A Long-Run, Short-Run and Politico-Economic Analysis of the Welfare Costs of Inflation

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Motivation

"Indeed, most central banks around the world aim to set inflation above zero, usually at about two percent."

- Federal Reserve Chairman Ben Bernanke, April 27, 2011

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WHY?

Question

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- in an environment with micro-foundations for holding money...
- that delivers a nondegenerate monetary distribution...
- that matches key moments of the empirical monetary distribution in US?

More Motivation

Several papers show that a distributional assessment of monetary policies can greatly affect welfare analysis

- Molico (2006): quantitatively assesses Trejos & Wright (1995)
- Chiu & Molico (2008, 2011): extend Lagos & Wright (2005)
- Dressler (2011): assumes Walrasian markets, various buyer-seller ratios & degrees of persistence

More Motivation

A distributional analysis captures a trade-off between two effects of inflation

- Real Balance Effect
  - inflation reduces real money balances for all agents
- Redistributive Effect
  - agents with below (above) average money holdings view inflation as a subsidy (tax)

Acurately assessing these effects requires a monetary distribution matching relevant moments of US data

- 2004 Survey of Consumer Finances

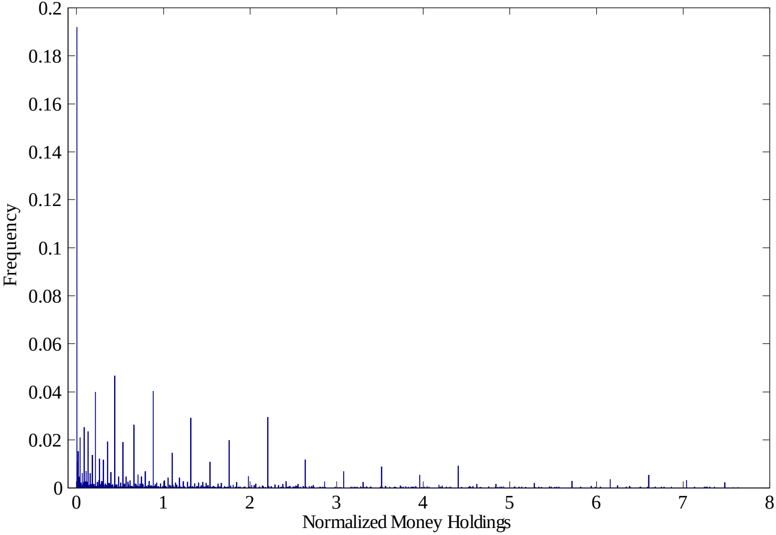

Figure: SCF Checking Data, truncated at 95th percentile

Percentiles:	25	50	75	*Gini*
Checking	0.0537	0.4400	1.3201	0.5107
Transaction	0.0837	0.4411	1.4230	0.5380

Table: Normalized distributions; SCF data truncated at 95th percentile

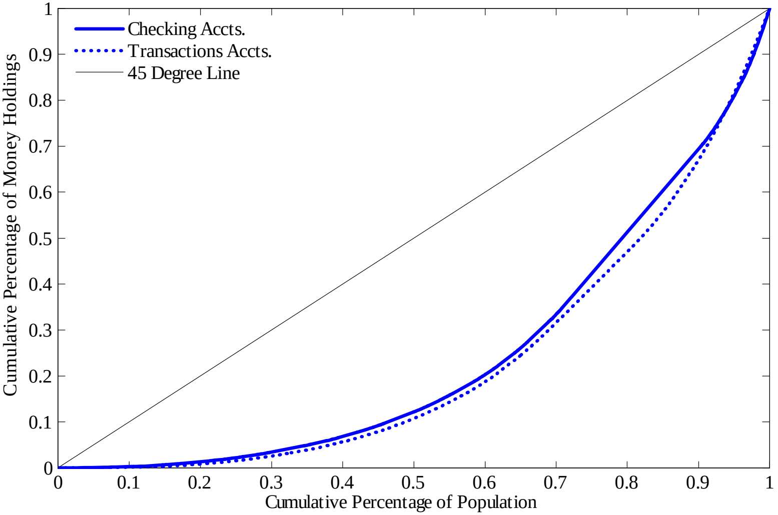

Figure: Lorenz Curves, SCF Data

This Paper

Follows Dressler (2011), alters environment to deliver monetary distribution in line with data

- all agents produce & consume, some receive a preference shock
- delivers a smaller precautionary demand for money
- mass of agents near zero (similar to data)

Environment calibrated to match

- Monetary Velocity
- Median-Mean ratio in SCF data

This Paper

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The welfare implications of inflationary monetary policies are assessed in three different ways

- Long-run: comparing a nonzero inflation steady state with the zero inflation steady state
- Short-run: compare transition to a nonzero inflation steady state with remaining at zero inflation steady state
- Politico-economic: let agents compare each inflation rate and vote.

