

# Credibility Dynamics and Disinflation Plans

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# Motivation

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- 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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- Application in a (modern) Barro-Gordon setup

- 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

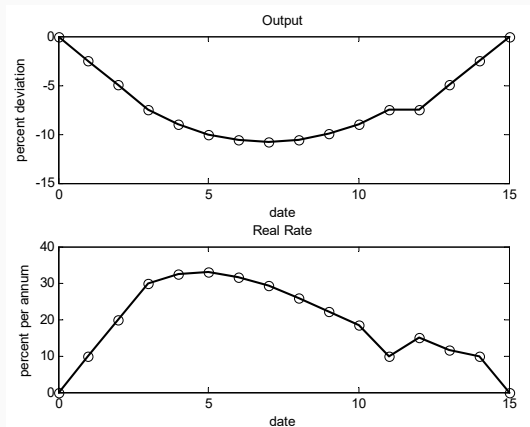
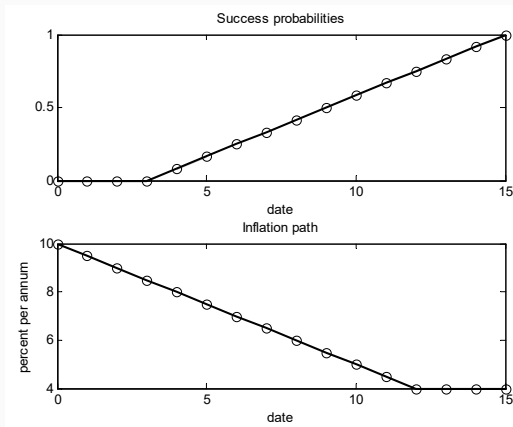
Planner chooses a  
**back-loaded** plan

- In application, gradual disinflation
- No real inertia, but good for incentives

- Consider the limit when initial reputation **vanishes** to zero

# Our want operator

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





- **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

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

# Model

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# 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  $\epsilon_t \stackrel{iid}{\sim} F_\epsilon$

# Reputation

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- 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  $\nu$  over  $\mathcal{C}$
- Private sector knows  $z$  and  $\nu$ 
  - Does inference over the government’s type
  - Uses announcement and inflation choices

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# Behavioral types

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

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

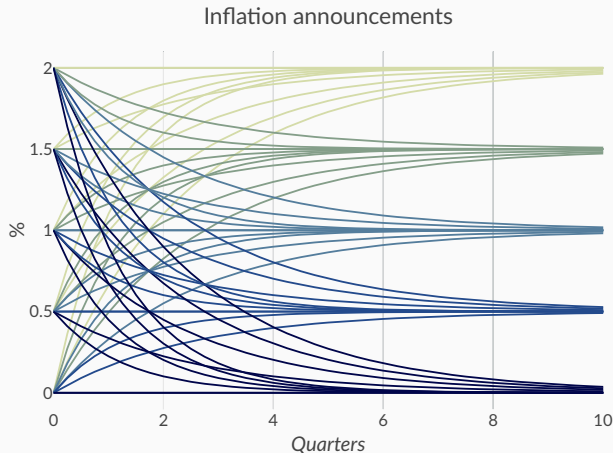
$$\phi(a) = \chi + e^{-\omega}(a - \chi)$$

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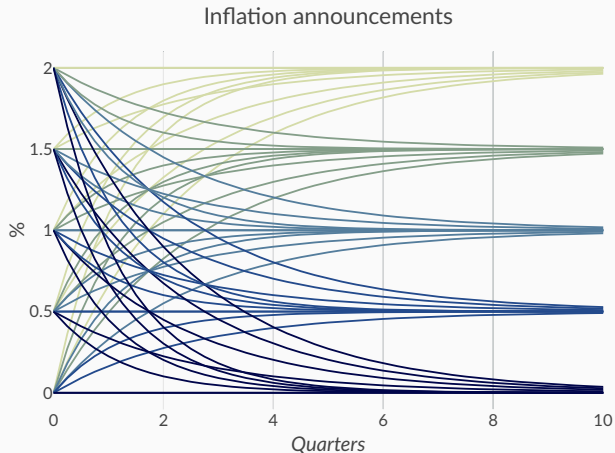
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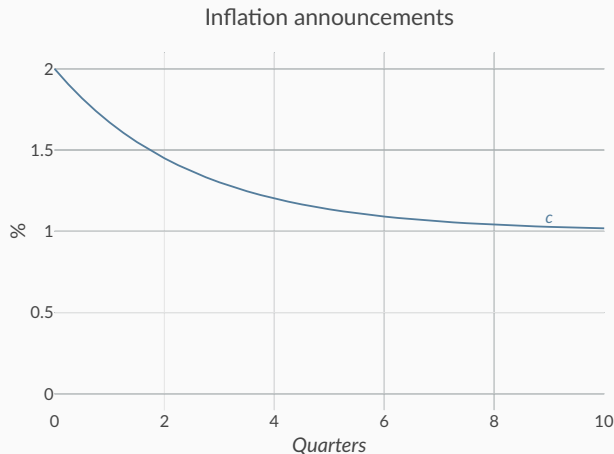
# Gameplay

