_{B'} + \varepsilon_{x'}\mathcal{X}'_B) + \beta\lambda'\varepsilon'_B &= 0 & (10) \\ \frac{\omega(u_x - f_x)}{2} + \lambda\varepsilon_x + \zeta(u_{xx} - f_{xx}) &= 0 & (11) \\ \omega(U_c - \alpha) + \lambda\varepsilon_c &= 0, & (12) \\ \omega(-\alpha + v_g) + 1 - \omega + \lambda\varepsilon_g &= 0, & (13) \end{aligned}$$

where

$$\begin{aligned} \varepsilon_{B'} &= \beta f'_x x' \\ \varepsilon_{x'} &= \beta\Big\{\frac{(u'_x + f'_x)}{2} + \frac{x'(u'_{xx} + f'_{xx})}{2} + B'(f'_x + f'_{xx}x')\Big\} \\ \varepsilon'_B &= -f'_x x' \\ \varepsilon_x &= -(1+B)(f_x + f_{xx}x) \\ \varepsilon_c &= u_c - \alpha + u_{cc}c \\ \varepsilon_g &= -\alpha. \end{aligned}$$

Notice that equation (10) has the derivative of the unknown function $\mathcal{X}(B)$. For this reason, this equation is usually referred to as the Generalized Euler Equation (GEE).

3.2 Long-run debt

There are two steady states to consider.

Proposition 1 *There exists a steady state $\hat{B} < -1$ with zero taxes and zero nominal interest rate.*

Proof. Consider the case $\lambda = 0$. From (12), we get $U_c = \alpha$ which implies $\tau = 0$.

Since $u_{xx} - f_{xx} < 0$, $\lambda = 0$ implies both $\zeta = 0$ and $u_x = f_x$. Given our assumptions on u and f, this implies a unique solution $\hat{x}$. This solution implies $q = 1$ and $\mu = \beta - 1$, i.e., the Friedman rule. We also get $U_c = \alpha$ and $v_g = \alpha + 1 - 1/\omega$. Thus, taxes are zero and only government expenditure is not at its first-best level.

From (9) we get

$$\hat{B} = -\frac{\alpha \hat{g}}{(1-\beta)\hat{f}_x \hat{x}} - 1.$$

■

Note that $\hat{B} < -1$, i.e., the government needs sufficient assets (negative debt) to implement the Friedman rule and finance the desired level of public good. In what follows, we will use the following auxiliary result.

Lemma 1 *$\mathcal{X}(B) = \hat{x}$ for all $B \leq -1$ and $\mathcal{X}(B) < \hat{x}$ for all $B > -1$.*

Proof. Focus on (11). If $\lambda = 0$, then $u_x = f_x$, $\zeta = 0$ is the only solution. From (10), $\lambda = 0$ only if $\lambda' = 0$. Thus, there are no distortions today or tomorrow, i.e., debt has to be sufficiently negative to finance $\hat{g}$ without current or future distortions, i.e., $B \leq \hat{B} < -1$.

Suppose $\lambda > 0$ now. If $B < -1$ then $\varepsilon_x > 0$ and thus, $\frac{\omega(u_x - f_x)}{2} + \lambda \varepsilon_x > 0$ which implies $\zeta > 0$ since $u_{xx} - f_{xx} < 0$. Thus, $x = \hat{x}$. If $B = -1$ then $\varepsilon_x = 0$ and $u_x = f_x$, $\zeta = 0$ is the only solution. If $B > -1$ then $\varepsilon_x < 0$ and $u_x = f_x$ cannot be a solution. Thus, $u_x > f_x$ and so, $x < \hat{x}$. ■

Proposition 2 *There exists a distortionary steady state $B^* > -1$ with positive taxes and positive nominal interest rate.*

Proof. Consider now the case $\lambda > 0$, which from (5) and (12) implies $\tau > 0$. In steady state, (10) becomes

$$\varepsilon_{B'} + \varepsilon_{x'} \mathcal{X}_B + \beta \varepsilon_B = 0,$$

which, given $\varepsilon_{B'} = -\beta \varepsilon_B$, implies

$$\varepsilon_{x'} \mathcal{X}_B = 0.$$

Since $\mathcal{X}_B = 0$ is inconsistent with a distortionary steady state[6], we get $\varepsilon_{x'} = 0$. In steady state, if $u_x - f_x > 0$ then B, x, c and g solve

$$\begin{aligned}
\frac{(u_x + f_x)}{2} + \frac{x(u_{xx} + f_{xx})}{2} + B(f_x + f_{xx}x) &= 0 \qquad (14)\\
-\frac{u_x - f_x}{2(1+B)(f_x + f_{xx}x)} - \frac{u_c - \alpha}{u_c - \alpha + u_{cc}c} &= 0 \qquad (15)\\
-\frac{\alpha U_{cc}c}{U_c - \alpha + U_{cc}c} + v_g + \frac{1}{\omega} - 1 &= 0 \qquad (16)\\
(U_c - \alpha)c - \alpha g + \frac{\beta x(u_x + f_x)}{2} - f_x x - (1-\beta) f_x x B &= 0. \qquad (17)
\end{aligned}$$

We now verify $u_x - f_x > 0$. From (14) we get

$$B = -\frac{u_x + f_x + x(u_{xx} + f_{xx})}{2(f_x + f_{xx}x)}.$$

Thus, $\varepsilon_x = \frac{-u_x + f_x - x(u_{xx} - f_{xx})}{2}$. Consider now (11). If $u_x - f_x = 0$, then $\varepsilon_x > 0$ and thus $\lambda\varepsilon_x + \zeta(u_{xx} - f_{xx}) > 0$, i.e., (11) has no solution. Hence, $u_x - f_x > 0$ at the distortionary steady state. From Lemma 1, $B^* > -1$. ■

The following proposition shows stability of the distortionary steady state, B^*, for a limiting case.

Proposition 3 *Assume $v(g) = \frac{\psi g^\nu}{\nu}$, $\psi > \alpha, \nu < 1$. Then, as $\nu \to 1$, $\mathcal{B}(B) \to B^*$ for all $B \geq -1$.*

Proof. From (13) we have $\lambda = \frac{\omega(v_g - \alpha) + 1 - \omega}{\alpha}$. As $\nu \to 1$, $\lambda \to \frac{\omega(\psi - \alpha) + 1 - \omega}{\alpha} > 0$ and (10) simplifies to $\varepsilon_{x'}\mathcal{X}'_B = 0$. Conjecture that $\mathcal{X}'_B < 0$; thus, $\varepsilon_{x'} = 0$. This is an equation in B' and $\mathcal{X}(B')$; thus, $\mathcal{B}(B)$ is a constant. Given $\mathcal{B}(B^*) = B^*$, we get $\mathcal{B}(B) = B^*$.