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- Median voter usually prefers less inflation than presently experiencing
  - e.g., median vote when currently at 5% inflation just under 0%
  - RB effect dominates, BUT redistributive effect results in (stationary) equilibrium vote **above** Friedman Rule

Related Literature

Monetary Literature:

- Molico (2006); Molico & Chiu (2008, 2011); Dressler (2011)
- Imrohoroglu (1992); Erosa & Ventura (2002); and others...
- Micro-founded monetary model delivers quantitative welfare costs while matching key moment of distribution

Politico-Economy (with Money) Literature:

- Bhattacharya et al. (2001, 2005); Bullard & Waller (2004); Albanesi (2007); and others...
- Prevailing inflation rate voted on by agents facing idiosyncratic shocks (Corbae et al., 2009)

Environment

- Discrete time, infinite horizon
- Exists a unit measure of infinitely-lived agents
  - All agents produce & consume a perfectly divisible, non-storable good
- Each agent receives an uninsurable, idiosyncratic preference-shock $e_t \in E$
  - finite state markov process $\Pi\left(e_{t+1} = e' | e_t = e\right)$
  - $E = \{b, s\}$
  - $e = b\,(s) \rightarrow$ relatively high (low) consumption-demand shock.

Environment

Preferences of type-e agent:

$$u(x_t, y_t, e_t) = \frac{e_t x_t^{1-\sigma}}{1-\sigma} - \frac{y_t^{(1+1/\gamma)}}{1+1/\gamma}$$

- x (y) denotes consumption (production) of the good
- Frisch elasticity: γ
- relatively high preference shock $\rightarrow$ $u(x, y, b) > u(x, y, s)$, $u_1'(x, y, b) > u_1'(x, y, s)$ $\forall x, y > 0$

Environment

- There exists a stock $\hat{M}_t$ of fiat money that grows at rate μ_t

$$\hat{M}' = (1 + \mu_t)\,\hat{M}$$

- Agents can hold any nonnegative amount of money $(\hat{m}_t \in \mathbb{R}_+)$
- New money injected via identical, lump-sum transfers τ_t to all agents at beginning of the period

Environment

- Agents receive shock, granted access to a competitive (Walrasian) market
  - take a single price for the good $(\hat{P})$ as given
  - type b agents may want to consume more than they produce (*net buyers*)
  - type s agents may want to produce more than they consume (*net sellers*)
- In addition to this *temporal* double coincidence problem, agents are anonymous (no credit)

Environment

- $\Gamma_t(\hat{m}_t, e_t)$ denotes joint distribution of money holdings & types across agents with $\Gamma_{t+1} = H(\Gamma_t, \mu_t)$

$$\hat{M}_t = \int \hat{m}_t d\Gamma_t(\hat{m}_t, e_t)$$

$$X_t = \int x_t d\Gamma_t(\hat{m}_t, e_t) \text{ and } Y_t = \int y_t d\Gamma_t(\hat{m}_t, e_t)$$

- Normalizing nominal variables by beginning-of-period money supply delivers resource constraints

$$M_t = \int m_t d\Gamma_t(m_t, e_t) = 1$$

Environment

$$V\left(m,e;\Gamma,\mu\right)=\max_{x,y,m'} u\left(x,y,e\right)+\beta\sum_{e'}\Pi\left(e'|e\right)V\left(m',e';\Gamma',\mu'\right)$$

subject to:

$$\frac{m+\mu}{1+\mu}+P\left(y-x\right)\geq m'$$

$$x,y,m'\geq 0$$

$$\Gamma'=H\left(\Gamma,\mu\right)\ \text{and}\ \mu'=\Psi\left(\Gamma,\mu\right)$$

Solution generates decision rules:

$$x=\eta\left(m,e;\Gamma,\mu\right),\quad y=g\left(m,e;\Gamma,\mu\right),\quad m'=h\left(m,e;\Gamma,\mu\right),$$

Recursive Competitive Equilibrium (RCE)

Definition: Given $\Psi(\Gamma, \mu)$, a *RCE* is a set of functions $\{V, \eta, g, h, H, P\}$ such that:

1. Given (Γ, μ, H, Ψ), functions $V(\cdot)$, $\eta(\cdot)$, $g(\cdot)$, and $h(\cdot)$ solve household's problem.
2. Aggregate resource constraint is satisfied

$$X = \int x d\Gamma(m, e) = \int y d\Gamma(m, e) = Y$$

3. Prices clear markets for goods (condition 2) and money.
4. The law of motion for money is satisfied.
5. $H(\Gamma, \mu)$ is given by

$$\Gamma'(m', e') = \int 1_{\{h(m,e;\Gamma,\mu)=m'\}} \Pi(e'|e) \, d\Gamma(m, e)$$

Politico-Economic Equilibrium

Agents consider a one-pd deviation: $\mu' \neq \Psi(\Gamma, \mu)$

$$\tilde{V}(m, e; \Gamma, \mu, \mu') = \max_{x, y, m'} u(x, y, e) + \beta E_{e'|e} V(m', e'; \Gamma', \mu')$$

s.t.

$$\frac{m+\mu}{1+\mu} + P(y - x) \geq m'$$

$$x, y, m' \geq 0$$

$$\Gamma' = \tilde{H}(\Gamma, \mu, \mu')$$

Solution generates decision rules:

$$x = \tilde{\eta}(m, e; \Gamma, \mu), \quad y = \tilde{g}(m, e; \Gamma, \mu), \quad m' = \tilde{h}(m, e; \Gamma, \mu),$$

Politico-Economic RCE (PRCE)

Definition: A *PRCE* is:

1. $\{V, \eta, g, h, H, P\}$ that satisfy a RCE;
2. $\left\{\tilde{V}, \tilde{\eta}, \tilde{g}, \tilde{h}\right\}$ that solves problem at a price that clears money & goods markets, with $\tilde{H}$ satisfying

$$\Gamma\left(m', e'\right) = \int 1_{\left\{\tilde{h}(m,e;\Gamma,\mu)=m'\right\}} \Pi\left(e'|e\right) d\Gamma\left(m, e\right)$$

3. in state $(m, e)_i$, household i's most preferred μ^i satisfies

$$\mu^i = \Psi\left((m, e)_i, \Gamma, \mu\right) = \arg\max_{\mu'} \tilde{V}\left((m, e)_i; \Gamma, \mu, \mu'\right)$$

4. policy outcome $\mu^m = \Psi\left(\Gamma, \mu\right) = \Psi\left((m, e)_m, \Gamma, \mu\right)$ satisfies

$$\int I_{\{(m,e):\mu^i \geq \mu^m\}} d\Gamma\left(m, e\right) \geq \frac{1}{2}, \quad \int I_{\{(m,e):\mu^i \leq \mu^m\}} d\Gamma\left(m, e\right) \geq \frac{1}{2}$$

Results contain three related analyses

- Long-run: compares nonzero inflation steady state with zero inflation steady state [Hugget (1993), Ayagari (1994)]
- Short-run: compares transition to nonzero steady state with remaining at zero inflation steady state [Ríos-Rull (1999)]
- Politico-economic: assumes agents vote on a future (permanent) inflation rate, monetary authority has full commitment
    - simplifies sequential voting problem, agents compare short-run transitions [Corbae et al. (2009)]

Parameter Values (all exercises)

- $\beta = 0.96$
- $\sigma = 2.0$
- $\gamma = 1/2$
- $e_b = 4.76, \; e_s = 1$
- $\Pi(b|e) = \Pi(b) = 0.69$ (transient shocks)

- Calibrated so steady state with $\mu = 2$ displays:
  - Velocity $= 5$
  - median of distribution $= 0.44$
  - Implied B/S ratio $= 2.26$

