Credibility Dynamics and Inflation Expectations

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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 ▸ Kreps-Wilson
- 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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Main result

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

Literature

- **Sustainable plans** – anything goes

  from Kydland and Prescott (1977), Chari and Kehoe (1990), Abreu, Pearce, and Stacchetti (1990), Phelan and Stacchetti (2001)

- **Reputation without noise** – zero inflation at onset

  Milgrom and Roberts (1982), Kreps and Wilson (1982), Barro (1986), Backus and Driffill (1985), Barro and Gordon (1986), Sleet and Yeltekin (2007)

  Dovis and Kirpalani (2019) – constant but more than zero

- **Reputation with noise**

  Commitment: Lu (2013), Lu, King, and Pastén (2008, 2016)

  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 $y^\star > 0$

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

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

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

- The government controls inflation only imperfectly (through g_t)

$$\pi_t = g_t + \epsilon_t$$

with $\epsilon_t \overset{iid}{\sim} F_\epsilon$

Reputation

- The government can be **rational** or one of many 'behavioral' types
  - Behavioral types $c \in \mathcal{C}$
  - 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 ν over $\mathcal{C}$
- Private sector knows z and ν
  - Does inference over the government's type
  - Uses announcement and inflation choices

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Behavioral types

- What is the set $\mathcal{C}$?
  - $\cdots$ and associated possible ϕ_c functions
- Consider $\{a_t\}_t$ paths characterized by
  - Starting point a_0
  - Decay rate ω
  - Asymptote χ

$$a_t = \chi + (a_0 - \chi)e^{-\omega t}$$
$$\phi(a) = \chi + e^{-\omega}(a - \chi)$$

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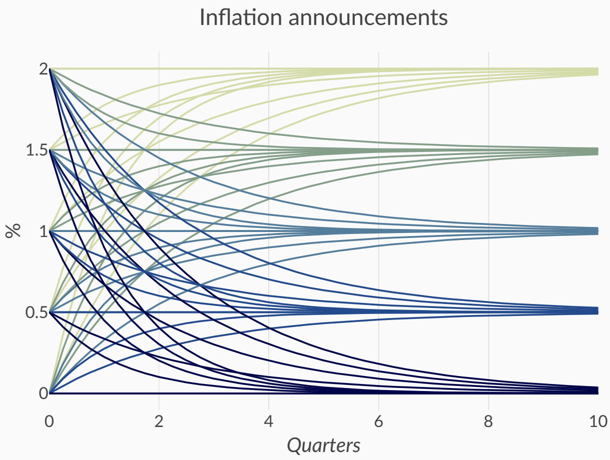

Gameplay

- At $t = 0$, inflation targets are announced
  - Type $c \in \mathcal{C}$ says c
  - Rational type **strategizes** announces r possibly $\in \mathcal{C}$
- At time $t \geq 0$, the government sets inflation
  - Behavioral type $c \in \mathcal{C}$ implements $g_t = a_t^c$
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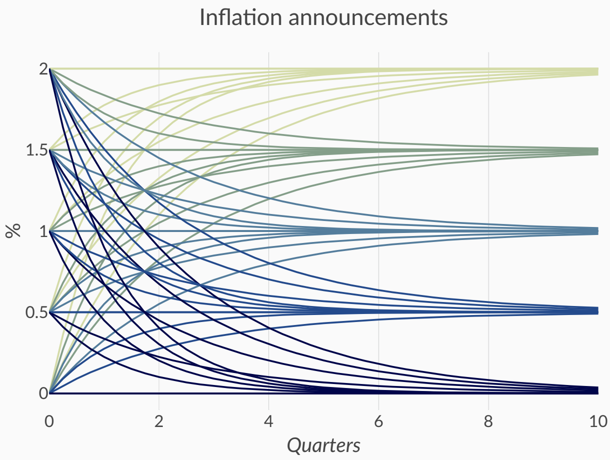

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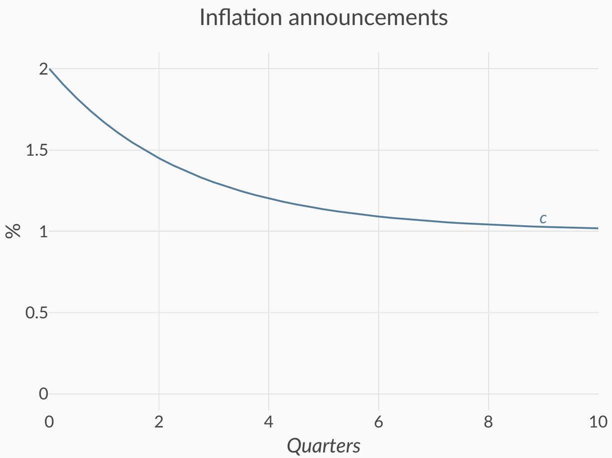

