Credibility Dynamics and Disinflation Plans

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The views expressed herein are those of the authors and should not be attributed to the IMF, its Executive Board, or its management.
Motivation

• Macro models: *expectations* of future policy determine current outcomes
• Policy typically set assuming *commitment* or *discretion*

• Governments actively attempt to influence beliefs about future policy
  • Forward guidance, inflation targets, fiscal rules

• This paper: rational-expectations theory of government credibility
  • Insights from reputation literature
  • Application in a (modern) Barro-Gordon setup
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Outline

- What is reputation?
  - Private sector posterior belief that the government is committed to a particular plan
  - Given a plan — [Continuation equilibrium]
    - Larger departures are easier to detect
      - Crucial feature: noise partially masks government’s current choice
    - ‘More time-inconsistent’ plans have a more negative average drift of reputation

- Planner anticipates credibility dynamics of plans — [Equilibrium]
- Consider the limit when initial reputation vanishes to zero
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<table>
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<th>Main result</th>
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| Planner chooses a back-loaded plan | - In application, gradual disinflation  
- No real inertia, but good for incentives |

- Consider the limit when initial reputation vanishes to zero
Our want operator

- Goodfriend and King (2005) describe the Volcker disinflation
Literature

• **Sustainable plans** – anything goes

• **Reputation without noise** – zero inflation at onset
  Dovis and Kirpalani (2019) – constant but more than zero

• **Reputation with noise**
  Static plans: Faingold and Sannikov (2011)

• **Preference uncertainty with noise** – announcements irrelevant
  Cukierman and Meltzer (1986), Faust and Svensson (2001), Phelan (2006), etc
Roadmap

- Model
- Continuation equilibria conditional on a plan
- Plans
- Discussion
- Conclusion
Model
Framework

- A government dislikes inflation and output away from a target $y^* > 0$

\[ L_t = \mathbb{E}_t \left[ \sum_{s=0}^{\infty} \beta^s \left( (y^* - y_{t+s})^2 + \gamma \pi_{t+s}^2 \right) \right] \]

- A Phillips curve relates output to current and expected future inflation

\[ \pi_t = \kappa y_t + \beta \mathbb{E}_t [\pi_{t+1}] \]

- The government controls inflation only imperfectly (through $g_t$)

\[ \pi_t = g_t + \epsilon_t \]

with $\epsilon_t \sim F_\epsilon$
Reputation

• The government can be rational or one of many ‘behavioral’ types
  • Behavioral types $c \in C$
  • Type $c$ is committed to an inflation plan $\{a_t\}_{t=0}^{\infty}$
  • For simplicity let all plans have $a_{t+1} = \phi_c(a_t)$ [Finding the state is an art]

• Behavioral types have (total) probability $z$
  • Conditional on behavioral, probability $\nu$ over $C$

• Private sector knows $z$ and $\nu$
  • Does inference over the government’s type
  • Uses announcement and inflation choices
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Behavioral types

- What is the set \( C \)?
  - and associated possible \( \phi_c \) functions
- Consider \( \{a_t\}_t \) paths characterized by
  - Starting point \( a_0 \)
  - Decay rate \( \omega \)
  - Asymptote \( \chi \)

\[
a_t = \chi + (a_0 - \chi)e^{-\omega t}
\]

\[
\phi(a) = \chi + e^{-\omega}(a - \chi)
\]
Behavioral types

- What is the set $\mathcal{C}$?
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Gameplay

- At $t = 0$, inflation targets are announced
  - Type $c \in C$ says $c$
  - Rational type strategizes
    announces $r$ possibly $\in C$
- At time $t \geq 0$, the government sets inflation
  - Behavioral type $c \in C$
    implements $g_t = a_t^c$
  - Rational type acts strategically
    chooses $g_t \leq a_t^c$
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Continuation equilibria conditional on a plan
Reputation and Outcomes