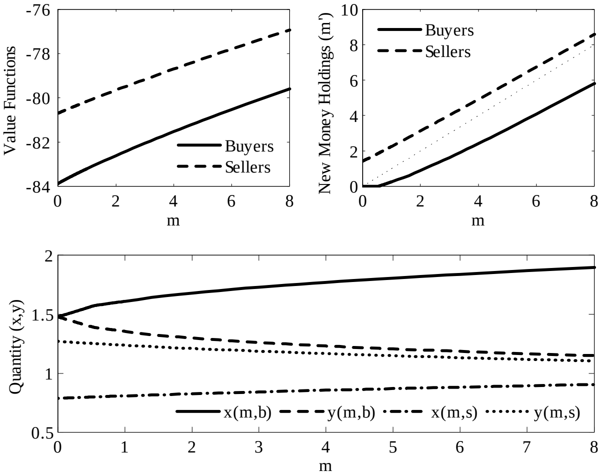

Figure: Value functions & decision rules, $\mu = 0.00$

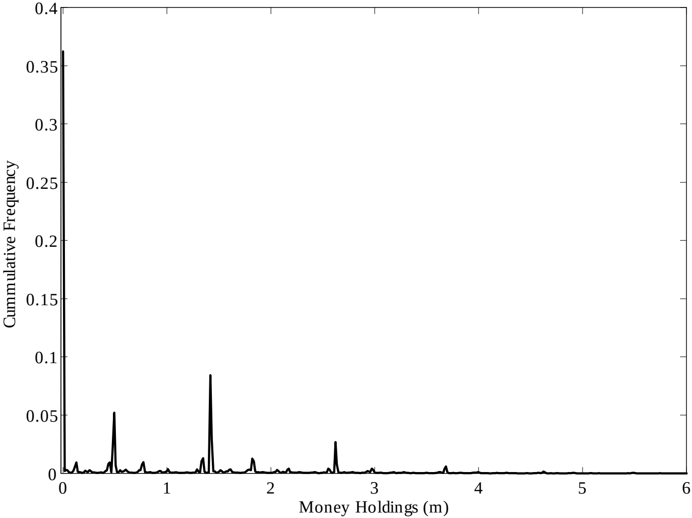

Figure: Stationary distribution of money holdings, $\mu = 0.00$

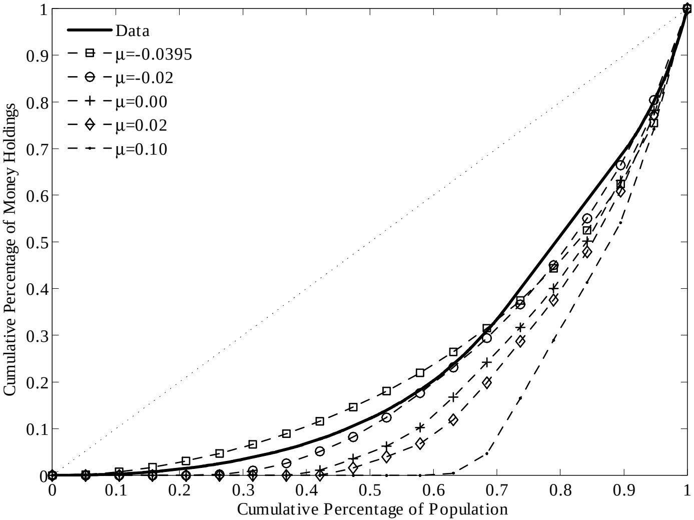

Figure: Lorenz curves

Long-Run Results

μ (%)	P	med(m)	Vel.	std(m)	Mkt(%)	Gini
−3.95	0.15	0.64	0.20	1.16	16.03	0.51
−3.0	1.28	0.76	1.72	0.92	14.45	0.50
−2.0	1.93	0.80	2.59	1.03	13.53	0.55
0	2.94	0.48	3.94	1.17	12.26	0.61
2.0	3.73	0.43	5.00	1.25	11.34	0.64
5.0	4.86	0.27	6.51	1.36	10.23	0.67
10	6.68	0.00	8.93	1.51	8.83	0.72

Long-Run Welfare Results

Calculated in standard consumption-equivalent manner

- Average expected value with inflation rate μ : $W(\mu)$

$$W(\mu) = \Pi(b) W(b,\mu) + (1 - \Pi(b)) W(s,\mu)$$

$$W(b,\mu) = \Phi \int \begin{pmatrix} (1 - \beta\Pi(s|s)) u(x_\mu, y_\mu, b) + \\ \beta(1 - \Pi(b|b)) u(x_\mu, y_\mu, s) \end{pmatrix} d\Gamma_\mu(m,b)$$

$$W(s,\mu) = \Phi \int \begin{pmatrix} \beta(1 - \Pi(s|s)) u(x_\mu, y_\mu, b) + \\ (1 - \beta\Pi(b|b)) u(x_\mu, y_\mu, s) \end{pmatrix} d\Gamma_\mu(m,s)$$

$$\Phi = \left(1 - \beta^2 - \beta(1-\beta)(\Pi(b|b) + \Pi(s|s))\right)^{-1}$$

Long-Run Welfare Results

- $(1-\Delta_0(\mu))\times 100\%$ is the welfare cost (in consumption) of having inflation rate μ relative to zero inflation

