Central Bank Independence, Government Debt and the Re-Normalization of Interest Rates

Tatiana Kirsanova[†] Campbell Leith[‡] Ding Liu[§]

[†]University of Glasgow [‡]University of Glasgow [§]Chongqing University

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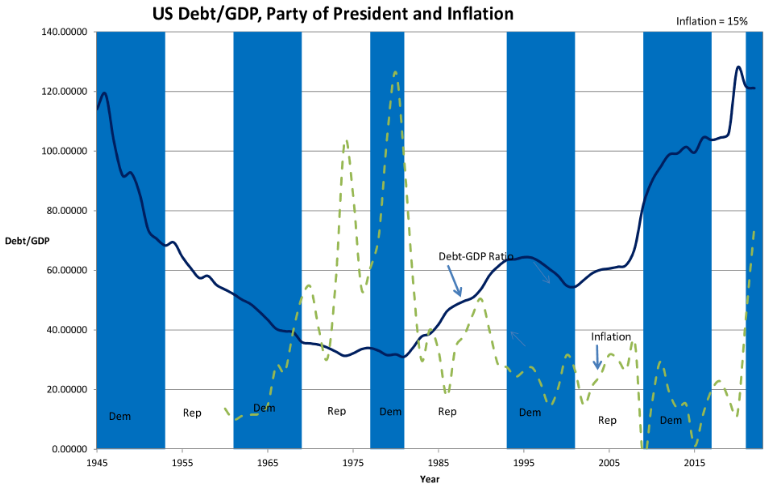
Motivation

- Surprisingly little interest in implications of high levels of government debt for (some?) central banks - perhaps independence precludes any 'unpleasant arithmetic'?
- We explore the possibility of stronger links between debt, inflation and interest rates than implicitly assumed even when central banks have full operational independence.

Motivation



US Debt/GDP, Party of President and Inflation
Inflation = 15%
140.00000
120.00000
100.00000
80.00000
60.00000
40.00000
20.00000
0.00000
Debt/GDP
Debt-GDP Ratio
Inflation
Dem
Rep
Dem
Rep
Dem
Rep
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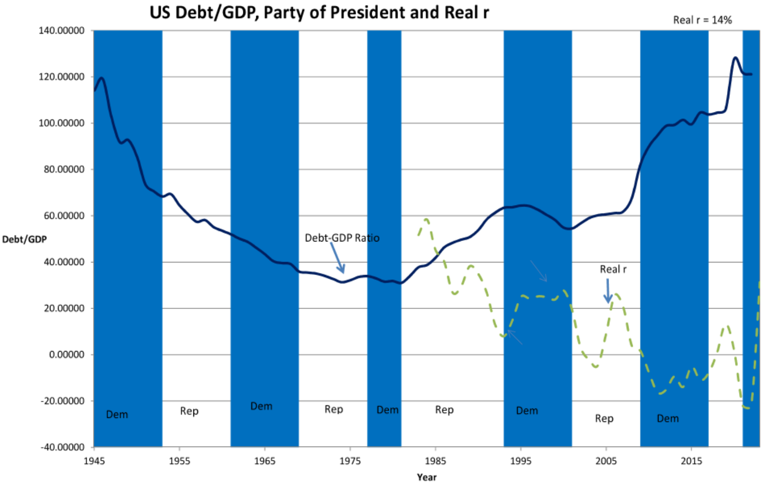
1945
1955
1965
1975
1985
1995
2005
2015
Year

Motivation


US Debt/GDP, Party of President and Real r
Real r = 14%
140.00000
120.00000
100.00000
80.00000
60.00000
40.00000
20.00000
0.00000
-20.00000
-40.00000
Debt/GDP
Debt-GDP Ratio
Real r
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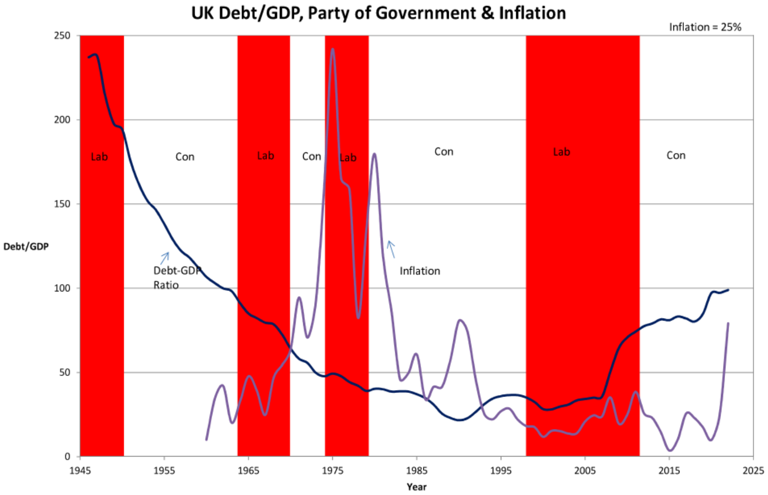