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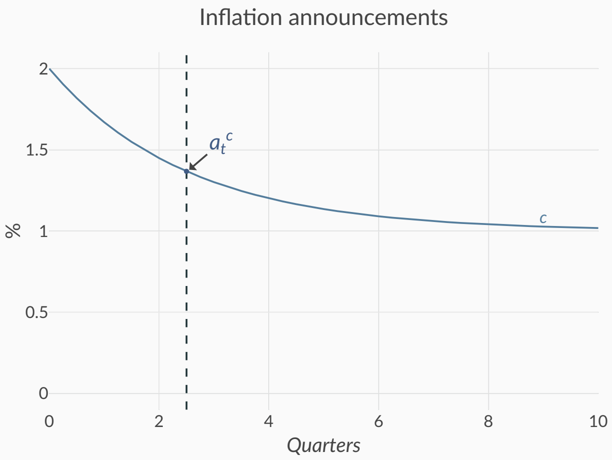

Continuation equilibria conditional on a plan

Reputation and Outcomes

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

$$\pi_t = \kappa y_t + \beta \mathbb{E}_t[\pi_{t+1}] = \kappa y_t + \beta \mathbb{E}_t\left[\mathbb{1}_c a^c_{t+1} + (1 - \mathbb{1}_c) g^\star_{t+1}\right]$$

- 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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Rational type's problem

▸ Sustainable ▸ Triggers ▸ Recursive

Given an announcement c,

- The problem of the rational type is, given expectations $g_c^\star$

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

$$\text{subject to } \pi = g + \epsilon$$

$$\pi = \kappa y + \beta\left[p'\phi_c(a) + (1-p')g_c^\star(p', \phi_c(a))\right]$$

$$p' = p + p(1-p)\frac{f_\epsilon(\pi - a) - f_\epsilon(\pi - g_c^\star(p,a))}{pf_\epsilon(\pi - a) + (1-p)f_\epsilon(\pi - g_c^\star(p,a))}$$

- Rational expectations requires $g_c^\star$ to be the policy associated with $\mathcal{L}^c$

Continuation Equilibrium

Definition

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

- $\mathcal{L}^c$ is the rational type's value function at expectations $g_c^\star$
- $g_c^\star$ is the policy function associated with $\mathcal{L}^c$

A First Look at Different Plans

Observation

- Plans $c \in \mathcal{C}$ are

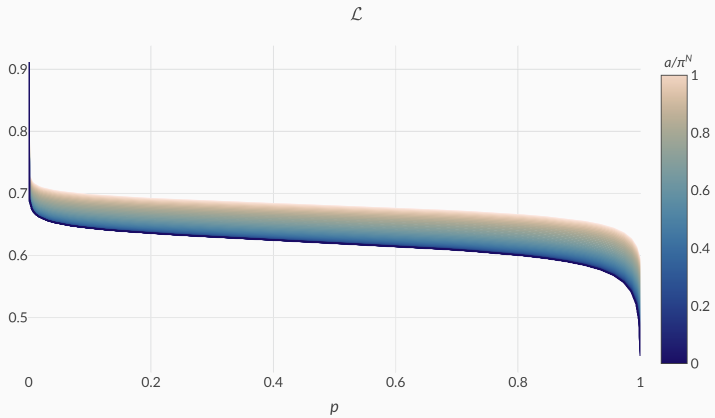
$$c = (a_0, \chi, \omega)$$

- For $a, b \in \mathbb{R}$

$$\begin{array}{ccc} (\mathcal{L}, g^\star) \text{ is a continuation} & & (\mathcal{L}, g^\star) \text{ is a continuation} \\ \text{equilibrium for } (a, \chi, \omega) & \iff & \text{equilibrium for } (b, \chi, \omega) \end{array}$$

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

The Value Function



- $\mathcal{L}$ decreasing in p
- $\mathcal{L}$ convex-concave in p
- $\mathcal{L}$ increasing in a for large p only