- Output is determined by beliefs $\mathbb{E}_t [\pi_{t+1}]$ and actual inflation $\pi_t = g_t + \epsilon_t$

  $$\pi_t = \kappa y_t + \beta \mathbb{E}_t [\pi_{t+1}] = \kappa y_t + \beta \mathbb{E}_t [\mathbb{1}_c a_{t+1}^c + (1 - \mathbb{1}_c)g_{t+1}^*]$$

- Private sector solves a signal extraction problem to update beliefs

  $$\mathbb{P} (c \mid \pi_t, \mathcal{F}_{t-1}) = \frac{\mathbb{P} (c \mid \mathcal{F}_{t-1}) \cdot f_\epsilon (\epsilon_t | c)}{\mathbb{P} (c \mid \mathcal{F}_{t-1}) \cdot f_\epsilon (\epsilon_t | c) + (1 - \mathbb{P} (c \mid \mathcal{F}_{t-1})) \cdot f_\epsilon (\epsilon_t | r)}$$
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$$\mathbb{P}(c \mid \pi_t, \mathcal{F}_{t-1}) = \frac{\mathbb{P}(c \mid \mathcal{F}_{t-1}) \cdot f_\epsilon(\pi_t - q^c_t)}{\mathbb{P}(c \mid \mathcal{F}_{t-1}) \cdot f_\epsilon(\pi_t - q^c_t) + (1 - \mathbb{P}(c \mid \mathcal{F}_{t-1})) \cdot f_\epsilon(\pi_t - g^*_t)}$$
Given an announcement $c$,

- The problem of the rational type is, given expectations $g^*_c$

$$
L^c(p, a) = \min_g \mathbb{E} \left[ (y^* - y)^2 + \gamma \pi^2 + \beta L^c(p', \phi_c(a)) \right]
$$
subject to

$$
\pi = g + \epsilon
$$
$$
\pi = \kappa y + \beta \left[ p' \phi_c(a) + (1 - p')g^*_c(p', \phi_c(a)) \right]
$$
$$
p' = p + p(1 - p) \frac{f_\epsilon(\pi - a) - f_\epsilon(\pi - g^*_c(p, a))}{pf_\epsilon(\pi - a) + (1 - p)f_\epsilon(\pi - g^*_c(p, a))}
$$

- Rational expectations requires $g^*_c$ to be the policy associated with $L^c$
Continuation Equilibrium

Definition
Given an announcement $c$, a continuation equilibrium is a pair $(\mathcal{L}^c, g^*_c)$ such that

- $\mathcal{L}^c$ is the rational type’s value function at expectations $g^*_c$
- $g^*_c$ is the policy function associated with $\mathcal{L}^c$
A First Look at Different Plans

Observation

• Plans $c \in C$ are

$$c = (a_0, \chi, \omega)$$

• For $a, b \in \mathbb{R}$

$$(\mathcal{L}, g^*)$$ is a continuation equilibrium for $(a, \chi, \omega)$ if and only if $$(\mathcal{L}, g^*)$$ is a continuation equilibrium for $(b, \chi, \omega)$

• Means $a \mapsto \mathcal{L}^c(p, a)$ compares the same plan at different times and different plans
The Value Function

\[ L \]

- \( L \) decreasing in \( p \)
- \( L \) convex-concave in \( p \)
- \( L \) increasing in \( a \) for large \( p \) only
Lemma 1

In any continuation equilibrium,

\[ E_t [p_{t+1} \mid \text{rational}] \leq p_t \]

So \( \{p_t\}_t \) is a supermartingale
Incentives

From the Phillips curve

\[
\frac{\partial y}{\partial \pi} = \frac{1}{\kappa} \left[ 1 - \beta \frac{\partial p'}{\partial \pi} \left( \phi_c(a) - g^*(p', \phi_c(a)) \right) + (1 - p') \frac{\partial g^*(p', \phi_c(a))}{\partial p'} \right]
\]

• More inflation
  1. Increases output by \( \frac{1}{\kappa} \)
  2. Shifts inflation expectations from \( \phi_c(a) \) towards \( g^*(p', \phi_c(a)) \)
     