UK Debt/GDP, Party of Government & Inflation
Inflation = 25%
250
200
150
100
50
0
Debt/GDP
Lab
Con
Lab
Con
Lab
Con
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Debt-GDP
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1945
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What we do:

- Revisit desirability of central bank independence.
- New Keynesian model augmented with fiscal policy - sticky prices, distortionary taxes, public consumption and debt maturity.
- Monetary Authority: An instrument independent central bank with an aversion to inflation beyond its social cost.
- Fiscal Authority: Chooses tax rate, public consumption and issues long-term debt.
- Equilibrium Concept: Time-consistent simultaneous moves Nash equilibrium.
- Extensions: (i)Allow for 'crisis' with large output fall, increase in transfers and flight-to-safety, (ii)Debt targets.

What we don't do:

- Not a question of Fiscal Dominance/Unpleasant Monetarist Arithmetic.
- Davig et al (2010) and Bianchi and Melosi(2019,2020) consider uncertainty over the resolution of the game of chicken between the monetary and fiscal authorities.
- In our set-up the central bank never has any fiscal objectives and does not lose its inflation aversion regardless of the level of government debt.
- Each policy maker takes the policy of the other as given when acting to maximize their objectives.

Related Literature:

- New Keynesian Models: Dixit and Lambertini(2003), Adam and Billi(2008, 2014), Chen et al(2016), Kirsanova et al(2023) and Schreger et al(2023). Only latter is non-linear and has meaningful role for debt, but is two period model.
- Monetary Friction Models: Alvarez et al(2004), Chari et al (2007), Niemann (2011), Niemann et al(2013), Aguari et al(2015) and Martin (2015).
- Gnocchi(2013), de Beauffort(2022) and Camous and Matveev(2023) assume a degree of 'commitment' on the part of the monetary authority, along with leader/follower assumptions.

Debt Stabilization Bias:

- Leeper et al(2021) discuss the debt stabilization bias:
    - Ramsey policy implies tax smoothing in response to shocks.

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  - Coordinating policy makers reduce debt until marginal costs of fiscal consolidation equal costs of inflation bias.

Debt Stabilization Bias:

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  - But nominal debt gives rise to inflation bias.
  - Can offset bias by reducing debt.
  - Coordinating policy makers reduce debt until marginal costs of fiscal consolidation equal costs of inflation bias.
  - The return of debt to steady-state following shocks is a costly deviation from tax smoothing which we labelled the "debt stabilization bias".

What we find:

- Granting independence to a conservative central bank reduces inflation... initially.
- However, the central bank's intolerence of inflation reduces the costs to the government of issuing debt.
- Government debt rises.
- Eventually it rises so much that inflation is higher than it was pre-independence.
- If the government shares the central bank's inflation aversion debt is higher and welfare lower.
- The impact of a flight to safety can explain a substantial increase in debt, initially with a fall in inflation, but with a large subsequent increase when the economy re-normalizes.
- After exiting a crisis the central bank enhances its response to cost-push shocks.

Intuition - 2 Period Model

- Household period 1 budget constraint,

$$Q_{1,2}b_1 = \gamma - c_1 - \tau_1 + \nu_1 b_0 \tag{1}$$

where $b_j \equiv B_j/P_j$, $\nu_t = \Pi_t^{-1}$ and $Q_{t,t+1}$ is the price of zero coupon debt in period t, which matures in period $t+1$. Endowment, γ, finances consumption c_1, taxation τ_1 and net savings.

- Period 2,

$$0 = \gamma - c_1 - \tau_2 + \nu_2 b_1 \tag{2}$$

- Household Utility,

$$\sum_{t=1}^{2} \beta^{t-1} u(c_t) \tag{3}$$

- Since $c_t = \gamma$, the bond pricing equations reduce to,

$$\beta \nu_{t+1} = Q_{t,t+1} \tag{4}$$

Intuition - 2 Period Model

- The government's budget constraints then mirror those of the household, in period $t = 1$,

$$\beta \nu_2 b_1 = -\tau_1 + \nu_1 b_0 \tag{5}$$

and the final period $t = 2$,

$$\tau_2 = \nu_2 b_1 \tag{6}$$

- Intertemporal budget constraint,

$$b_0 \nu_1 = \tau_1 + \beta \tau_2 \tag{7}$$

Commitment Policy

- Lagrangian

$$\mathcal{L} = \sum_{t=1}^{2} \beta^{t-1}[-\frac{1}{2}\left(\tau_t^2 + \theta(\nu_t - 1)^2\right)]$$
$$+\lambda[b_0\nu_1 - \tau_1 - \beta\tau_2]$$