Reputation Dynamics

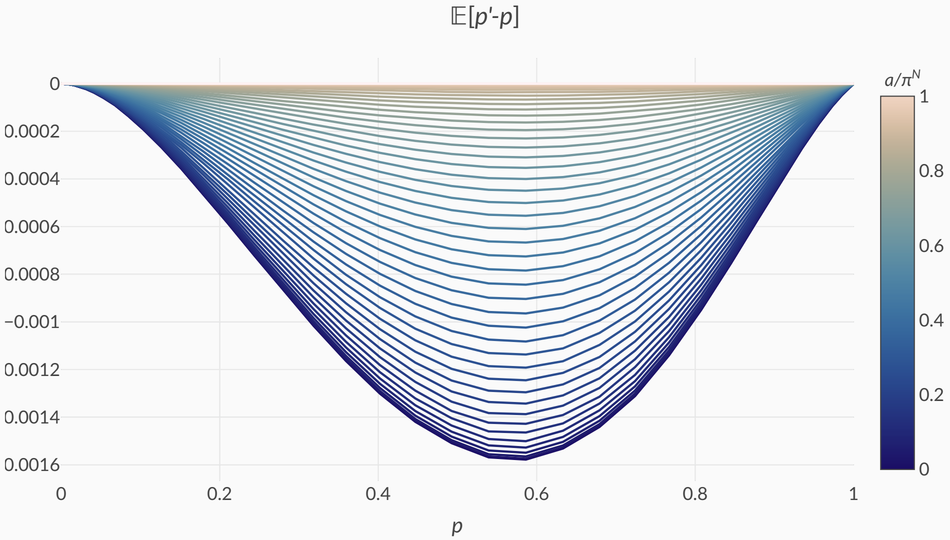
Lemma 1 ▸ Idea

In any continuation equilibrium,

$$\mathbb{E}_t\left[p_{t+1} \mid \text{rational}\right] \leq p_t$$

So $\{p_t\}_t$ is a supermartingale

Reputation Dynamics



Incentives

From the Phillips curve

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

- More inflation
  1. Increases output by $\frac{1}{\kappa}$
  2. Shifts inflation expectations from $\phi_c(a)$ towards $g^\star(p', \phi_c(a))$

     ... p' decreases with higher π when $g^\star(p, a) > a$
  3. Shifts expectations of the rational type's future choice

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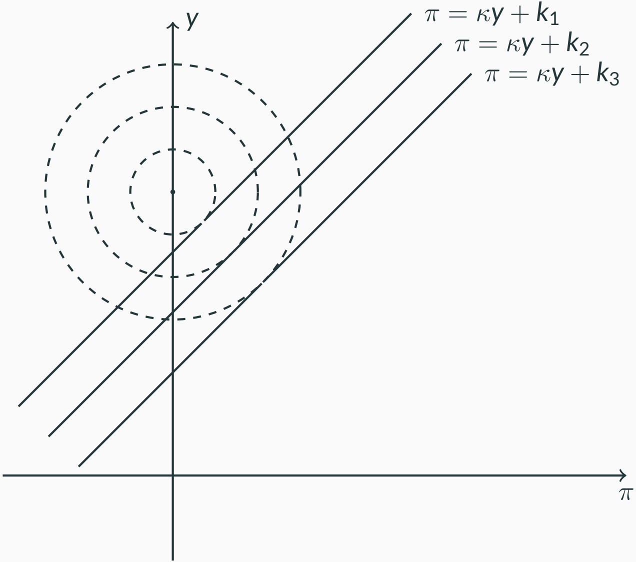
Phillips curves

▸ Bayes



- Without reputation:
  if $\beta \mathbb{E}[\pi'] = k_j$
  choose point on jth PC

- If announced a
  and in eq'm
  $g^\star(p, a) = a$
  $\implies$ get flat PC

- If $g^\star(p, a) > a$
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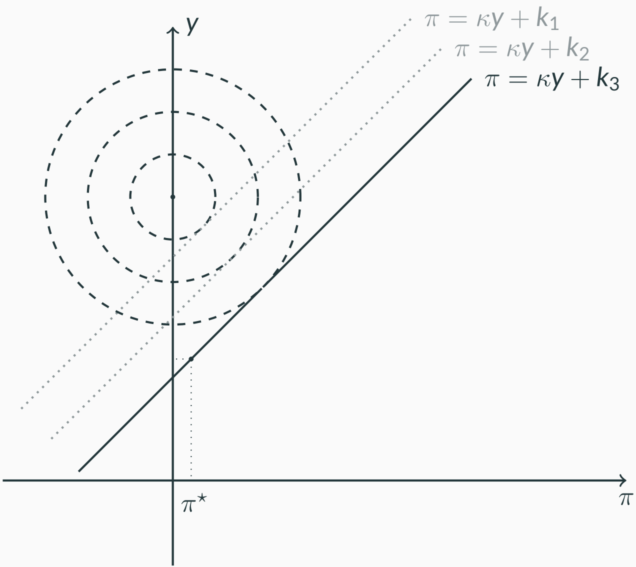

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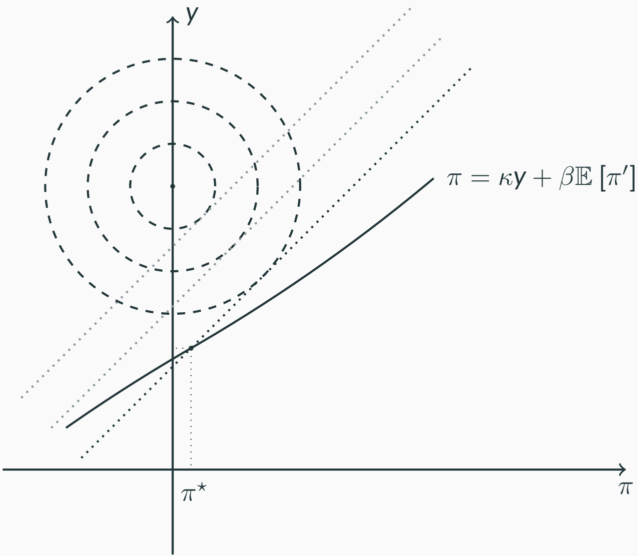