Now we verify $\mathcal{X}'_B < 0$. Given Lemma 1, for any $B \geq -1$, we can re-arrange (11) as

$$\frac{u_x - f_x}{f_x + f_{xx}x} = \frac{2(\omega(\psi - \alpha) + 1 - \omega)(1+B)}{\alpha\omega},$$

which determines $\mathcal{X}(B)$. Differentiating both sides with respect to B implies

$$\left(\frac{u_{xx} - f_{xx}}{f_x + f_{xx}x} - \frac{(u_x - f_x)(2f_{xx} + f_{xxx}x)}{(f_x + f_{xx}x)^2}\right)\mathcal{X}_B = \frac{2(\omega(\psi - \alpha) + 1 - \omega)}{\alpha\omega}.$$

The term multiplying $\mathcal{X}_B$ is strictly negative and the right-hand side of the equation is greater than zero; thus, $\mathcal{X}_B < 0$. Since $B^* > -1$, we verify $\mathcal{X}'_B < 0$. ■

[6] $\mathcal{X}_B = 0$ would imply locally exploding debt (to minimize current distortions), since whatever the current government does will have no effect on future governments actions (i.e., future distortions are fixed). Note that $\mathcal{X}_B = 0$ is allowed at the Pareto optimum, since there are no distortions there.

Given the results above, we can concentrate on government policy around B^*. In particular, for any $B \geq -1$, the MPME is characterized by

$$\begin{aligned}
\omega\beta f'_x x'(v_g - v'_g) + (\omega(v_g - \alpha) + 1 - \omega)\varepsilon_{x'}\mathcal{X}'_B &= 0 \\
\alpha\omega(u_x - f_x) - 2(\omega(v_g - \alpha) + 1 - \omega)(f_x + f_{xx}x)(1 + B) &= 0 \\
(\omega v_g + 1 - \omega)(u_c - \alpha) + (\omega(v_g - \alpha) + 1 - \omega)U_{cc}c &= 0 \\
(U_c - \alpha)c - \alpha g + \beta x'\Big\{\frac{u'_x}{2} + f'_x(\frac{1}{2} + B')\Big\} - f_x x(1 + B) &= 0.
\end{aligned}$$

4 Central Bank Independence

4.1 Simultaneous actions

Suppose there is an institutional reform that makes the central bank independent from the fiscal authority. Let ω and Ω be the degrees of "benevolence" of the fiscal and monetary authorities, respectively. We now have two government institutions with potentially different objectives: a fiscal authority, which decides taxes and expenditure, and a monetary authority, in charge of printing money. Assume policy choices are made simultaneously at the beginning of the period, before agents make decisions. Debt is determined residually, to satisfy the government budget constraint. If $\Omega = \omega$, then the incentives of the two authorities are aligned and there is no change in policy. If $\Omega > \omega$, then the reform is akin to sheltering—at least partially—the monetary authority from political frictions. In the extreme case of $\Omega = 1$, the reform endows the central bank with the objective of maximizing agent's welfare.

As analyzed above, choosing μ is equivalent to choosing x, while choosing τ is equivalent to choosing c. Thus, we can write the problem of the monetary and fiscal authorities in terms of allocations and debt only. Since the two institutions move simultaneously, they will each take as given the policy followed by the other.

Suppose the fiscal authority expects current and future monetary authorities to implement $\mathcal{X}(B)$. Then, the problem of the current fiscal authority is

$$\mathcal{F}(B) = \max_{B',c,g} \ \omega\left\{\frac{u(\mathcal{X}(B)) - f(\mathcal{X}(B))}{2} + U(c) - \alpha(c+g) + v(g)\right\} + (1-\omega)g + \beta\mathcal{F}(B')$$

subject to

$$\varepsilon(B, B', \mathcal{X}(B), \mathcal{X}(B'), c, g) = 0.$$

Let us consider the monetary side now. Suppose the monetary authority expects current and future fiscal authorities to implement $\mathcal{C}(B)$ and $\mathcal{G}(B)$, and future monetary authorities to implement $\mathcal{X}(B)$. Then, the problem of the current monetary authority is

$$\mathcal{M}(B) = \max_{B',x} \ \Omega\left\{\frac{u(x) - f(x)}{2} + U(\mathcal{C}(B)) - \alpha(\mathcal{C}(B) + \mathcal{G}(B)) + v(\mathcal{G}(B))\right\} + (1-\Omega)\mathcal{G}(B) + \beta\mathcal{M}(B')$$

subject to

$$\begin{aligned}
\varepsilon(B, B', x, \mathcal{X}(B'), \mathcal{C}(B), \mathcal{G}(B)) &= 0 \\
u_x - f_x &\geq 0.
\end{aligned}$$

A Markov-Perfect Monetary equilibrium (MPME) is a set of functions $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}, \mathcal{F}, \mathcal{M}\}$ that solve both problems above for all B.

Proposition 4 *For any $B \geq -1$, a MPME when the fiscal and monetary authority move simultaneously each period is characterized by:*

$$\begin{aligned}
\lambda(\varepsilon_{B'} + \varepsilon_{x'}\mathcal{X}'_B) + \beta\lambda'\varepsilon'_B + \beta\Big\{\frac{\omega(u'_x - f'_x)}{2} + \lambda'\varepsilon'_x\Big\}\mathcal{X}'_B &= 0 \quad (18)\\
\Lambda(\varepsilon_{B'} + \varepsilon_{x'}\mathcal{X}'_B) + \beta\Lambda'\varepsilon'_B + \beta\Big\{(\Omega(u'_c - \alpha) + \Lambda'\varepsilon'_c)\mathcal{C}'_B + (\Omega(-\alpha + v'_g - 1) + 1 - \alpha\Lambda')\mathcal{G}'_B\Big\} &= 0 \quad (19)\\
(\omega v_g + 1 - \omega)(U_c - \alpha) + (\omega(v_g - \alpha) + 1 - \omega)U_{cc}c &= 0 \quad (20)\\
(U_c - \alpha)c - \alpha g + \frac{\beta x'(u'_x + f'_x)}{2} + \beta f'_x x' B' - f_x x(1+B) &= 0, (21)
\end{aligned}$$

where $\lambda = (\omega(v_g - \alpha) + 1 - \omega)/\alpha$ and $\Lambda = -\Omega(u_x - f_x)/(2\varepsilon_x)$.