- Under commitment pure tax smoothing is applied. Inflation is only generated to the extent that the time $t = 1$ policy maker inherits debt from the previous period, $b_0 > 0$. In which case,

$$\frac{1}{\nu_1} = 1 + \theta^{-1}\frac{b_0^2}{(1+\beta)},\ \nu_2 = 1$$

and,

$$\tau_1 = \tau_2 = \frac{b_0\nu_1}{(1+\beta)}$$

Simultaneous Moves - Period 2

- Lagrangian

$$\mathcal{L} = -\frac{1}{2}\left(\tau_2^2 + \theta^F\left(\nu_2 - 1\right)^2\right) \\ + \lambda_2\left[-b_1\nu_2 + \tau_2\right]$$

- Optimal trade-off,

$$\theta^F \nu_2(1-\nu_2) = \tau_2^2 \qquad \text{(ICC)}$$

- The solution for taxation and deflation,

$$\tau_2 = \frac{\theta^F b_1}{\theta^F + b_1^2} \text{ and } \nu_2 = 1 - \frac{b_1^2}{\theta^F + b_1^2}$$

- N.B. Period 2 inflation, $\nu_2 < 1$, was anticipated when the debt was issued and does not help reduce the real value of debt.

Simultaneous Moves - Period 1

- Monetary Authority's Lagrangian

$$\mathcal{L} = \sum_{t=1}^{2} (\beta^M)^{t-1} [-\frac{1}{2} \left(\tau_t^2 + \theta^M (\nu_t - 1) \right)^2)] + \mu^M [b_0 \nu_1 - \tau_1 - \beta \tau_2] + \beta^M \lambda^M \left[-\theta^F \nu_2 (\nu_2 - 1) - \tau_2^2 \right]$$

which differs from the problem under commitment in three ways (1)the monetary authority may be more inflation averse, $\theta^M \geq \theta^F$, (2)they take the fiscal authority's tax policy in period 1, τ_1 as given and (3)they cannot make commitments about future behaviour and must respect the period 2 ICC.

- Can solve to get the central bank's reaction function,

$$\nu_1 = f^M(\tau_1, b_0)$$

Simultaneous Moves - Period 1

- Fiscal Authority's Lagrangian

$$\mathcal{L} = \sum_{t=1}^{2} (\beta^F)^{t-1} [-\frac{1}{2} \left(\tau_t^2 + \theta^F (\nu_t - 1) \right)^2)]$$
$$+ \mu^F [b_0 \nu_1 - \tau_1 - \beta \tau_2]$$
$$+ \beta^F \lambda^F \left[-\theta^F \nu_2 (\nu_2 - 1) - \tau_2^2 \right]$$

  Here the fiscal authority takes the central banks monetary policy (the value of ν_1) as given when setting its tax policy in period 1, and is also constrained by the ICC in period 2.

- Can solve to get the government's reaction function,

$$\tau_1 = f^F (\nu_1, b_0)$$

Impact of Central Bank Independence

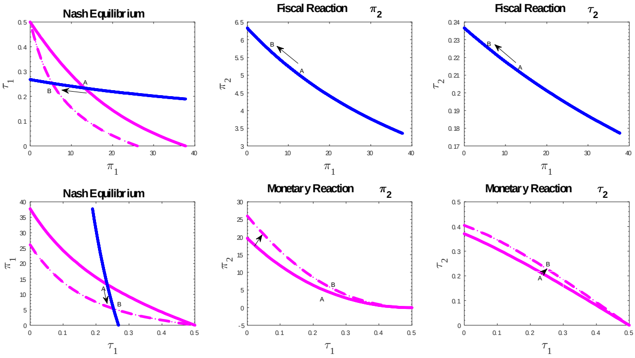

Figure: Nash Equilibrium Under Central Bank Independence

Increasing Central Bank Independence

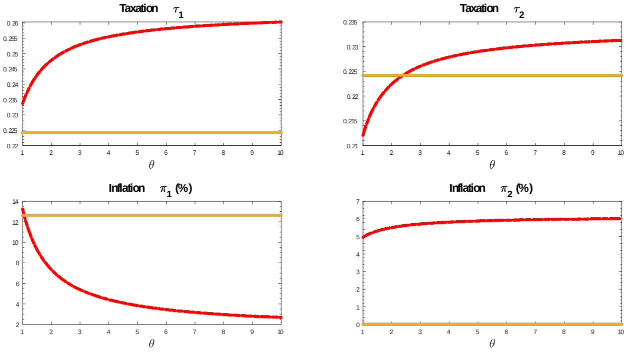

Figure: Impact of Inflation Aversion on Nash Equilibrium

The Environment

- Benchmark case: standard NK model, augmented with distortionary taxation, endogenous government spending and nominal debt of mixed maturity
- Households: consume, work, save by maximizing

$$E_0 \sum_{t=0}^{\infty} \left(\prod_{i=-1}^{t-1} \beta_i \right) \left(\frac{C_t^{1-\sigma}}{1-\sigma} + \chi \frac{G_t^{1-\sigma_g}}{1-\sigma_g} - \frac{N_t^{1+\varphi}}{1+\varphi} \right)$$