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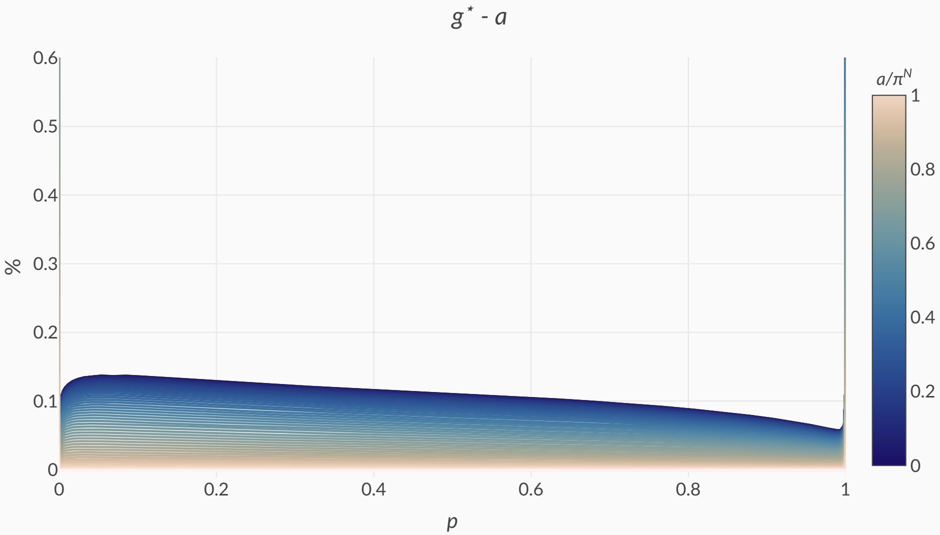
Equilibrium Deviations



Conjecture

- Let π^N be the Nash equilibrium inflation of the stage game. Then

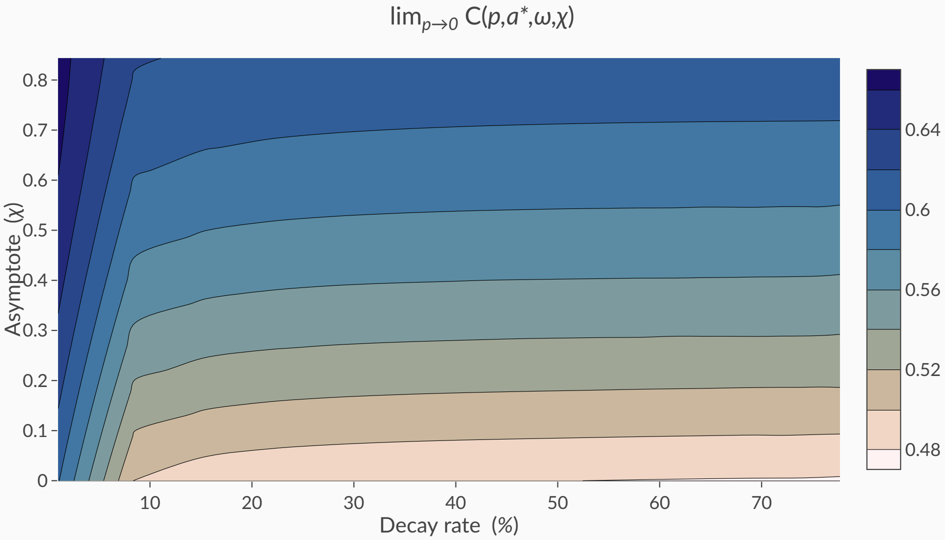
$$\forall c \in \mathcal{C} : \qquad g_c^\star(p, a) \le \pi^N$$

- Define the *remaining credibility* of a plan as

$$C_c(p, a) = (1 - \beta)\frac{\pi^N - g_c^\star(p, a)}{\pi^N - a} + \beta \mathbb{E}\left[C_c(p_c'(p, a), \phi_c(a))\right]$$

Plans

Credibility



Plans

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

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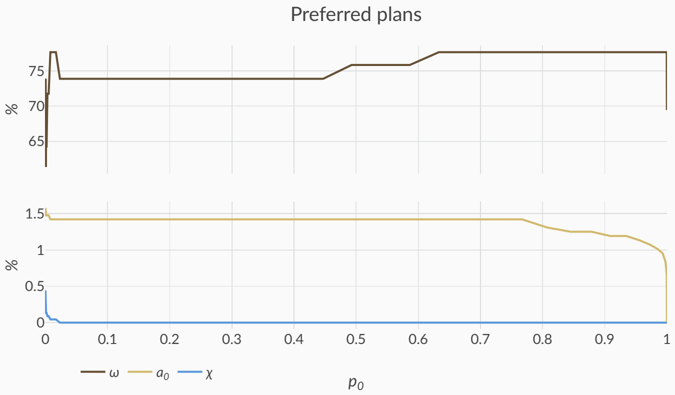

What plan to choose?