     \( \ldots \quad p' \) decreases with higher \( \pi \) when \( g^*(p, a) > a \)
  3. Shifts expectations of the rational type’s future choice
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Phillips curves

\[ \pi = \kappa y + k_1 \]
\[ \pi = \kappa y + k_2 \]
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- Without reputation:
  \[ \text{if } \beta \mathbb{E} [\pi'] = k_j \]
  choose point on \( j \)th PC

- If announced \( a \)
  and in eq’m
  \[ g^*(p, a) = a \]
  \[ \implies \text{get flat PC} \]

- If \( g^*(p, a) > a \)
  \[ \implies \frac{\partial p'}{\partial \pi} \text{ matters} \]
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Conjecture

• Let $\pi^N$ be the Nash equilibrium inflation of the stage game. Then

$$\forall c \in \mathcal{C} : \quad g^*_c(p, a) \leq \pi^N$$

• Define the remaining credibility of a plan as

$$C_c(p, a) = (1 - \beta) \frac{\pi^N - g^*_c(p, a)}{\pi^N - a} + \beta \mathbb{E} [C_c(p'_c(p, a), \phi_c(a))]$$
Plans
\[
\lim_{p \to 0} C(p, a^*, \omega, \chi)
\]
Plans

- For each \( c \in C \), find \( \mathcal{L}^c(p, a), g^*_c(p, a) \).
- Generates big matrix \( \mathcal{L}(p, a; \omega, \chi) \).
- First pass: preferred plan at each \( p \).
• For each $c \in \mathcal{C}$, find $\mathcal{L}_c^c(p, a), g^*_c(p, a)$.

• Generates big matrix $\mathcal{L}(p, a; \omega, \chi)$

• First pass: preferred plan at each $p$
What plan to choose?

Back to the initial announcement: two notions

• If in equilibrium gov’t announces type $c$ with density $\mu(c)$,

$$p_0(c; z, \mu) = \frac{z\nu(c)}{z\nu(c) + (1 - z)\mu(c)}$$

• So study

$$\lim_{z \to 0} \min_{\mu} \int L(p_0(a_0, \omega, \chi; z, \mu), a_0, \omega, \chi) d\mu$$

• Kambe (1999): gov’t announces type $c$ and becomes committed to $c$ with exogenous $p_0$ probability
  • Tractable: $p_0$ independent of $c$
  • So the limit we consider is

$$\lim_{p_0 \to 0} \min_{a_0, \omega, \chi} L(p_0, a_0, \omega, \chi)$$

• Not entirely arbitrary
  • For given $p_0$, plans that minimize $L$ should be played often
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    - Not entirely arbitrary
      - For given \( p_0 \), plans that minimize \( \mathcal{L} \) should be played often
K-equilibrium

\[
\lim_{p \to 0} \min_a \mathcal{L}(p,a,\omega,\chi)
\]
Equilibrium for given $z$

- We want $k$ and $\mu$ such that

$$\int_\mathcal{C} \mu(c) = 1$$

$$p_0(c) = \frac{z\nu(c)}{z\nu(c) + (1-z)\mu(c)}$$

$$\mathcal{L}(p_0(c), c) = k \quad \text{if } \mu(c) > 0$$

$$\mathcal{L}(p_0(c), c) \geq k \quad \text{if } \mu(c) = 0$$

- We do

  - Start with $k_0 \leq \mathcal{L}(0, c) = \mathcal{L}^N$
  - Partition states

    $$\mathcal{L}(1, c) \geq k \quad \rightarrow \quad \mu(c) = 0$$

    $$\mathcal{L}(1, c) < k$$

  - In second case find $\mu(c)$ such that

    $$\mathcal{L}(p_0(c), c) = k$$

    This is possible if $k \leq \text{value in static Nash}$

  - Set $\mu(c) = B^{-1}(p_0(c); \nu, z)$ if unset
  - Check whether $\int_\mathcal{C} \mu(c) = 1$
Equilibrium distribution of announcements

\[
\lim_{z \to 0} \int \mu_z(\omega, \chi, a_0) \, d\omega
\]

\[
\lim_{z \to 0} \int \mu_z(\omega, \chi, a_0) \, da_0
\]