$$W(\mu)=\Pi(b)\,W(b,0)+(1-\Pi(b))\,W(s,0)$$

$$W(b,0)=\Phi\int\begin{pmatrix}(1-\beta\Pi(s|s))\,u(\Delta_0(\mu)\,x_0,y_0,b)+\\ \beta(1-\Pi(b|b))\,u(\Delta_0(\mu)\,x_0,y_0,s)\end{pmatrix}d\Gamma_0(m,b)$$

$$W(s,0)=\Phi\int\begin{pmatrix}\beta(1-\Pi(s|s))\,U(\Delta_0(\mu)\,x_0,y_0,b)+\\ (1-\beta\Pi(b|b))\,U(\Delta_0(\mu)\,x_0,y_0,s)\end{pmatrix}d\Gamma_0(m,s)$$

- Note overall welfare affected by a change in decision rule & distribution (can be decomposed)

Long-Run Welfare Results

	Welfare Results (%)		
μ (%)	Overall	DRs only	Dist only
−3.95	−11.92	−13.43	5.80
−3.0	−4.00	−5.14	1.56
−2.0	−2.23	−2.84	0.75
0	–	–	–
2.0	1.50	1.81	−0.30
5.0	3.18	3.88	−0.55
10	5.10	6.36	−0.61

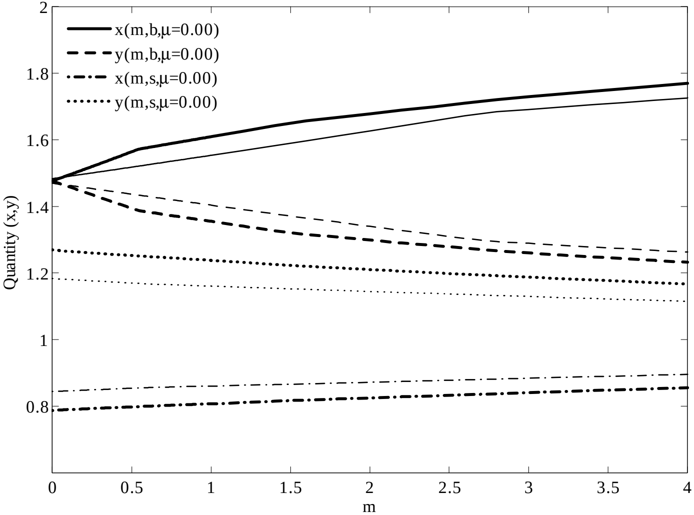

Figure: Decision rules for $\mu = 0.00$ (thick lines) and $\mu = 0.10$ (thin lines)

Short-Run Analysis

- Calculate transition from $\mu_0 = 0.00$ to $\mu = \{-0.0395, \; -0.03, \; -0.02, \; 0.02, \; 0.05, \; 0.10\}$
- Determine length of transition (T) for each transition from $\mu_0 = 0.00$ to $\mu_t = \mu$ for $t = 1, \ldots, T$
  - T is shorter (longer) when transitioning to positive (negative) inflation rates
  - due to more agents running into liquidity constraint at higher inflation
  - higher inflation distributions contain more mass points