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

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

- 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

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

- Not entirely arbitrary
  - For given p_0, plans that minimize $\mathcal{L}$ should be played *often*

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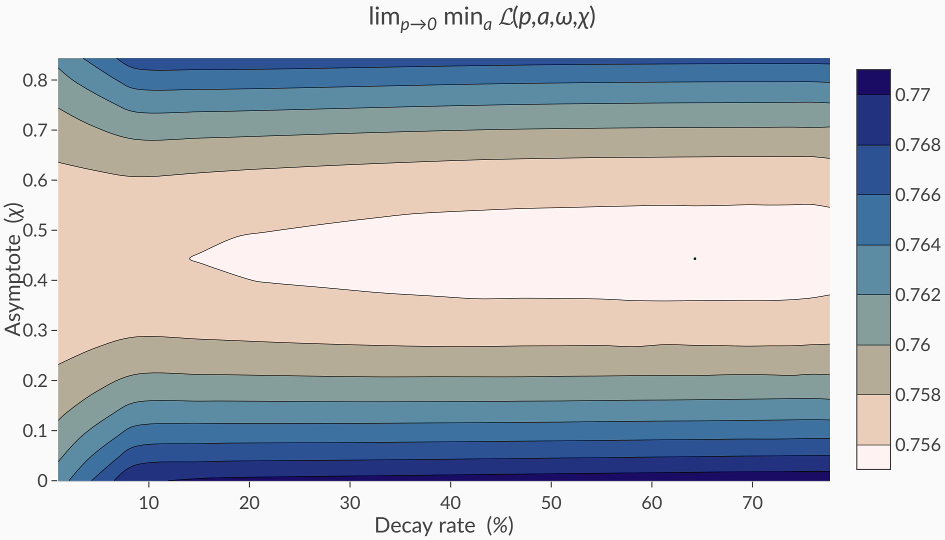
K-equilibrium



Equilibrium for given z

- We want k and μ 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

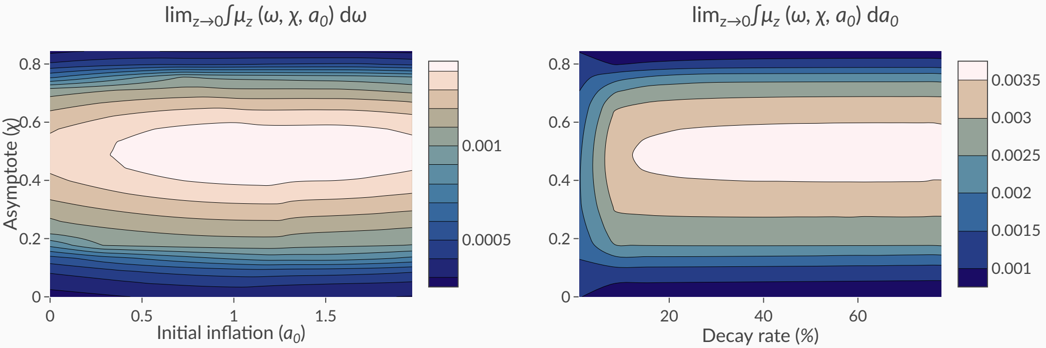
$$\begin{aligned} \mathcal{L}(1, c) &\geq k \quad \rightarrow \quad \mu(c) = 0 \\ \mathcal{L}(1, c) &< k \end{aligned}$$

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

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

    This is possible if $k \leq$ value in static Nash
  - Set $\mu(c) = \mathcal{B}^{-1}(p_0(c); \nu, z)$ if unset
  - Check whether $\int_{\mathcal{C}} \mu(c) = 1$

Equilibrium distribution of announcements



- Gradualism: $\mathbb{P}(a_0 > \chi) = 71.1\%$. $\mathbb{P}(a_0 > 5\chi) = 17.9\%$. $\mathbb{P}(\text{decay} \leq 10\%) = 8.01\%$.
- Imperfect credibility: $\mathbb{P}(\chi = 0) = 1.51\%$.