- Gradualism: \( P(a_0 > \chi) = 70.5\% \). \( P(a_0 > 5\chi) = 17.2\% \). \( P(\text{decay} \leq 10\%) = 8.09\% \).
- Imperfect credibility: \( P(\chi = 0) = 1.35\% \).
Discussion
We dissect our gradualism result by linking to sustainable-plans literature

- Four models
  1. Ramsey plan
  2. Sustainable plans
     - Threat of high inflation expectations
  3. Sustainable plans with a control shock
     - Threat of inflation threshold that triggers punishment regime
  4. Recursive plans with reputation
     - Sustained with promise of anchoring of favorable expectations
A Planning Problem

\[ v^{FB}(\theta) = \max_{\theta'} \min_{y, \pi} (y - y^*)^2 + \gamma \pi^2 + \theta'(\pi - \kappa y) - \theta \pi + \beta v^{FB}(\theta') \]

- Recursive version of Ramsey plan
  - Initial \( \theta = 0 \)
  - Time inconsistency: \( \theta'(0) \neq 0 \)
- FOC for \( \theta' \): \( \pi - \kappa y + \beta \frac{\partial v^{FB}(\theta')}{\partial \theta'} = 0 \) \( \rightarrow \) \( \pi = \kappa y + \beta \pi' \)
- Simulate by iterating on \( \pi_t = \pi(\theta), \theta_{t+1} = \theta'(\theta) \)
- Imperfect control irrelevant \( \rightarrow \) only adds \( \sigma^2_\epsilon (\gamma + \frac{1}{\kappa \pi}) \)
A Planning Problem

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Sustainable plans with expectations as threats

Descentralization

• Perfect control of inflation
• Private sector ‘threatens’ to expect $\xi$ after deviations

$$v^\xi(p, a) = \min_{y, \pi, a'} (y - y^*)^2 + \gamma \pi^2 + \beta v^\xi(p', a')$$

subject to

$$\pi = \kappa y + \beta (p' g^\xi_{\pi}(1, a') + (1 - p') \xi)$$

$$p' = \begin{cases} 
1 & \text{if } \pi = a \\
0 & \text{otherwise}
\end{cases}$$

• Use $p$ to denote whether the government has deviated
Sustainable plans with expectations as threats
Sustainable plans with revertig triggers

- Trigger ‘punishment regime’ if deviation large enough (as in Green & Porter, 1984)

\[
v^G(a) = \min_{g,a'} \mathbb{E} \left[ (y - y^*)^2 + \gamma \pi^2 + \beta \left( p'v^G(a) + (1 - p')v^P \right) \right]
\]

subject to \quad \pi = g + \epsilon

\[
\pi = \kappa y + \beta \left( p'g^G(a') + (1 - p')\xi \right)
\]

\[
p' = \begin{cases} 
1 & \text{if } \frac{|\pi - a|}{a} < D \\
0 & \text{otherwise}
\end{cases}
\]

\[
v^P = \min_{\pi,a'} (y - y^*)^2 + \gamma \pi^2 + \beta \left( \theta v^G(a) + (1 - \theta)v^P \right) + \sigma^2 \epsilon \left( \gamma + \frac{1}{\kappa^2} \right)
\]

subject to \quad \pi = \kappa y + \beta \xi
Sustainable plans with reverting triggers (cont’d)

\[ v^{GP}(p, a) = \min_{g, a'} \mathbb{E} \left[ (y - y^*)^2 + \gamma \pi^2 + \beta \left( v^{GP}(p', a') \right) \right] \]

subject to \( \pi = g + \epsilon \)

\[ \pi = \kappa y + \beta \left( p' g^{GP}(p', a') + (1 - p')\xi \right) \]

\[ p' = \begin{cases} 
1 & \text{if } \frac{|\pi - a|}{a} < D \\
0 & \text{otherwise} \end{cases} \]

if \( p = 1 \)

\[ p' = \begin{cases} 
1 & \text{with prob } \theta \\
0 & \text{with prob } 1 - \theta \end{cases} \]

if \( p = 0 \)
Sustainable plans with reverting triggers

![Graph showing plans over quarters with reverting triggers](image-url)
Recursive plans with reputation

