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...
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- that delivers a nondegenerate monetary distribution...
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What are the welfare costs of inflation...

- 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

- 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
<table>
<thead>
<tr>
<th>Percentiles:</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>Gini</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking</td>
<td>0.0537</td>
<td>0.4400</td>
<td>1.3201</td>
<td>0.5107</td>
</tr>
<tr>
<td>Transaction</td>
<td>0.0837</td>
<td>0.4411</td>
<td>1.4230</td>
<td>0.5380</td>
</tr>
</tbody>
</table>

**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

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
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- **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
This Paper

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.
Results

- Long-run welfare costs are large
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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 \( \Pi (e_{t+1} = e' | e_t = e) \)
  - \( E = \{b, s\} \)
  - \( e = b(s) \rightarrow \) 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: \(\gamma\)
- relatively high preference shock \(\rightarrow u(x, y, b) > u(x, y, s), u_1'(x, y, b) > u_1'(x, y, s) \quad \forall x, y > 0\)
Environment

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

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

- Agents can hold any nonnegative amount of money ($\hat{m}_t \in \mathbb{R}_+$)

- New money injected via identical, lump-sum transfers $\tau_t$ to all agents at beginning of the period
Introduction

Model

Results

Conclusion

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 $\Gamma_{t+1} = H(\Gamma_t, \mu_t)$

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

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

- 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

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

subject to:

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

\[ x, y, m' \geq 0 \]

\[ \Gamma' = H (\Gamma, \mu) \text{ and } \mu' = \Psi (\Gamma, \mu) \]

Solution generates decision rules:

\[ x = \eta (m, e; \Gamma, \mu), \quad y = g (m, e; \Gamma, \mu), \quad m' = h (m, e; \Gamma, \mu) \]
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 $(\Gamma, \mu, H, \Psi)$, functions $V(\cdot)$, $\eta(\cdot)$, $g(\cdot)$, and $h(\cdot)$ solve household’s problem.
2. Aggregate resource constraint is satisfied

$$X = \int xd\Gamma(m, e) = \int yd\Gamma(m, e) = Y$$

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. \( \{ \tilde{V}, \tilde{\eta}, \tilde{g}, \tilde{h} \} \) that solves problem at a price that clears money & goods markets, with \( \tilde{H} \) satisfying

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

3. in state \((m, e)\), household \(i\)'s most preferred \(\mu^i\) satisfies

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

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

\[
\int I_{\{(m,e):\mu^i \geq \mu^m\}} d\Gamma (m, e) \geq \frac{1}{2}, \quad \int I_{\{(m,e):\mu^i \leq \mu^m\}} d\Gamma (m, e) \geq \frac{1}{2}
\]
Results contain three related analyses


- 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

<table>
<thead>
<tr>
<th>$\mu$ (%)</th>
<th>$P$</th>
<th>med($m$)</th>
<th>Vel.</th>
<th>std($m$)</th>
<th>Mkt(%)</th>
<th>Gini</th>
</tr>
</thead>
<tbody>
<tr>
<td>−3.95</td>
<td>0.15</td>
<td>0.64</td>
<td>0.20</td>
<td>1.16</td>
<td>16.03</td>
<td>0.51</td>
</tr>
<tr>
<td>−3.0</td>
<td>1.28</td>
<td>0.76</td>
<td>1.72</td>
<td>0.92</td>
<td>14.45</td>
<td>0.50</td>
</tr>
<tr>
<td>−2.0</td>
<td>1.93</td>
<td>0.80</td>
<td>2.59</td>
<td>1.03</td>
<td>13.53</td>
<td>0.55</td>
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<tr>
<td>0</td>
<td>2.94</td>
<td>0.48</td>
<td>3.94</td>
<td>1.17</td>
<td>12.26</td>
<td>0.61</td>
</tr>
<tr>
<td>2.0</td>
<td>3.73</td>
<td>0.43</td>
<td>5.00</td>
<td>1.25</td>
<td>11.34</td>
<td>0.64</td>
</tr>
<tr>
<td>5.0</td>
<td>4.86</td>
<td>0.27</td>
<td>6.51</td>
<td>1.36</td>
<td>10.23</td>
<td>0.67</td>
</tr>
<tr>
<td>10</td>
<td>6.68</td>
<td>0.00</td>
<td>8.93</td>
<td>1.51</td>
<td>8.83</td>
<td>0.72</td>
</tr>
</tbody>
</table>
Long-Run Welfare Results