Proof. The first-order conditions for the fiscal authority imply

$$\begin{aligned}
\lambda(\varepsilon_{B'} + \varepsilon_{x'}\mathcal{X}'_B) + \beta\lambda'\varepsilon'_B + \beta\Big(\frac{\omega(u'_x - f'_x)}{2} + \lambda'\varepsilon'_x\Big)\mathcal{X}'_B &= 0\\
\omega(U_c - \alpha) + \lambda\varepsilon_c &= 0\\
\omega(-\alpha + v_g) + 1 - \omega + \lambda\varepsilon_g &= 0,
\end{aligned}$$

where λ is the Lagrange multiplier associated with the government budget constraint.

The first-order conditions for the monetary authority imply

$$\begin{aligned}
\Lambda(\varepsilon_{B'} + \varepsilon_{x'}\mathcal{X}'_B) + \beta\Lambda'\varepsilon'_B + \beta(\Omega(U'_c - \alpha) + \Lambda'\varepsilon'_c)\mathcal{C}'_B + \beta(\Omega(-\alpha + v'_g) + 1 - \Omega + \Lambda'\varepsilon'_g)\mathcal{G}'_B &= 0\\
\frac{\Omega(u_x - f_x)}{2} + \Lambda\varepsilon_x + \zeta(u_{xx} - f_{xx}) &= 0,
\end{aligned}$$

where Λ and ζ are the Lagrange multipliers associated with the government budget constraint and the non-negativity constraint, respectively. Using an argument similar to that of Lemma 1, we get $\zeta = 0$ for $B \geq -1$.

The expressions in the statement of the proposition follow from suitably rearranging all the above equations. ■

The first two terms of (18) and (19) look functionally similar. The third term in each equation reflects the fact that each authority needs to take into account how its current actions affect the other institution's future policy. This is reflected in the derivatives of the policy functions.

Proposition 5 *If $\omega \neq \Omega$ then the distortionary steady state with two government authorities differs from the distortionary steady state with one government authority.*

Proof. At the distortionary steady state, we have $\lambda > 0$ and $\Lambda > 0$. The GEEs for the fiscal and monetary authority become

$$\begin{aligned}
\beta\varepsilon_x(\Omega\lambda - \Lambda\omega) + \Omega\lambda\varepsilon_{x'} &= 0 \quad (22)\\
\omega\Lambda\varepsilon_{x'}\mathcal{X}_B + \beta(-\Omega\lambda + \omega\Lambda)\varepsilon_c\mathcal{C}_B + \beta(-\Omega(1 - \alpha\lambda) + \omega(1 - \alpha\Lambda))\mathcal{G}_B &= 0. \quad (23)
\end{aligned}$$

Regardless of the degree of benevolence of the government with a single policy authority, the distortionary steady state features $\varepsilon_{x'} = 0$, $\varepsilon_x < 0$. If the solutions to the two problems were there same, then from (11) and (12) we get $(u_c - \alpha)/\varepsilon_c = (u_x - f_x)/(2\varepsilon_x)$, which implies $\Omega\lambda = \omega\Lambda$. Then, (22) is automatically satisfied since $\varepsilon_{x'} = 0$ and (23) becomes $\beta(-\Omega + \omega)\mathcal{G}_B = 0$, which cannot be satisfied for $\omega \neq \Omega$. ■

One critical feature of the steady state with an independent central bank is that it depends on the derivatives of policy functions $\mathcal{X}$, $\mathcal{C}$ and $\mathcal{G}$.

4.2 Sequential actions

Arguably, central banks operate at higher frequencies than fiscal bodies. For example, in the U.S., the federal budget is submitted by the the President to Congress before the beginning of each fiscal year[7], whereas the Federal Open Market Committee holds eight scheduled meetings each year to determine the Federal Reserve's stance on monetary policy.

One way to address the frequency disconnect described above is to allow the central bank in the model to move *after* the fiscal authority has announced its policy for the period. The two authorities will now play a sequential game with each other and both future selves. Since monetary policy directly affects agents' decisions in the day, let us keep the assumption that the central bank announces its policy *before* agents take decisions. Thus, the monetary authority's problem is the same as in the case of simultaneous actions and its behavior is still characterized by (19).

Since the fiscal authority moves before the central bank, it will take the optimal behavior of the current monetary authority as given. In other words, (19) will be a constraint in the fiscal authorities problem. We can write (19) in compact form as

$$\phi(B, B', x, \mathcal{X}(B'), \mathcal{C}(B'), \mathcal{G}(B')) = 0. \tag{24}$$

Note that the equation above also contains the derivatives of the equilibrium functions $\mathcal{X}$, $\mathcal{C}$ and $\mathcal{G}$, evaluated tomorrow. Also note that current c and g do not affect the central bank's current policy.

Suppose the fiscal authority expects future governments to implement $\{\mathcal{X}(B), \mathcal{C}(B), \mathcal{G}(B)\}$. Then, the problem of the current fiscal authority is

$$\widetilde{\mathcal{F}}(B) = \max_{B',x,c,g} \ \omega \left\{ \frac{u(x) - f(x)}{2} + U(c) - \alpha(c+g) + v(g) \right\} + (1-\omega)g + \beta \widetilde{\mathcal{F}}(B')$$

subject to

$$\begin{aligned} \varepsilon(B, B', \mathcal{X}(B), \mathcal{X}(B'), c, g) &= 0 \\ \phi(B, B', x, \mathcal{X}(B'), \mathcal{C}(B'), \mathcal{G}(B')) &= 0 \\ u_x - f_x &\geq 0. \end{aligned}$$

[7] There is some discretion in the form of supplemental appropriation and emergency bills, but fiscal policy is largely determined once a year.

The first-order conditions are

$$
\begin{aligned}
\lambda(\varepsilon_{B'} + \varepsilon_{x'}\mathcal{X}'_B) + \kappa(\phi_{B'} + \phi_{x'}\mathcal{X}'_B + \phi_{c'}\mathcal{C}'_B + \phi_{g'}\mathcal{G}'_B) + \beta(\lambda'\varepsilon'_B + \kappa'\phi'_B) &= 0 \\
\frac{\omega(u_x - f_x)}{2} + \lambda\varepsilon_x + \kappa\phi_x + \zeta(u_{xx} - f_{xx}) &= 0 \\
\omega(U_c - \alpha) + \lambda\varepsilon_c &= 0 \\
\omega(-\alpha + v_g) + 1 - \omega + \lambda\varepsilon_g &= 0.
\end{aligned}
$$

5 Numerical Evaluation

5.1 Basic calibration

The model has definite predictions for the following policy variables: debt, inflation, taxes, real interest rate, expenditure and velocity of circulation. All these variables enter the government budget constraint (indirectly in the case of velocity); thus, we cannot target all of them since the constraint needs to be satisfied. I will take the tax rate τ as the residual. This leaves five targets.