- Firms: monopolistically competitive, facing Rotemberg price adjustment costs
- Government:
  - monetary authority controls R_t
  - fiscal authority decides on G_t, τ_t and on debt policy b_t

Competitive Equilibrium Conditions

- Consumption Euler equation,

$$\beta_t R_t E_t \left\{ \left(\frac{C_t}{C_{t+1}} \right)^{\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right\} = 1$$

- Pricing of longer-term bonds,

$$\beta_t E_t \left\{ \left(\frac{C_t}{C_{t+1}} \right)^{\sigma} \left(\frac{P_t}{P_{t+1}} \right) \left(1 + \rho P_{t+1}^M \right) \right\} = P_t^M$$

- Labor supply,

$$N_t^{\varphi} C_t^{\sigma} = (1 - \tau_t) w_t$$

- Resource constraint,

$$Y_t \left[1 - \frac{\phi}{2} (\Pi_t - 1)^2 \right] = C_t + G_t$$

Competitive Equilibrium Conditions

- NKPC,

$$0 = (1 - \epsilon_t) + \epsilon_t mc_t - \phi \Pi_t (\Pi_t - 1)$$
$$+ \phi \beta E_t \left[\left(\frac{C_t}{C_{t+1}} \right)^{\sigma} \frac{Y_{t+1}}{Y_t} \Pi_{t+1} (\Pi_{t+1} - 1) \right]$$

- Government budget constraint,

$$P_t^M b_t = (1 + \rho P_t^M) \frac{b_{t-1}}{\Pi_t} - w_t N_t \tau_t + G_t + Tr_t$$

- Production technology,

$$Y_t = N_t$$

- Real marginal costs,

$$mc_t = w_t = \frac{Y_t^{\varphi} C_t^{\sigma}}{(1 - \tau_t)}$$

Optimal Policy Problem - Central Bank

- The Lagrangian for the policy problem is,

$$\mathcal{L}^m = (1-\alpha_\pi)\left(\frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\chi G_t^{1-\sigma_g}}{1-\sigma_g} - \frac{(Y_t)^{1+\varphi}}{1+\varphi}\right) - \frac{\alpha_\pi}{2}(\Pi_t - 1)^2 + \beta^M E_t[V_{t+1}^m(.)]$$

$$+ \lambda_{1t}^m \left[Y_t \left(1 - \frac{\phi}{2}(\Pi_t - 1)^2\right) - C_t - G_t \right]$$

$$+ \lambda_{2t}^m \left[\begin{array}{c} (1-\epsilon_t) + \epsilon_t (1-\tau_t)^{-1} Y_t^\varphi C_t^\sigma - \phi \Pi_t (\Pi_t - 1) \\ + \phi \beta_t C_t^\sigma Y_t^{-1} E_t [M(.)] \end{array} \right]$$

$$+ \lambda_{3t}^m \left[\begin{array}{c} \beta_t b_t C_t^\sigma E_t [L(.)] - \frac{b_{t-1}}{\Pi_t}\left(1 + \rho \beta_t C_t^\sigma E_t [L(.)]\right) \\ + \left(\frac{\tau_t}{1-\tau_t}\right)(Y_t)^{1+\varphi} C_t^\sigma - G_t \end{array} \right]$$

- Two auxilliary functions,

$$M(b_t, \beta_{t+1}, \epsilon_{t+1}) \equiv (C_{t+1})^{-\sigma} Y_{t+1} \Pi_{t+1} (\Pi_{t+1} - 1)$$

$$L(b_t, \beta_{t+1}, \epsilon_{t+1}) \equiv (C_{t+1})^{-\sigma} (\Pi_{t+1})^{-1} (1 + \rho P_{t+1}^M)$$