- Planner + policy maker structure (as in Dovis & Kirpalani, 2019)

\[ v^R(p, a) = \min_{g,a'} \mathbb{E} \left[ (y - y^*)^2 + \gamma \pi^2 + \beta v^R(p', a') \right] \]

subject to
\[ \pi = g + \epsilon \]
\[ \pi = \kappa y + \beta (p'a' + (1 - p')g^R(p', a')) \]
\[ p' = p + p(1 - p) \frac{f_\epsilon(\pi - a) - f_\epsilon(\pi - g^R(p, a))}{pf_\epsilon(\pi - a) + (1 - p)f_\epsilon(\pi - g^R(p, a))} \]
Recursive plans with reputation
Comparison of models

![Graph showing plans over quarters for different models: Ramsey, Average eq'm, Kambe eq'm, Recursive.](image-url)
Comparison of models

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Table 1: Inflation plans
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<td>0.3364</td>
<td>0.7552</td>
<td>0.7589</td>
<td>0.7554</td>
</tr>
</tbody>
</table>

**Table 1: Inflation plans**

- Kambe gains from pre-announcing: lower asymptote, more credibility esp. early on
Comparison of models

<table>
<thead>
<tr>
<th>Model</th>
<th>Ramsey</th>
<th>Kambe eq’m</th>
<th>‘Average’ rec plan</th>
<th>Recursive plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial inflation</td>
<td>1.40%</td>
<td>1.63%</td>
<td>1.58%</td>
<td>1.58%</td>
</tr>
<tr>
<td>Long-run inflation</td>
<td>0%</td>
<td>0.44%</td>
<td>0.65%</td>
<td>0.65%</td>
</tr>
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Table 1: Inflation plans

- Recursive gains from flexibility: modulates $a'$ to developments in $p$
Conclusion
Concluding Remarks

• Model of reputational dynamics and policy
  • Simple environment
  • Focus on low reputation limit

• Credibility-dynamics concerns influence choice of policy
  • Tradeoff between literal promises and incentives
  • Gradual plans boost reputation-building incentives for future decision-makers

• Structure of reputation maps into the incentive constraint of a planner’s problem
  ... creating large option values of complying
  ... which are larger when the plan is backloaded
Bayes’ Law

\[ B(p, \pi, a, g) = p + p(1 - p) \frac{f_\epsilon(\pi - a) - f_\epsilon(\pi - g)}{pf_\epsilon(\pi - a) + (1 - p)f_\epsilon(\pi - g)} \]
Results

\[
\lim_p \arg\min_a \mathcal{L}(p,a,\omega,\chi)
\]

Decay (\(\omega\))

\(\chi = 0\%\)
\(\chi = 0.0978\%\)
\(\chi = 0.196\%\)
\(\chi = 0.294\%\)
\(\chi = 0.392\%\)
\(\chi = 0.49\%\)
\(\chi = 0.588\%\)
\(\chi = 0.686\%\)
\(\chi = 0.784\%\)
\(\chi = 0.883\%\)
\(\chi = 0.981\%\)
Imagine an incumbent facing a sequence of potential entrants

- Each period, entrant decides entry, incumbent fights or accommodates
  - Incumbent prefers entrant to stay out but prefers to accommodate if entry
- Fighting the first entrant doesn’t affect the decision of following entrants

- Reputation as incomplete information
  - What if the incumbent could be behavioral and always produce \( q \) upon entry?
- Incentive for the rational incumbent to pretend to be behavioral
- Independent of the ‘objective’ probability of behavioral
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MACROECONOMISTS

WHETHER OR NOT SOMEONE DEVIATED ON THE EQUILIBRIUM PATH

IS THIS REPUTATION?