Discussion

Other Models

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

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

- Recursive version of *Ramsey plan*
  - Initial $\theta = 0$
  - Time inconsistency: $\theta'(0) \neq 0$
- FOC for θ': $\pi - \kappa y + \beta \frac{\partial v^{FB}(\theta')}{\partial \theta'} = 0 \quad \longrightarrow \quad \pi = \kappa y + \beta\pi'$
- Simulate by iterating on $\pi_t = \pi(\theta), \theta_{t+1} = \theta'(\theta)$
- Imperfect control irrelevant $\quad \longrightarrow \quad$ only adds $\sigma_\epsilon^2 \left(\gamma + \frac{1}{\kappa^2}\right)$

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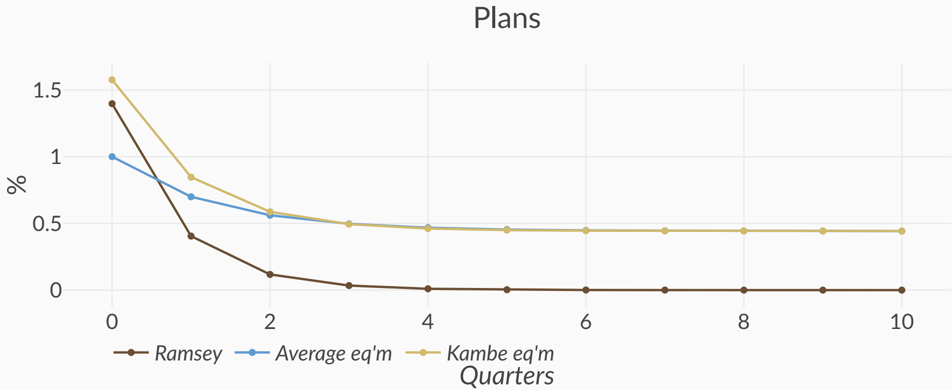


Sustainable plans with expectations as threats

◂ Plan

Descentralization

- Perfect control of inflation
- Private sector 'threatens' to expect ξ after deviations

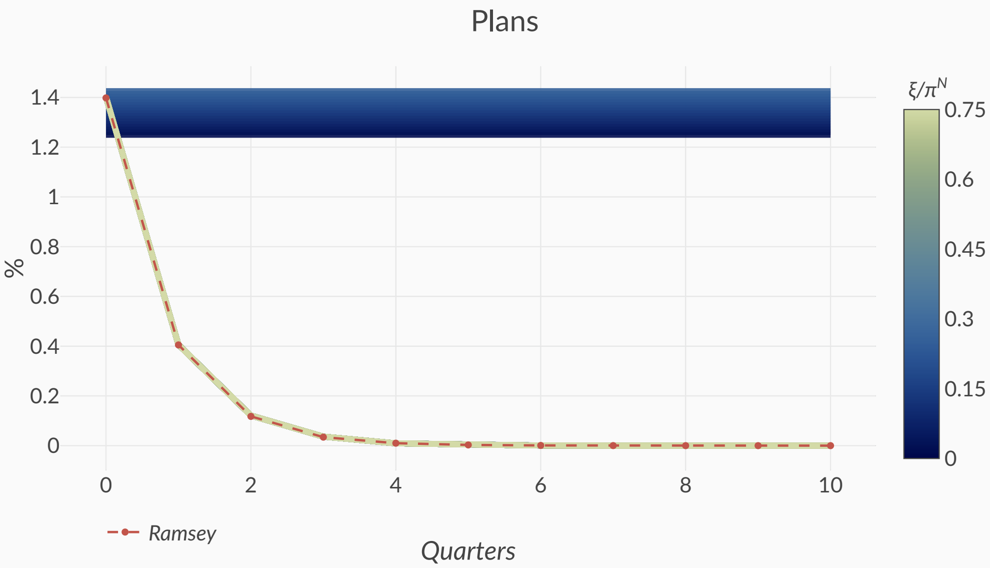
$$v^{\xi}(p,a) = \min_{y,\pi,a'} \; (y-y^{\star})^2 + \gamma\pi^2 + \beta v^{\xi}(p',a')$$

$$\text{subject to} \quad \pi = \kappa y + \beta\left(p' g_{\pi}^{\xi}(1,a') + (1-p')\xi\right)$$

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

- Use p to denote whether the government has deviated ▸ Is this Reputation?