Key Policy Tradeoffs

- The FOC for Π_t shows the role of surprise inflation,

$$\underbrace{\underbrace{-\alpha_\pi\left(\Pi_t-1\right)}_{\text{additional cost of inflation aversion}}+\underbrace{\lambda_{1t}^m\left[\phi Y_t\left(\Pi_t-1\right)\right]}_{\text{resource cost of inflation, }\lambda_{1t}\geq 0}}_{\text{marginal cost}} =$$

$$\underbrace{\underbrace{\lambda_{3t}^m\left[\frac{b_{t-1}}{\Pi_t^2}\left(1+\rho\beta C_t^\sigma E_t\left[L(.)\right]\right)\right]}_{\text{eroding the real value of government debt, }\lambda_{3t}\geq 0} - \underbrace{\lambda_{2t}^m\left[\phi\left(2\Pi_t-1\right)\right]}_{\text{stimulating the economy, }\lambda_{2t}\leq 0}}_{\text{marginal benefit}}$$

Optimal Policy Problem - Fiscal Authority

- The Lagrangian for the policy problem is,

$$
\begin{aligned}
\mathcal{L}^f = {} & \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\chi G_t^{1-\sigma_g}}{1-\sigma_g} - \frac{(Y_t)^{1+\varphi}}{1+\varphi} + \beta^F E_t[V_{t+1}^f(.)] \\
& + \lambda_{1t}^f \left[Y_t \left(1 - \frac{\phi}{2} (\Pi_t - 1)^2 \right) - C_t - G_t \right] \\
& + \lambda_{2t}^f \left[\begin{array}{c} (1-\epsilon_t) + \epsilon_t (1-\tau_t)^{-1} Y_t^{\varphi} C_t^{\sigma} - \phi \Pi_t (\Pi_t - 1) \\ + \phi \beta_t C_t^{\sigma} Y_t^{-1} E_t [M(.)] \end{array} \right] \\
& + \lambda_{3t}^f \left[\begin{array}{c} \beta_t b_t C_t^{\sigma} E_t [L(.)] - \frac{b_{t-1}}{\Pi_t} (1 + \rho \beta_t C_t^{\sigma} E_t [L(.)]) \\ + \left(\frac{\tau_t}{1-\tau_t} \right) Y_t^{1+\varphi} C_t^{\sigma} - G_t \end{array} \right]
\end{aligned}
$$

Key Policy Tradeoffs

- The FOC for b_t shows the role of nominal debt in intertemporal tax distortion smoothing,

$$\underbrace{\lambda_{3t}^{f} P_t^M = \beta E_t\{\frac{\lambda_{3t+1}^{f}}{\Pi_{t+1}}(1+\rho P_{t+1}^M)\}}_{\text{trade-off between current and future distortions}}$$

$$\underbrace{+\lambda_{3t}^{f}\beta C_t^{\sigma}\left[\phi\epsilon^{-1}E_t\{M_1(b_t,.)\} - (b_t - \rho\frac{b_{t-1}}{\Pi_t})E_t\{L_1(b_t,.)\}\right]}_{\text{additional terms due to lack of commitment}}$$

- Higher debt raises expected inflation and lowers expected bond prices. Hence, $E_t\left[L_1(b_t,\beta_{t+1},\epsilon_{t+1})\right] < 0$ and $E_t\left[M_1(b_t,\beta_{t+1},\epsilon_{t+1})\right] > 0$. Intuitively, we can interpret $\lambda_{3t} \geq 0$ as the marginal cost of government debt.

Simultaneous Moves Nash Equilibrium

- The Nash solution to this simultaneous moves game is then obtained by simultaneously solving the FOCs for both policy makers alongside the three constraints.
- We solve for the following thirteen variables, $\{C_t, Y_t, \Pi_t, b_t, \tau_t, G_t, P_t^M, \lambda_{1t}^m, \lambda_{2t}^m, \lambda_{3t}^m, \lambda_{1t}^f, \lambda_{2t}^f, \lambda_{3t}^f\}$ using the three constraints, the bond pricing equation, and the nine first order conditions.
- Specifically, we need to find these thirteen time-invariant Markov-perfect equilibrium policy functions which depend on the three state variables $\{b_{t-1}, \beta_t, \epsilon_t\}$.
- We use the Chebyshev collocation method with time iteration to search for continuous MPE where policy rules depend only on payoff-relevant state variables $\{b_{t-1}, \beta_t, \epsilon_t\}$.

Calibration and Solution Method

Table: Parameterization

Parameter	Value	Definition
β	0.995	Quarterly discount factor
$\beta^F = \beta^M$	0.982	Policy Maker Myopia
σ	2	Relative risk aversion coefficient
σ^g	2	Relative risk aversion coefficient for government spending
φ	3	Inverse Frish elasticity of labor supply
ϵ	14.33	Elasticity of substitution between varieties
ρ	0.95	Debt maturity structure (about 5 years)
χ	0.0076	Scaling parameter associated with government spending
ρ_a	0.95	AR-coefficient of cost-push shock
σ_a	0.01	Standard deviation of cost-push shock
ϕ	50	Rotemberg adjustment cost coefficient (about 6 months)

- Steady-State: $\frac{bP^M}{4Y} = 41\%, (\Pi^4 - 1) = 3.2\%, Y = 0.97, G/Y = 7.8\%, \tau = 0.19$ and $r = 2\%$.