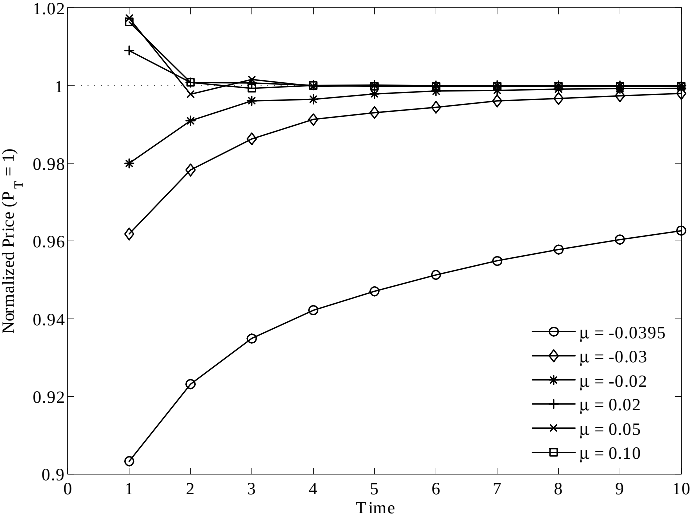

Figure: Transition paths of normalized price levels from $\mu_0 = 0.00$

Short-Run Welfare Results

- Average expected value as economy transitions to μ

$$\hat{W}(\mu) = \Pi(b)\hat{W}(b,\mu) + (1-\Pi(b))\hat{W}(s,\mu)$$

$$\begin{bmatrix} \hat{W}(b,\mu) \\ \hat{W}(s,\mu) \end{bmatrix} = \sum_{t=0}^{T} \beta^t \Pi^t \begin{bmatrix} \int u\left(x_{\mu t}, y_{\mu t}, b\right) d\Gamma_{\mu t}(m,b) \\ \int u\left(x_{\mu t}, y_{\mu t}, s\right) d\Gamma_{\mu t}(m,s) \end{bmatrix}$$

Short-Run Welfare Results

- $\left(1-\hat{\Delta}_0(\mu)\right) \times 100\%$ is the welfare cost (in consumption) of *transitioning* to μ relative to remaining at $\mu_0 = 0.00$

$$\hat{W}(\mu) = \Pi(b)\,\hat{W}(b,0) + (1-\Pi(b))\,\hat{W}(s,0)$$

$$\begin{bmatrix} \hat{W}(b,\mu) \\ \hat{W}(s,\mu) \end{bmatrix} = \sum_{t=0}^{T} \beta^t \Pi^t \begin{bmatrix} \int u\left(\hat{\Delta}_0(\mu)\, x_{\mu t}, y_{\mu t}, b\right) d\Gamma_{\mu t}(m,b) \\ \int u\left(\hat{\Delta}_0(\mu)\, x_{\mu t}, y_{\mu t}, s\right) d\Gamma_{\mu t}(m,s) \end{bmatrix}$$

Short-Run Welfare Results

μ (%)	Overall (%)	T
-3.95	-0.07	120
-3.0	-1.57	27
-2.0	-0.91	30
0	–	–
2.0	0.64	6
5.0	1.42	5
10	2.25	5

Note: welfare directly related to change in dispersion between stationary distributions

Calculating Politico-Economic Outcome

- When assuming commitment, dynamics amount to transitions between steady states
  - Initial steady state inflation vs. all potential inflation rates
- Dynamic paths at $t = 1$ are used to calculate indirect utility at $t = 0$
- Indirect utility function used to determine voting outcome
  - must be single-peaked

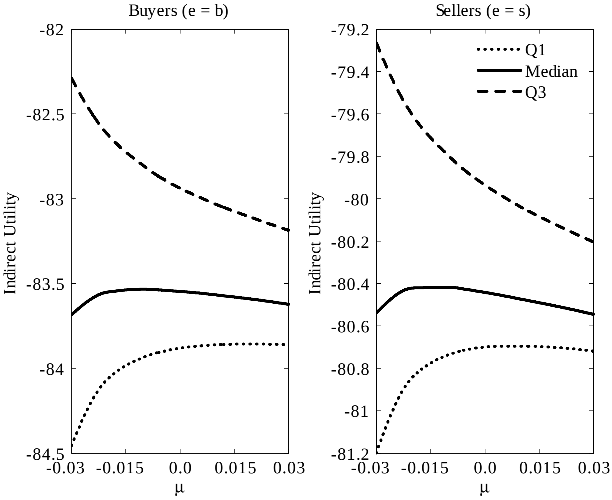

Figure: Indirect utility functions for $\mu_0 = 0.00$

Median Vote Depends on Initial Inflation

Initial Inflation	Voting Outcome
−3.95	−2.0
−3.0	−3.0
−2.0	−3.0
−1.0	−2.0
0	−1.01
2.0	−1.00
5.0	0.00

The Steady-State PRCE?

$$\mu^* = \Psi(\Gamma^*, \mu^*) \quad \text{and } \Gamma^* = H(\Gamma^*, \mu^*)$$

- What is the initial inflation rate, μ^*, such that the median vote is to remain at μ^*?

The Steady-State PRCE?

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- What is the initial inflation rate, μ^*, such that the median vote is to remain at μ^*?
- $\mu^* = -0.03$
  - Deflation is due to dominating real-balance effect
  - Redistributive effect delivers outcome above the Friedman rule (-4.19%)

Conclusion

- This paper assesses the long-run, short-run & politico-economic welfare implications of inflation in a micro-founded monetary model that delivers a monetary distribution similar to US data
- Long-run & short-run welfare costs can be substantial
  - Need robustness analysis
- Politico-Economic outcome suggests deflation, but above Friedman Rule
  - Need extension with persistent shocks (more sophisticated model)