Sustainable plans with expectations as threats



Sustainable plans with reverting triggers

Plan

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

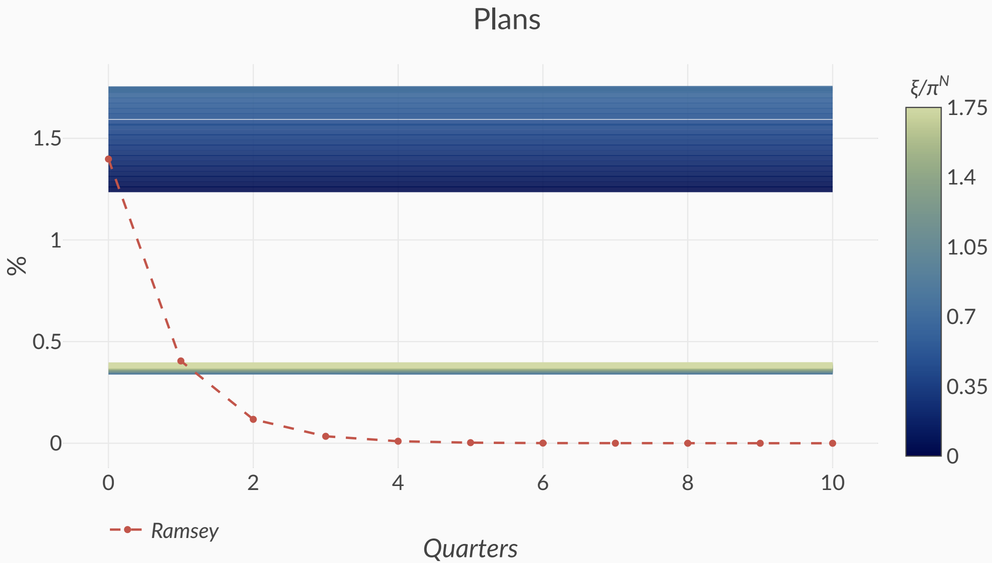
$$
\begin{aligned}
v^G(a) = \min_{g,a'} \mathbb{E}\left[(y-y^\star)^2 + \gamma\pi^2 + \beta\left(p'v^G(a) + (1-p')v^P\right)\right] \\
\text{subject to} \quad & \pi = g + \epsilon \\
& \pi = \kappa y + \beta\left(p' g^G(a') + (1-p')\xi\right) \\
& p' = \begin{cases} 1 & \text{if } \frac{|\pi - a|}{a} < D \\ 0 & \text{otherwise} \end{cases}
\end{aligned}
$$

$$
\begin{aligned}
v^P = \min_{\pi,a'} (y-y^\star)^2 + \gamma\pi^2 + \beta\left(\theta v^G(a) + (1-\theta)v^P\right) + \sigma_\epsilon^2\left(\gamma + \frac{1}{\kappa^2}\right) \\
\text{subject to} \quad \pi = \kappa y + \beta\xi
\end{aligned}
$$

Sustainable plans with reverting triggers (cont'd)

$$
\begin{aligned}
v^{GP}(p,a) = \min_{g,a'} \mathbb{E}\left[(y-y^\star)^2 + \gamma\pi^2 + \beta\left(v^{GP}(p',a')\right)\right] \\
\text{subject to} \quad & \pi = g + \epsilon \\
& \pi = \kappa y + \beta\left(p' g^{GP}(p',a') + (1-p')\xi\right) \\
& p' = \begin{cases} \begin{cases} 1 & \text{if } \frac{|\pi - a|}{a} < D \\ 0 & \text{otherwise} \end{cases} & \text{if } p = 1 \\ \begin{cases} 1 & \text{with prob } \theta \\ 0 & \text{with prob } 1-\theta \end{cases} & \text{if } p = 0 \end{cases}
\end{aligned}
$$