Inflation Aversion

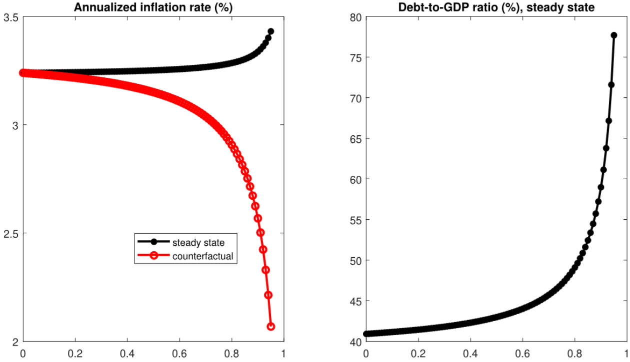

Figure: Increasing Central Bank Inflation Aversion

Impact of Central Bank Independence

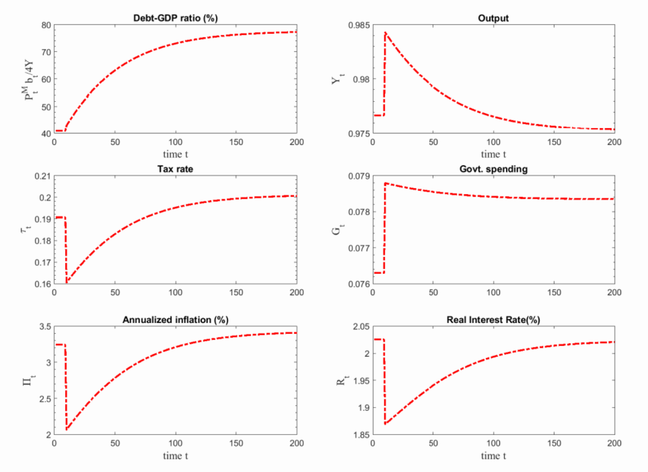

Figure: Impact of Granting Central Bank Independence

Welfare Gains from Central Bank Independence

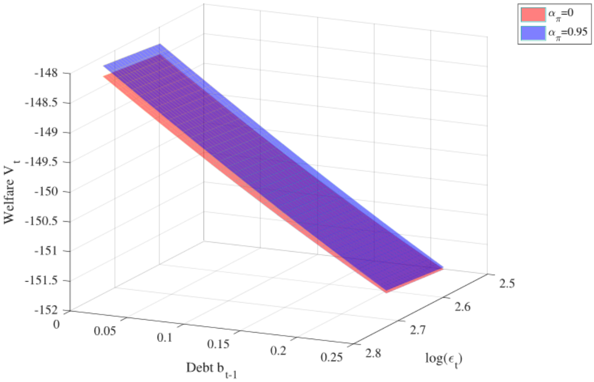

Figure: Welfare Gains from Central Bank Independence Across State Space

Policy Coordination

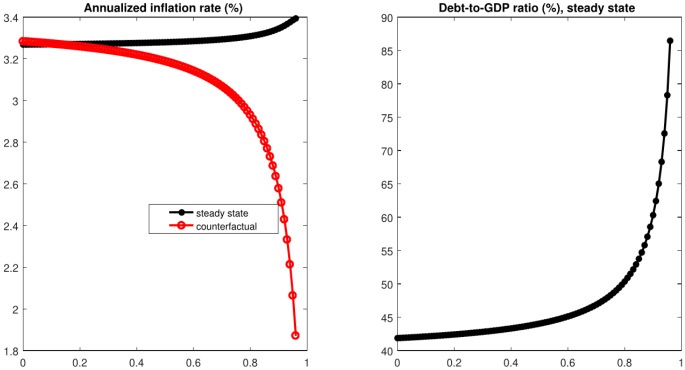

Figure: Coordinated Inflation Aversion

Welfare Cost of Policy Coordination

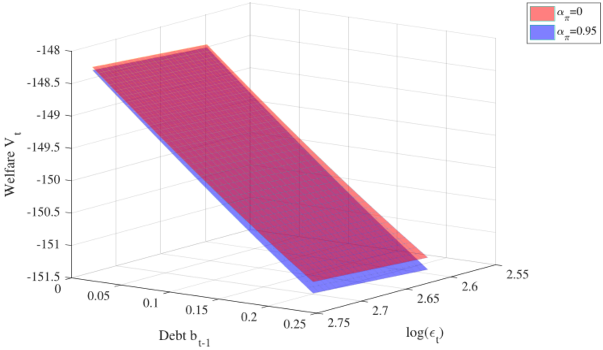

Figure: Coordinated Increase in Inflation Aversion

Policy Maker Myopia

- We first examine the case without any inflation aversion on the part of either policy maker, $\alpha_\pi = 0$, but allow for three possible permutations of β^M and β^F:
- $(1)\beta^M = \beta^F = \beta = 0.989$, $(2)\beta^M = 0.982 < \beta^F = 0.989$ and $(3)\beta^F = 0.982 < \beta^M = 0.989$.
- We then assume we were in the initial steady-state where $\beta^M = \beta^F = 0.982$ before, unexpectedly, one of these three cases emerges.
- We therefore capture the dynamic path from the old steady-state to the new in each case.