- 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  $g_t = a_t^c$
  - Rational type acts strategically chooses  $g_t \lesseqgtr a_t^c$



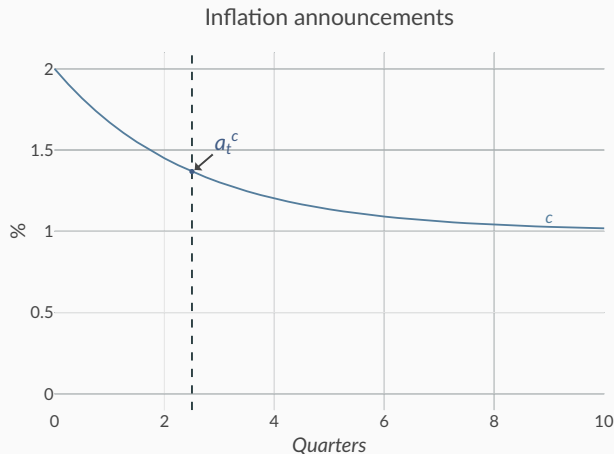
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## Continuation equilibria conditional on a plan

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- 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

$$\mathbb{P}(c \mid \pi_t, \mathcal{F}_{t-1}) = \frac{\mathbb{P}(c \mid \mathcal{F}_{t-1}) \cdot f_\epsilon(\epsilon_t \mid c)}{\mathbb{P}(c \mid \mathcal{F}_{t-1}) \cdot f_\epsilon(\epsilon_t \mid c) + (1 - \mathbb{P}(c \mid \mathcal{F}_{t-1})) \cdot f_\epsilon(\epsilon_t \mid r)}$$

## Reputation and Outcomes

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

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$$\mathbb{P}(c \mid \pi_t, \mathcal{F}_{t-1}) = \frac{\mathbb{P}(c \mid \mathcal{F}_{t-1}) \cdot f_\epsilon(\pi_t - a_t^c)}{\mathbb{P}(c \mid \mathcal{F}_{t-1}) \cdot f_\epsilon(\pi_t - a_t^c) + (1 - \mathbb{P}(c \mid \mathcal{F}_{t-1})) \cdot f_\epsilon(\pi_t - g_t^*)}$$

Given an announcement  $c$ ,

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

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

subject to  $\pi = g + \epsilon$

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

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

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

## 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  $c \in \mathcal{C}$  are

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

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

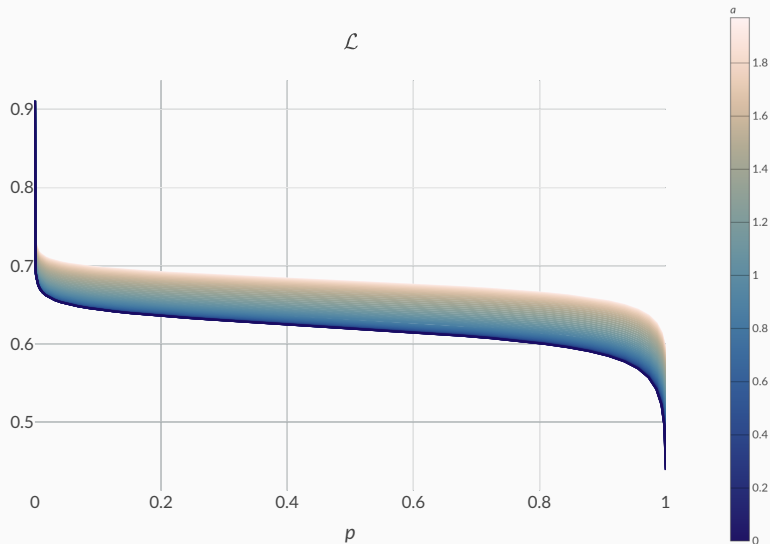
$(\mathcal{L}, g^*)$  is a continuation  
equilibrium for  $(a, \chi, \omega)$