Sustainable plans with reverting triggers



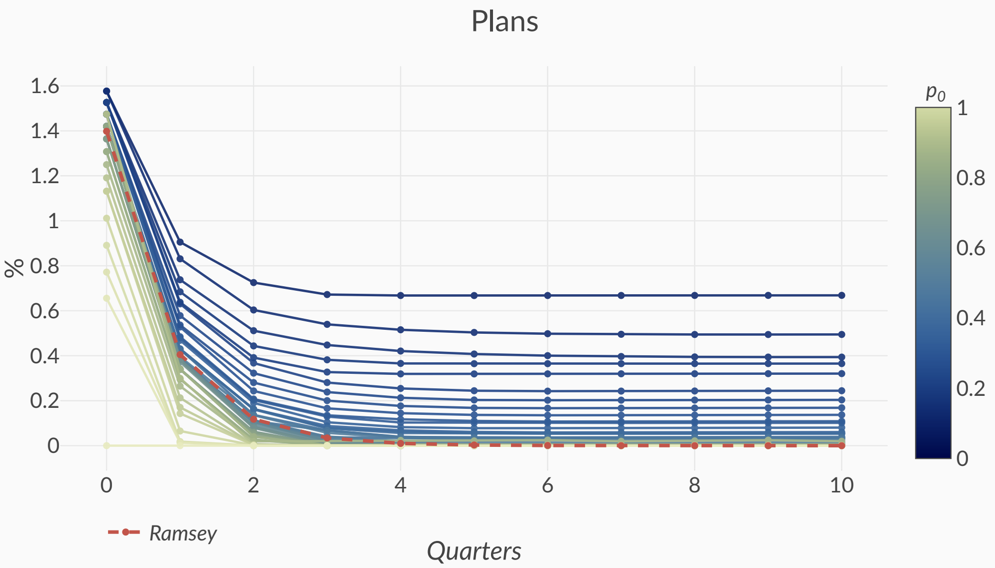
Recursive plans with reputation

◀ Plan

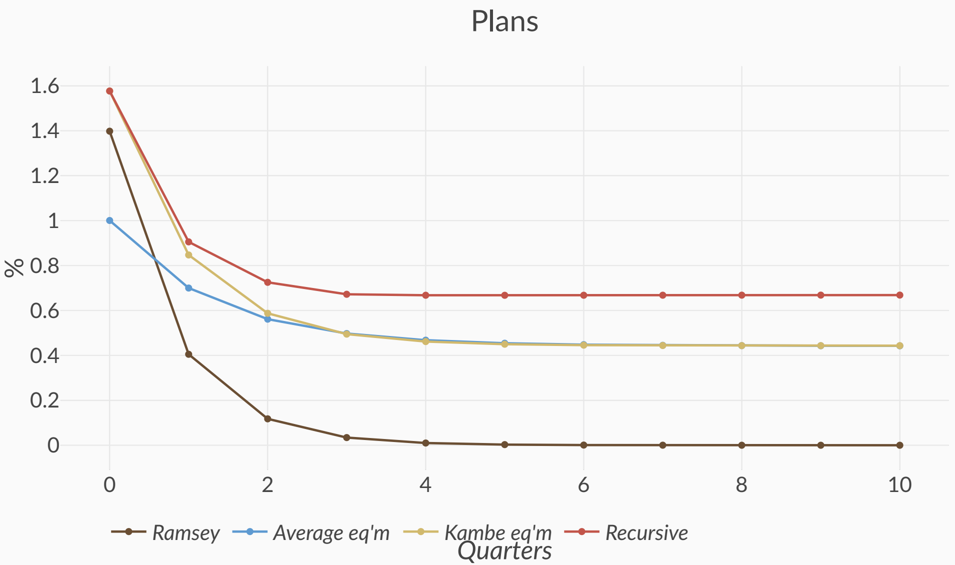
- Planner + policy maker structure (as in Dovis & Kirpalani, 2019)

$$
\begin{aligned}
v^R(p,a) = \min_{g,a'} \mathbb{E}\left[(y-y^\star)^2 + \gamma\pi^2 + \beta v^R(p',a')\right] \\
\text{subject to} \quad & \pi = g + \epsilon \\
& \pi = \kappa y + \beta\left(p'a' + (1-p')g^R(p',a')\right) \\
& p' = p + p(1-p)\frac{f_\epsilon(\pi-a) - f_\epsilon(\pi - g^R(p,a))}{pf_\epsilon(\pi-a) + (1-p)f_\epsilon(\pi-g^R(p,a))}
\end{aligned}
$$

Recursive plans with reputation



Comparison of models



Comparison of models

Model	Ramsey	Kambe eq'm	'Average' rec plan	Recursive plan
Initial inflation	1.40%	1.63%	1.58%	1.58%
Long-run inflation	0%	0.44%	0.65%	0.65%
Value function	0.3364	0.7552	0.7589	0.7554

Table 1: Inflation plans

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Table 1: Inflation plans

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

Comparison of models

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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

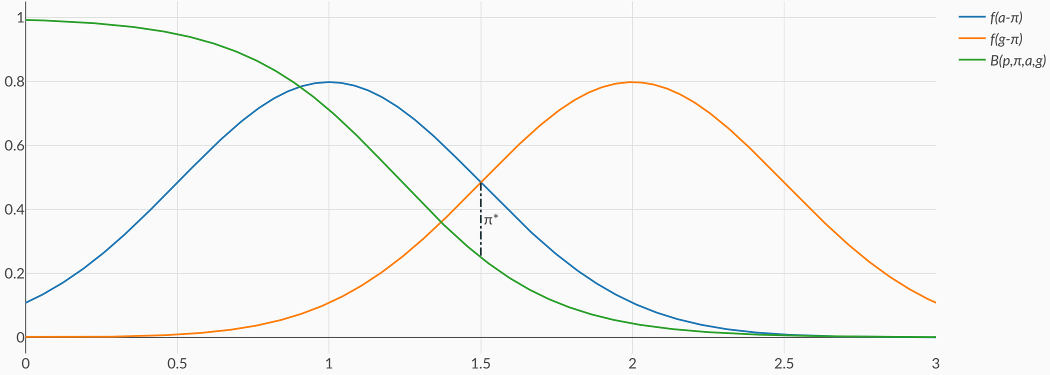
  . . . creating large option values of complying

  . . . which are larger when the plan is backloaded

Bayes' Law

to Lemma to Phillips curves

$$\mathcal{B}(p,\pi,a,g) = p + p(1-p)\frac{f_\epsilon(\pi-a) - f_\epsilon(\pi-g)}{pf_\epsilon(\pi-a) + (1-p)f_\epsilon(\pi-g)}$$



Reputation (Kreps and Wilson, 1982; Milgrom and Roberts, 1982)

Back

Imagine an incumbent facing a sequence of potential entrants

- Each period, entrant decides entry, incumbent **fights** or **accomodates**
  - Incumbent prefers entrant to stay out but prefers to accomodate 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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