Consider the following functional forms:

$$
\begin{aligned}
u(x) &= \frac{x^{1-\sigma} - 1}{1-\sigma} \\
f(x) &= \theta x \\
U(c) &= \frac{c^{1-\rho} - 1}{1-\rho} \\
v(g) &= \ln g.
\end{aligned}
$$

The parameters are then: α, β, ω, Ω, ρ, σ and θ. Let us take ω and Ω, which represent the degree of government benevolence, as a free parameters for now. Specifically, let $\omega = 0.5$ and $\Omega = 1$.

We will be calibrating the environment without an independent central bank and evaluate the effects of passing a reform that endows the central bank with independence, as defined in the previous section. As a benchmark, we will consider the case of simultaneous actions. The calibration targets for the real interest rate, expenditure and velocity are taken from U.S. annual data for the period 1962-2006. On the other hand, since we want to analyze the effect of increased central bank independence, let us theorize that a reform occurred at some point in the early 80s. Thus, for inflation and debt over GDP, take the averages for the 1970-1982 period.

First, define nominal GDP as the sum of nominal output in the day and night markets. Let y be nominal GDP normalized by the aggregate money stock, i.e., $y = \frac{\tilde{p}x}{2} + p(c+g)$. Since $\tilde{p} = \frac{1}{x}$ we get $y = \frac{1}{2} + p(c+g)$. Note that by the equation of exchange, velocity of circulation is defined as the nominal GDP divided by the aggregate money stock. Thus, the first target is to set y^* equal to the velocity of circulation in the data. If we take M_1 as the definition of money, then velocity is 6.3.

The change in the price level in the day and night markets are $\frac{\tilde{p}'(1+\mu)}{\tilde{p}}$ and $\frac{p'(1+\mu)}{p}$, respectively. Thus, in steady state we get $\pi^* = \mu^*$, where π is the inflation rate, i.e., the change in the aggregate price level. Using the CPI as the measure of the price level, the inflation rate for 1970-1982 averaged 7.8% annual.

The third target is debt over GDP. Government debt is measured at the end of the period. Thus, the relevant numerator is $B^*(1+\mu^*)$. Since B is the bond-to-money ratio, debt over GDP is given by $\frac{B^*(1+\mu^*)}{y^*}$. In the U.S., debt over GDP, excluding holdings by federal agencies and the Federal Reserve Banks, averaged 20.8% between 1970 and 1982. Given that we are targeting $\mu^* = 0.078$ and $y^* = 6.3$, this implies a target for B^* roughly equal to 1.216.

Evaluating (4) and (7) in steady state, we get $q^*(1+\mu^*) = \beta$. Given that $q \equiv \frac{1}{1+R}$, where R is the nominal interest rate, $\beta = \frac{1+\mu^*}{1+R^*}$. For the nominal interest rate, we take the 1-year treasury constant maturity rate, which averaged 6.3% annual between 1962 and 2006. For the same period, inflation averaged 4.4% annual. Thus, $\beta = \frac{1.044}{1.063} \approx 0.982$.

The last target is government expenditure. In the model, pg represents nominal government expenditure normalized by the aggregate money stock. In the data, federal government outlays, net of debt interest payments, averaged 18% per year in terms of GDP. Thus, we set $\frac{p^*g^*}{y^*} = 0.18$ or, equivalently, $p^*g^* = 1.134$. This also allows us to simplify the target for velocity. We have $y^* = 0.5 + p^*(c^* + g^*) = 6.3$. Given, $p^*g^* = 1.134$ this implies a target $p^*c^* = 4.666$.

Using (1), we can write labor taxes in terms of all the above targets. After some work we get $\tau^* = \frac{(1-\beta)B^* - \mu + p^*g^*}{p^*c^* + p^*g^*} \approx 0.186$. The strategy is then to choose α, ρ, σ and θ so that $B^* = 1.216$, $\mu^* = 0.078$, $p^*g^* = 4.666$ and $p^*c^* = 1.134$. Table 1 summarizes the parameter choice.

Table 1: Calibrated Parameters

α	β	ω	ρ	σ	θ
7.471	0.982	0.500	4.413	3.872	1.345

5.2 The effects of central bank independence

To evaluate the effects of a reform that makes the central bank independent, we can compare the policy functions and steady state statistics of the environments with and without central bank independence. I consider three cases: "BNV" (benevolent) corresponds to the case $\omega = \Omega = 1$ and is presented as a benchmark; "PR" (pre-reform) features $\omega = \Omega = 0.5$ and corresponds to an environment with political frictions and without an independent central bank; and "ICB" (independent central bank with simultaneous actions) features $\omega = 0.5$, $\Omega = 1$ and corresponds to an environment with political frictions and an independent (benevolent) central bank. Figures 1—3 show debt, money growth rate and taxes as functions of current debt, for all cases considered. Table 2 reports steady state statistics.

In terms of debt policy, Figure 1 shows that the differences between the cases "BNV" and "PR" are insignificant. On the other hand, the case "ICB" shows significantly higher debt. Figure 2 shows that an independent central bank (ICB) implements a money growth policy indistinguishable from that of a benevolent government (BNV) and lower than a non-benevolent government without an independent central bank (PR). Figure 3 shows that the tax function with an independent central bank (ICB) lies in between the other tow cases, but is much closer to that of the pre-reform government (PR) than a benevolent one (BNV).

Table 2: Selected steady state statistics

	BNV	PR	ICB
$B(1+\mu)/y$	0.209	0.208	0.246
π	0.066	0.078	0.078
τ	0.167	0.186	0.187
pg/y	0.160	0.180	0.180
Velocity	6.025	6.301	6.306

BNV: $\omega = \Omega = 1$*; PR:* $\omega = \Omega = 0.5$*; ICB:* $\omega = 0.5$, $\Omega = 1$.