Calculated in standard consumption-equivalent manner

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

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

\[
W(b, \mu) = \Phi \int \left( (1 - \beta \Pi(s|s)) u(x_{\mu}, y_{\mu}, b) + \beta (1 - \Pi(b|b)) u(x_{\mu}, y_{\mu}, s) \right) d\Gamma_{\mu}(m, b)
\]

\[
W(s, \mu) = \Phi \int \left( \beta (1 - \Pi(s|s)) u(x_{\mu}, y_{\mu}, b) + (1 - \beta \Pi(b|b)) u(x_{\mu}, y_{\mu}, s) \right) d\Gamma_{\mu}(m, s)
\]

\[
\Phi = (1 - \beta^2 - \beta (1 - \beta) (\Pi(b|b) + \Pi(s|s)))^{-1}
\]
Long-Run Welfare Results

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

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

$$W(b,0) = \Phi \int \left( (1 - \beta \Pi(s|s)) u(\Delta_0(\mu)x_0, y_0, b) + \beta(1 - \Pi(b|b)) u(\Delta_0(\mu)x_0, y_0, s) \right) d\Gamma_0(m, b)$$

$$W(s,0) = \Phi \int \left( \beta(1 - \Pi(s|s)) U(\Delta_0(\mu)x_0, y_0, b) + (1 - \beta \Pi(b|b)) U(\Delta_0(\mu)x_0, y_0, s) \right) d\Gamma_0(m, s)$$

• Note overall welfare affected by a change in decision rule & distribution (can be decomposed)
## Long-Run Welfare Results

<table>
<thead>
<tr>
<th>$\mu$ (%)</th>
<th>Overall</th>
<th>DRs only</th>
<th>Dist only</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.95</td>
<td>-11.92</td>
<td>-13.43</td>
<td>5.80</td>
</tr>
<tr>
<td>-3.0</td>
<td>-4.00</td>
<td>-5.14</td>
<td>1.56</td>
</tr>
<tr>
<td>-2.0</td>
<td>-2.23</td>
<td>-2.84</td>
<td>0.75</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2.0</td>
<td>1.50</td>
<td>1.81</td>
<td>-0.30</td>
</tr>
<tr>
<td>5.0</td>
<td>3.18</td>
<td>3.88</td>
<td>-0.55</td>
</tr>
<tr>
<td>10</td>
<td>5.10</td>
<td>6.36</td>
<td>-0.61</td>
</tr>
</tbody>
</table>
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 $\mu$

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

\[
\begin{bmatrix}
\hat{W}(b, \mu) \\
\hat{W}(s, \mu)
\end{bmatrix} = \sum_{t=0}^{T} \beta^t \Pi^t \left[ \int u(x_{\mu t}, y_{\mu t}, b) \, d\Gamma_{\mu t}(m, b) \right] \\
\sum_{t=0}^{T} \beta^t \Pi^t \left[ \int u(x_{\mu t}, y_{\mu t}, s) \, d\Gamma_{\mu t}(m, s) \right]
\]
Short-Run Welfare Results

- \((1 - \hat{\Delta}_0(\mu)) \times 100\%\) is the welfare cost (in consumption) of transitioning to \(\mu\) 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) \\
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Short-Run Welfare Results

<table>
<thead>
<tr>
<th>µ (%)</th>
<th>Overall (%)</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>−3.95</td>
<td>−0.07</td>
<td>120</td>
</tr>
<tr>
<td>−3.0</td>
<td>−1.57</td>
<td>27</td>
</tr>
<tr>
<td>−2.0</td>
<td>−0.91</td>
<td>30</td>
</tr>
<tr>
<td>0</td>
<td>－</td>
<td>－</td>
</tr>
<tr>
<td>2.0</td>
<td>0.64</td>
<td>6</td>
</tr>
<tr>
<td>5.0</td>
<td>1.42</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>2.25</td>
<td>5</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Initial Inflation</th>
<th>Voting Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>−3.95</td>
<td>−2.0</td>
</tr>
<tr>
<td>−3.0</td>
<td>−3.0</td>
</tr>
<tr>
<td>−2.0</td>
<td>−3.0</td>
</tr>
<tr>
<td>−1.0</td>
<td>−2.0</td>
</tr>
<tr>
<td>0</td>
<td>−1.01</td>
</tr>
<tr>
<td>2.0</td>
<td>−1.00</td>
</tr>
<tr>
<td>5.0</td>
<td>0.00</td>
</tr>
</tbody>
</table>
The Steady-State PRCE?

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

- What is the initial inflation rate, \( \mu^* \), such that the median vote is to remain at \( \mu^* \)?
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- What is the initial inflation rate, \( \mu^* \), such that the median vote is to remain at \( \mu^* \)?
- \( \mu^* = -0.03 \)
  - 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).