Myopia

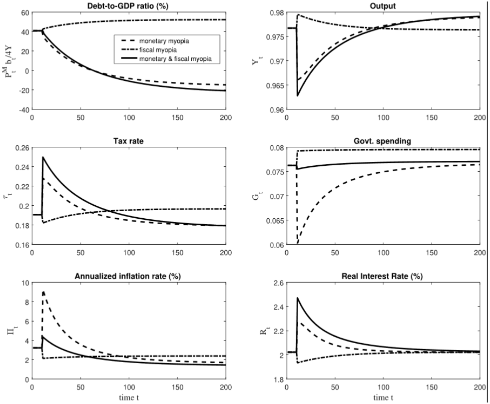

Figure: Decreasing Policy Maker Myopia

Impact of an unexpected crisis

- Once we are in steady-state conventional shocks (mark-up, technology, transfers etc) cannot explain the large movements in government debt we see in practice.
- In the US, we have not obviously seen an increase in central bank conservatism since the time of Volcker (see Chen et al(2016) and Kirsanova et al(2023)) which could explain the rise in debt.
- We have, however, seen a financial crisis/pandemic which gave rise to large falls in output, increases in fiscal transfers and a flight-to-safety.

Describing a Stylized Crisis

- Markov switching between 'normal' regime and a 'crisis' regime with transition matrix,

$$\begin{bmatrix} p_N & 1-p_N \\ 1-p_C & p_C \end{bmatrix} = \begin{bmatrix} 0.986 & 1-0.986 \\ 1-0.987 & 0.987 \end{bmatrix}$$

- Introduce time-varying productivity, $Y_t(j) = A_t N_t(j)$. In crisis productivity falls by 2% immediately and then gradually by a further 4%. After exiting the crisis it gradually recovers.
- In a crisis fiscal transfers rise by 50% immediately and then return to calibrated value in normal times immediately.
- Flight-to-safety: household discount factor gradually rises to 1.005 in a crisis and then gradually returns to 0.995 upon exiting the crisis. 2% real interest rate in normal times, -2% in crisis.
- We look at individual impact of these three shocks in following slide.

Impact of a Crisis I

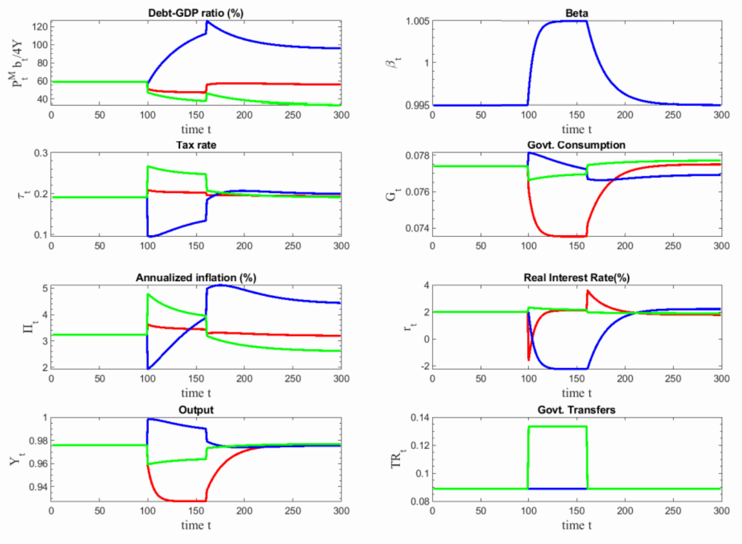

Figure: Impact of an Unexpected Crisis

Impact of a Crisis II

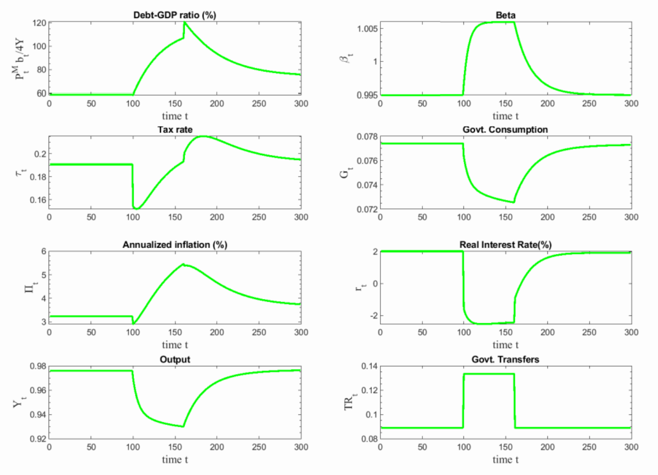

Figure: Impact of an Unexpected ‘Crisis’ - All Factors

Response to Shocks with High/Low Debt:

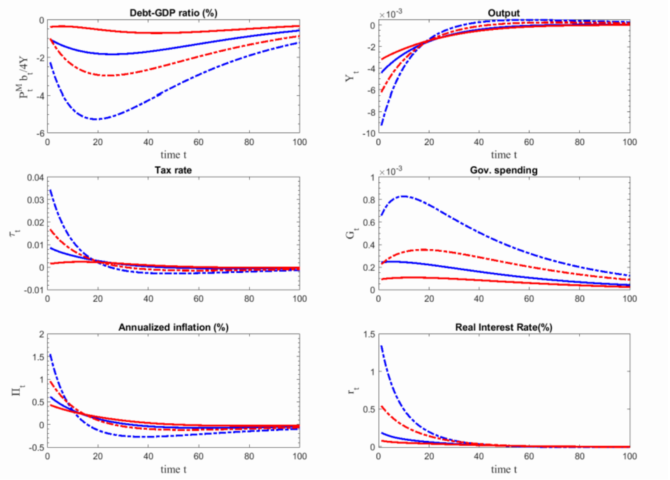

Figure: Differing responses to cost push shock with high and low debt and/or a flight to safety.

Debt Targeting

- We add an aversion to debt on the part of the fiscal authority,

$$U_t^F = (1-\alpha_d)\left(\frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\chi G_t^{1-\sigma_g}}{1-\sigma_g} - \frac{(Y_t)^{1+\varphi}}{1+\varphi}\right) - \frac{\alpha_d}{2}\left(\frac{P_t^M b_t}{Y_t}\right)^2$$

- $\alpha_d = 0.0002$ maximizes social welfare across a wide range of values of α_π.
- This very modest aversion to debt begins to return control of inflation to the central bank.

Increasing Inflation Aversion - No Debt Targeting

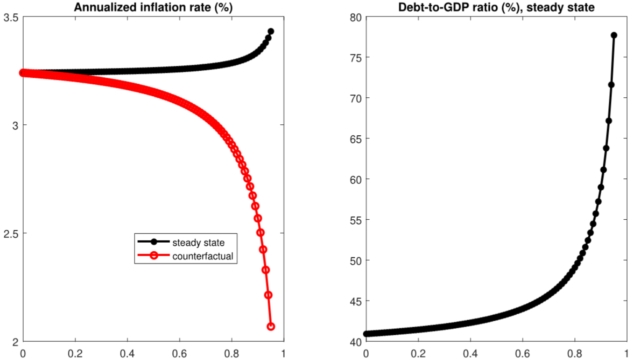

Figure: Increasing Central Bank Inflation Aversion

Increasing Inflation Aversion - Debt Targeting

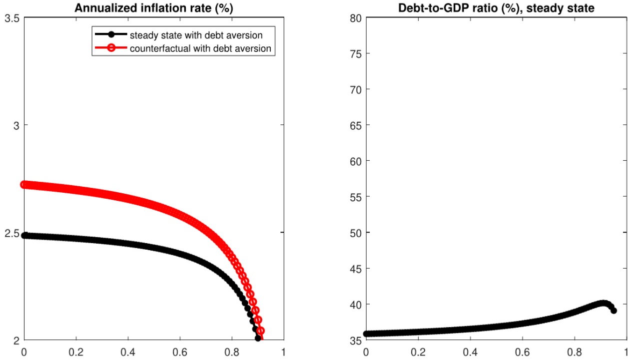

Figure: Increasing Central Bank Inflation Aversion

Conclusions

- Central bank conservatism initially reduces, but then increases inflation above pre-independence levels due to higher debt.
- Not due to a lack of coordination - if govt shares the central bank's inflation aversion debt is higher and welfare lower.
- Central bank myopia matters more than fiscal myopia - usual political economy frictions unlikely to explain rise in debt.
- Large recessions and increases in fiscal transfers do not drive large increases in debt. Real rates matter.
- After exiting a crisis with high levels of debt the central bank enhances its response to cost-push shocks.
- Modest amount of debt aversion can greatly enhance CBI.