Figures 1—3 show that for any given level of debt, a reform that makes the central bank independent from political frictions implies higher debt, lower inflation and lower taxes. Table 2 shows that the differences in inflation and tax rates between the cases with and without an independent central bank vanish in the long-run. In effect, the only salient difference between these two cases is debt over GDP. What happens is the following. An independent central bank implements an inflation policy similar to a benevolent government. This in turn, generates more debt as a lower fraction of the expenditure is financed with inflation. As debt grows, both taxes and inflation grow to finance the added financial burden. In the end, debt increases and both inflation and taxes return to their respective initial levels. It is worth noting that results are not significantly different if instead, we analyze the case with sequential actions.

Next, I verify that the reform increases welfare. At the pre-reform steady state, agents are willing to give consumption in order to switch to a regime with an independent central bank. However, the consumption equivalence measure—although positive—is insignificant. To check that agents are indeed better-off with a reform, I solve for Δ such that

$$\frac{u(x^*(1+\Delta)) - f(x^*)}{2} + +U(c^*(1+\Delta)) - \alpha(c^* + g^*) + v(g^*) + \beta V(B^*) = V^{ICB}(B^*),$$

where all steady state variables correspond to case PR and V^{ICB} is the value function of the agent under regime ICB. Thus, Δ represents the one-time fee (in terms of consumption) that agents would be willing to pay to make the central bank independent. For benchmark parameters, we get $\Delta = 0.003\%$.

5.3 Robustness

To verify the robustness of the above results, I perform some comparative statics and consider alternative specifications for the utility functions.

Table 3 shows policy variables at steady state for cases PR and ICB for perturbed values for α, ω, ρ and σ. In all cases, the steady state statistics for the pre-reform economy (PR) are significantly different from benchmark. As we can see, debt over GDP is the only variable that registers a significant long-run change after a central bank becomes independent. Inflation, taxes and expenditure all show insignificant long-run variations. Of particular interest is the case with an initially less benevolent government. As Table 3 shows, when $\omega = 0.3$ the increase in debt over GDP

Table 3: Comparative statics at steady states

	$\alpha = 5.000$		$\omega = 0.300$		$\rho = 7.000$		$\sigma = 5.000$	
	PR	ICB	PR	ICB	PR	ICB	PR	ICB
$B(1+\mu)/y$	0.270	0.341	0.206	0.328	0.159	0.194	0.360	0.416
π	0.116	0.117	0.099	0.101	0.032	0.033	0.110	0.111
τ	0.245	0.246	0.220	0.222	0.169	0.169	0.183	0.183
pg/y	0.239	0.239	0.215	0.215	0.158	0.158	0.180	0.180

All parameters at benchmark except where noted. PR: $\Omega = \omega$; ICB: $\Omega = 1$.

after the reform, about 12 percentage points, is much larger than in the benchmark case (about three times as large). Figure 4 shows the change in long-run debt over GDP for different values of ω. The welfare gains of reform are also larger the smaller ω. For $\omega = 0.3$ we get $\Delta = 0.032\%$, i.e., welfare gains an order of magnitude higher than under benchmark.

Table 4 and Figure 5 show steady state debt over GDP as a function of (ω, Ω). The idea is to evaluate how non-linear the changes in debt are as a function of Ω, for different degrees of political frictions (i.e., ω). As we can see, half the total change in debt over GDP after the central bank reform comes from increasing Ω by 0.2. For example, if $\omega = 0.3$ then debt over GDP increases 0.061 percentage points if Ω increases from 0.3 to 0.5, whereas it would increase by 0.122 percentage points if Ω goes all the way to 1. Thus, even partial central bank reform may have significant changes in debt. As before, inflation, taxes and expenditure do not change significantly.

Table 4: Steady State Debt/GDP as a function of ω and Ω

$\Omega =$	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
$\omega = 0.3$	0.206	0.242	0.267	0.286	0.300	0.311	0.320	0.328
$\omega = 0.5$	0.191	0.167	0.208	0.220	0.229	0.236	0.241	0.246
$\omega = 0.7$	0.155	0.176	0.191	0.201	0.209	0.215	0.219	0.223

Next, I explore the possibility that the results are due to particular functional forms chosen. I focus on the utility functions for c and g. Consider the following alternative specification:

$$
\begin{aligned}
U(c) &= \frac{\gamma(c^{1-\rho} - 1)}{1-\rho} \\
v(g) &= \frac{(1-\gamma)(g^{1-\psi} - 1)}{1-\psi}.
\end{aligned}
$$

I keep the same values for β, σ and ρ. Since there is now an additional parameter—ψ—I set $\theta = 1$. To match the calibration targets for the pre-reform case, I set $\alpha = 7.471$, $\gamma = 0.900$ and $\psi = 2.083$. The steady state with an independent central bank and simultaneous actions now features: $B(1+\mu)/y = 0.232$, $\pi = 0.078$, $\tau = 0.186$, $pg/y = 0.180$ and Velocity$= 6.304$. The statistics are not significantly different from the benchmark case, except for debt over GDP, which now increases by less. The statistics are the same for the case with sequential actions.

Now consider non-separable utility in c and g, i.e., let

$$U(c,g) = \frac{\left(\gamma c^{\psi} + (1-\gamma) g^{\psi}\right)^{\frac{1-\rho}{\psi}} - 1}{1-\rho}$$

The non-separability assumption does not change the functional forms of the equations used above (simply replace v_g by U_g), except for the partial derivative of the government budget constraint with respect to g. We now have $\varepsilon_g = U_{cg} c - \alpha$.

I keep β and σ at their benchmark values and again set $\theta = 1$. The parametrization that targets the pre-reform statistics features now $\alpha = 4.403$, $\gamma = 0.850$, $\psi = -0.049$, $\rho = 5.049$. The steady state with an independent central bank and simultaneous actions features: $B(1+\mu)/y = 0.278$, $\pi = 0.078$, $\tau = 0.187$, $pg/y = 0.180$ and Velocity$= 6.304$. Again, the only significant change is debt over GDP, which now by quite a bit more relative to the benchmark. In this case, the variant with sequential actions implies a larger increase in debt over GDP, going to 0.283.

6 Empirical Support for the Theory

How can we evaluate the empirical validity of the findings in this paper? A quick survey of news articles would indicate that the perceived independence of the Federal Reserve from other political bodies has changed dramatically in the last three decades, especially in terms of inflation policy.[8] Though there has been no major formal reform since the Treasury-Federal Reserve Accord of 1951, the general perception is that the Federal Reserve has become more independent in recent time. A notable example is given by Abrams (2006) who elaborates on how then Fed chairman Arthur Burns was successfully pressured by President Nixon to run expansionary monetary policy.

Looking at examples of formal policy or institutional reform in other countries is problematic since these reforms may not have been binding. For example, Bernanke, Laubach, Mishkin and Posen (1999) argue that both Canada and New Zealand adopted formal inflation targets only after inflation was significantly reduced and the success of achieving the targets appeared likely. In this view, inflation targeting did not put a constraint of policy, but rather made pre-existing policy objectives explicit. The "real" central bank reform came about whenever the central bank managed to set its monetary policy independent from the fiscal authority's financing needs or other policy objectives.

Figure 6 shows that during the 1980s, the U.S. and other industrialized countries experienced sharp increases in debt that were not associated with corresponding increases in financing needs.[9] This increase in debt follows a decade of high and volatile inflation. The data shows that between 1981 and 1991, the increase in debt over GDP was about 20 percentage points, whereas federal outlays and revenue kept roughly constant. Inflation, although lower than in the 1970s, stabilized around historical levels. The theory in this paper provides a plausible explanation for the large

[8] Links are available at http://www.sfu.ca/∼fmartin.

[9] The debt increase has long puzzled economist, although some theories have been proposed, mainly in the political economy literature. See Persson and Tabellini (1998) for a survey.

increase in debt, as long as one is willing to accept that the Federal Reserve became more independent around the late 1970s or early 1980s, as the anecdotal evidence cited above suggests. The theory also suggests that the Great Inflation of the 1970s and its resolution were not associated with the degree of central bank independence. As Posen (1993) argues, the inflation performance of the 1970s may have created a demand for both lower long-run inflation and central bank independence. Similarly, Meltzer (2009) argues that the end of the 1970s inflation in the U.S. was mainly due to a change in public attitudes about inflation.

The numerical exercises suggest that central bank independence may have been responsible for the increase in debt during the 1980s, but is not the cause for the lower inflation observed. This last result is consistent with the empirical literature—most notably Campillo and Miron (1997) and Posen (1993) which propose that central bank independence does not determine inflation performance.

References

[1] Abrams, B. A. (2006), "How Richard Nixon Pressured Arthur Burns: Evidence from the Nixon Tapes", *The Journal of Economic Perspectives*, 20(4), 177-188.

[2] Aruoba, S. B., Waller, C. and Wright, R. (2007), "Money and Capital", Working Paper 0714, Federal Reserve Bank of Cleveland.

[3] Barro, R. J. and Gordon, D. B. (1983), "A positive theory of monetary policy in a natural-rate model", *The Journal of Political Economy*, 91, 589-610.

[4] Bernanke, B. S., Laubach, T., Mishkin, F. S. and Posen, A. S. (1999), "Inflation Targeting. Lessons from the International Experience", Princeton University Press.

[5] Campillo, M. and Miron, J. 1997, "Why Does Inflation Differ Across Countries?" in C. D. Romer and D. H. Romer (eds), *Reducing Inflation: Motivation and Strategy*, University of Chicago Press, 335-357.

[6] Cukierman, A. (1992), "Central bank strategy, credibility, and independence: theory and evidence", The MIT Press.

[7] Lagos, R. and Wright, R. (2005), "A Unified Framework for Monetary Theory and Policy Analysis", *Journal of Political Economy*, 113(3), 463-484.

[8] Martin, F. M. (2009), "A Positive Theory of Government Debt", *Review of Economic Dynamics*, in press.

[9] Meltzer, A. H. (2009), "A History of the Federal Reserve, Volume 2, Book 1, 1951-1969", The University of Chicago Press.

[10] Persson, T. and Tabellini, G. (1998), "Political economics and macroeconomic policy", in J. B. Taylor and M. Woodford, eds., *Handbook of Macroeconomics*, Vol. 1C, North Holland, Amsterdam, chapter 22.

[11] Posen, A. (1993), "Why Central Bank Independence Does Not Cause Low Inflation: There is No Institutional Fix for Politics", in R. O'Brien (ed.), *Finance and the International Economy*, Oxford University Press 7, 1993, 40-65.

[12] Rogoff, K. (1985), "The Optimal Commitment to an Intermediate Monetary Target", *Quarterly Journal of Economics*, 100, 1169-1189.

[13] Telyukova, I. and Wright R. (2008), "A Model of Money and Credit, with Application to the Credit Card Debt Puzzle", *Review of Economic Studies*, 75(2), 629-647.

[14] Walsh, C. E. (2008), "Central Bank Independence", in S. N. Durlauf and L. E. Blume, eds., *The New Palgrave Dictionary of Economics*, 2nd edition, Palgrave Macmillan.

Figure 1: Debt

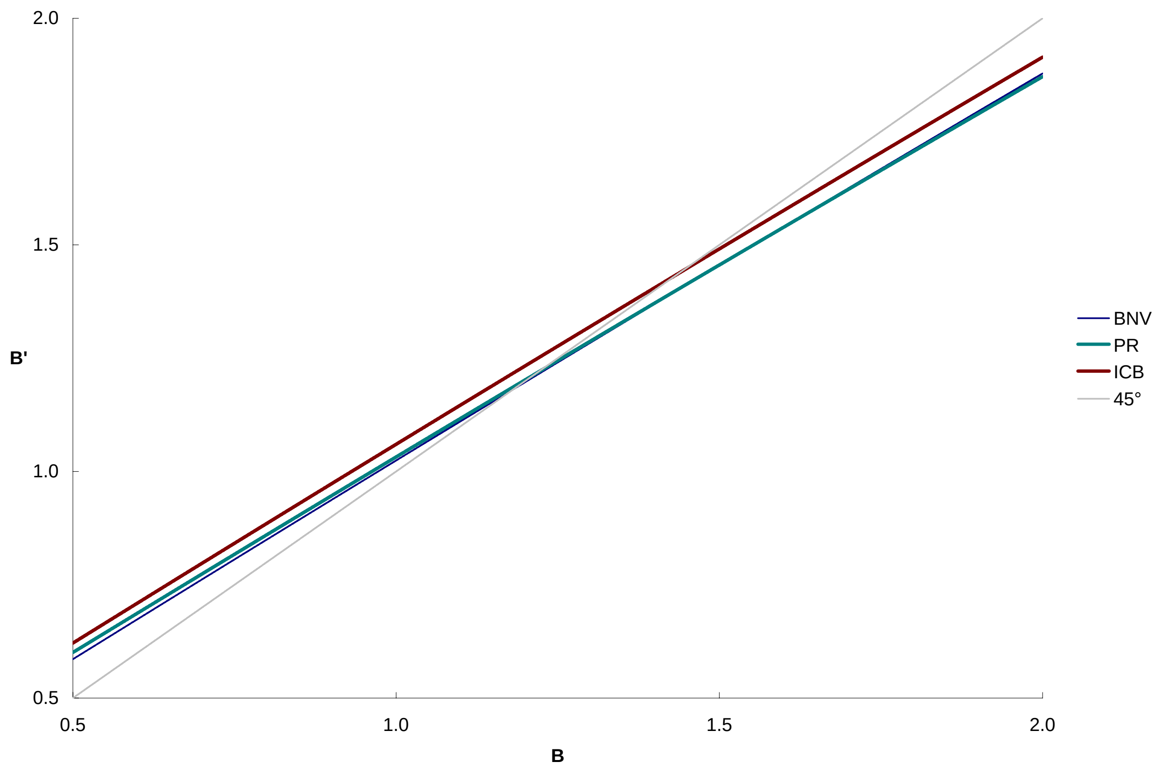

Figure 2: Money Growth Rate

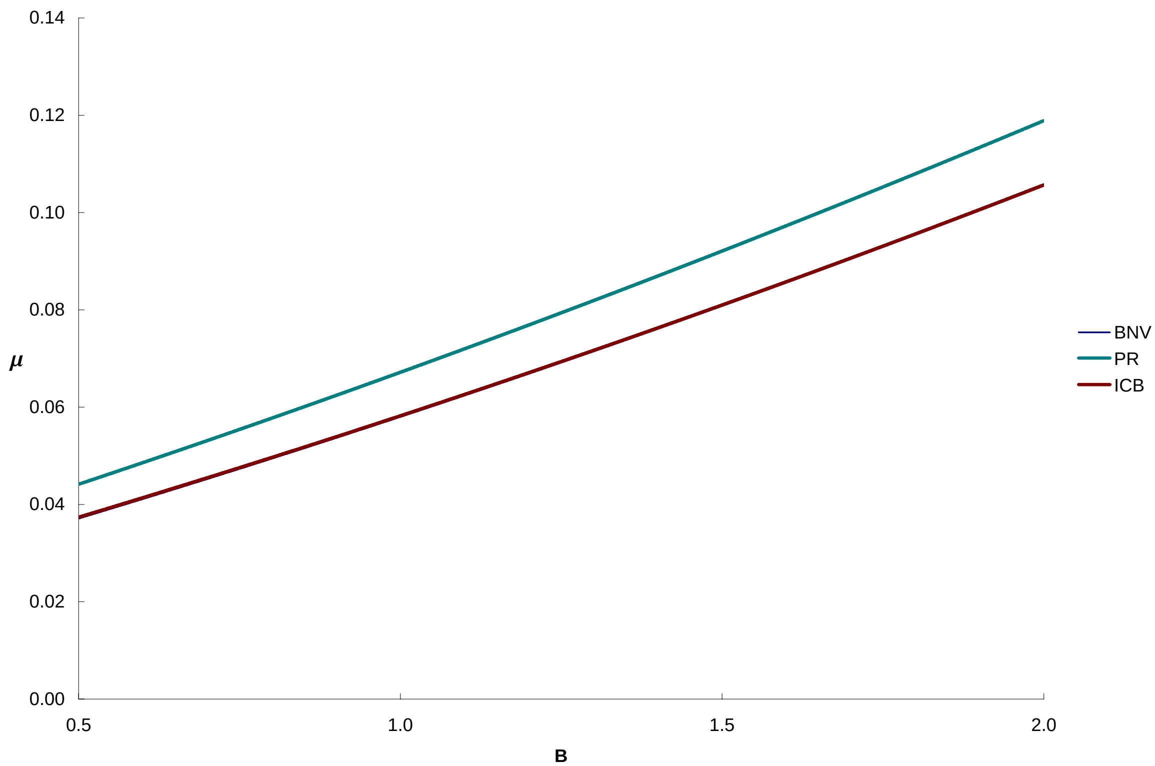

Figure 3: Tax Rates

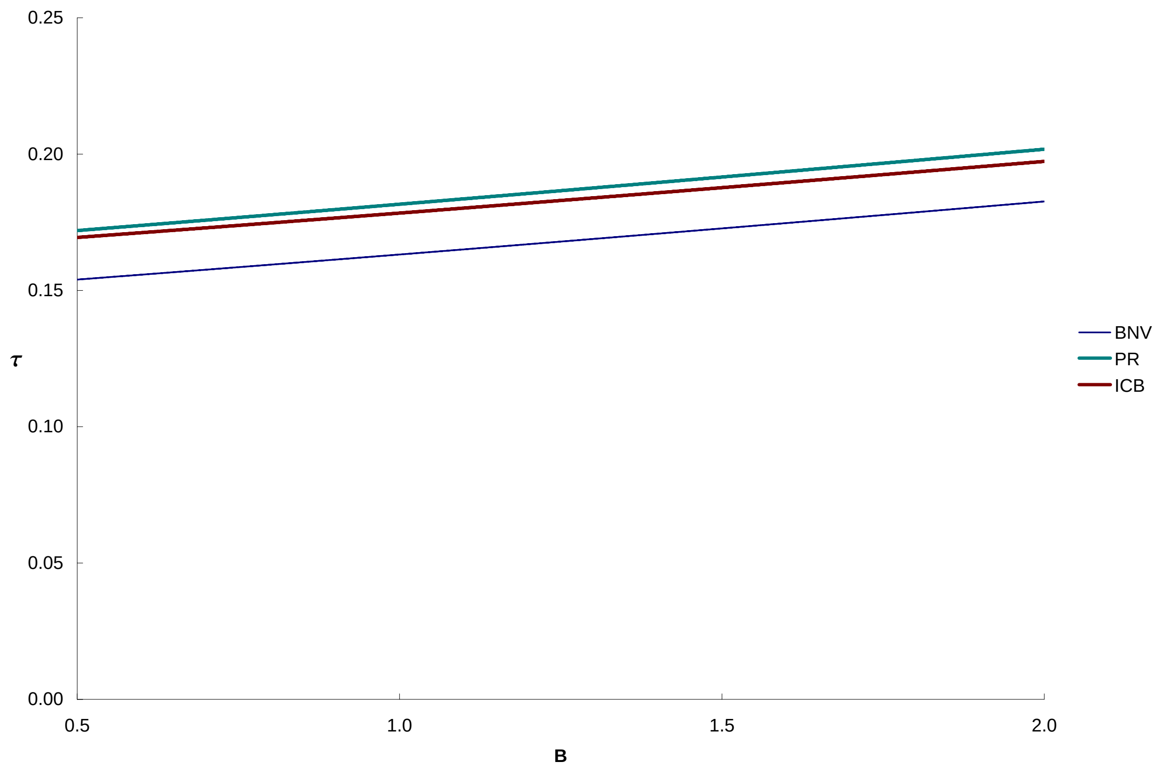

Figure 4: After-reform change in steady state Debt/GDP as a function of ω

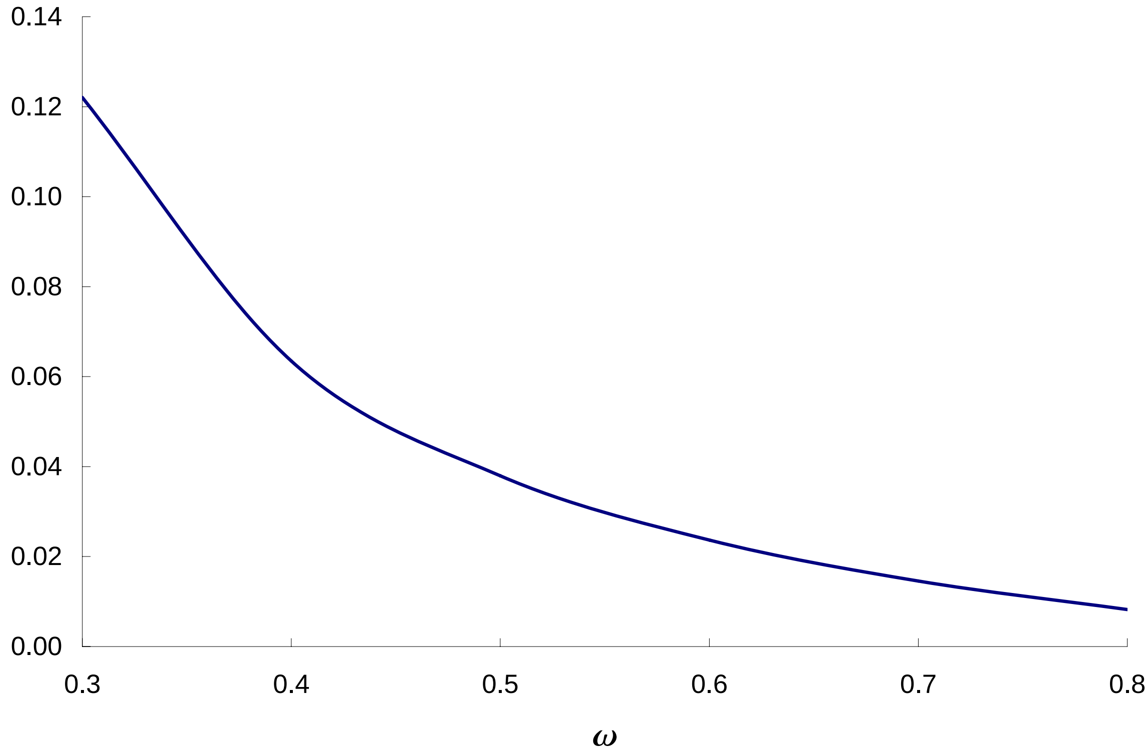

Figure 5: Steady state Debt/GDP as a function of ω and Ω

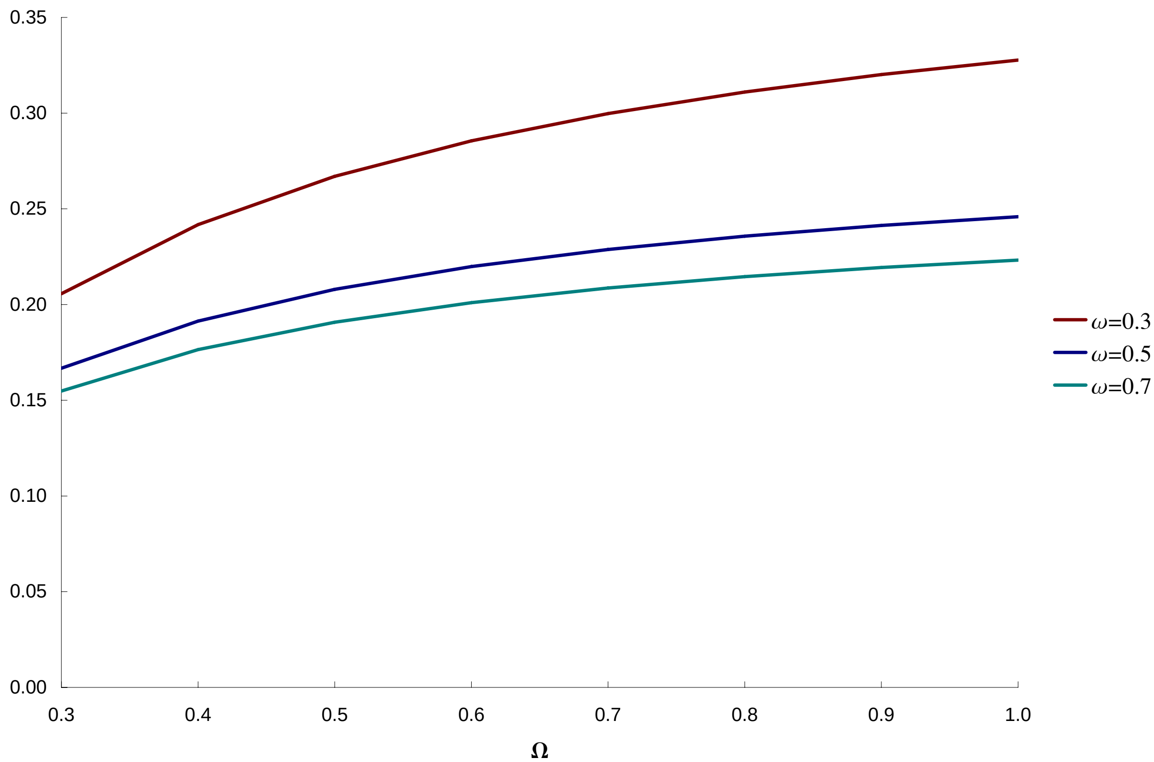

Figure 6: Debt, Expenditure and Inflation for Selected Countries