$(\mathcal{L}, g^*)$  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



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

## Lemma 1

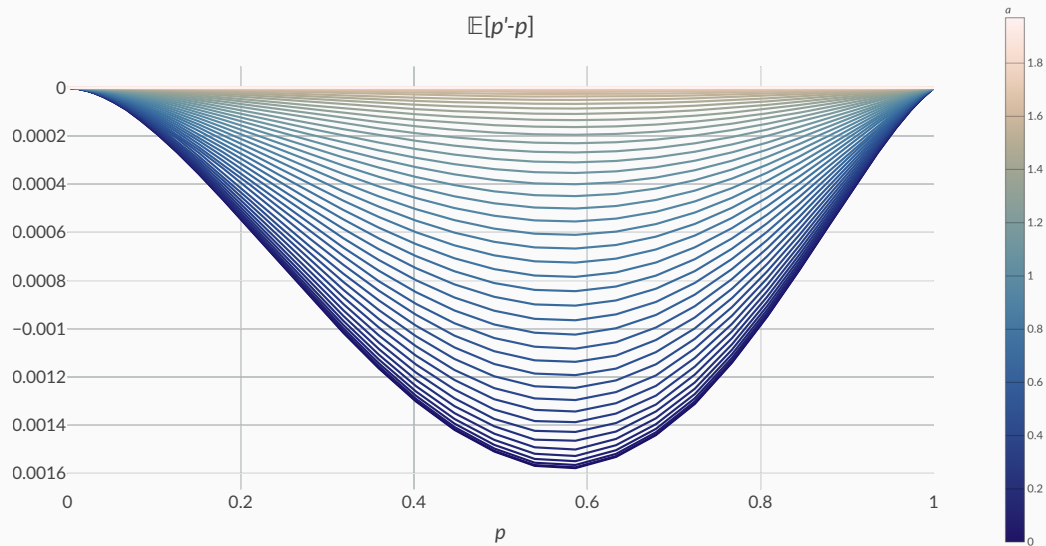
► Idea

In any continuation equilibrium,

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

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

# Reputation Dynamics



From the Phillips curve

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

- More inflation

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

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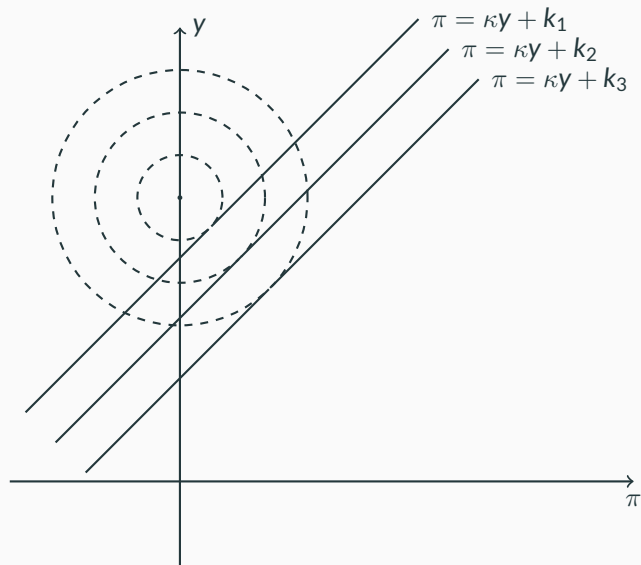
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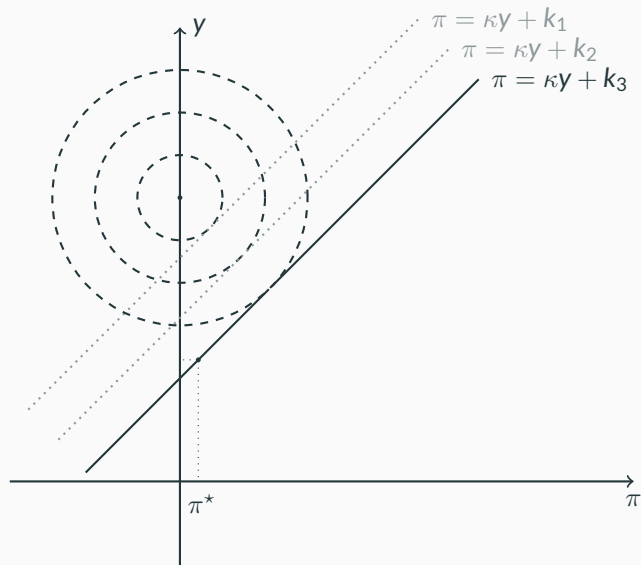
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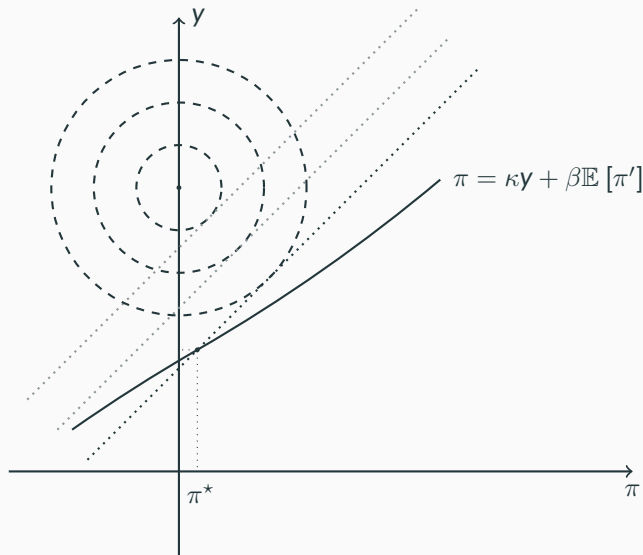




- Without reputation:  
if  $\beta \mathbb{E} [\pi'] = k_j$   
choose point on  $j$ th PC
- If announced  $a$   
and in eq'm  
 $g^*(p, a) = a$   
 $\implies$  get flat PC
- If  $g^*(p, a) > a$   
 $\implies \frac{\partial p'}{\partial \pi}$  matters

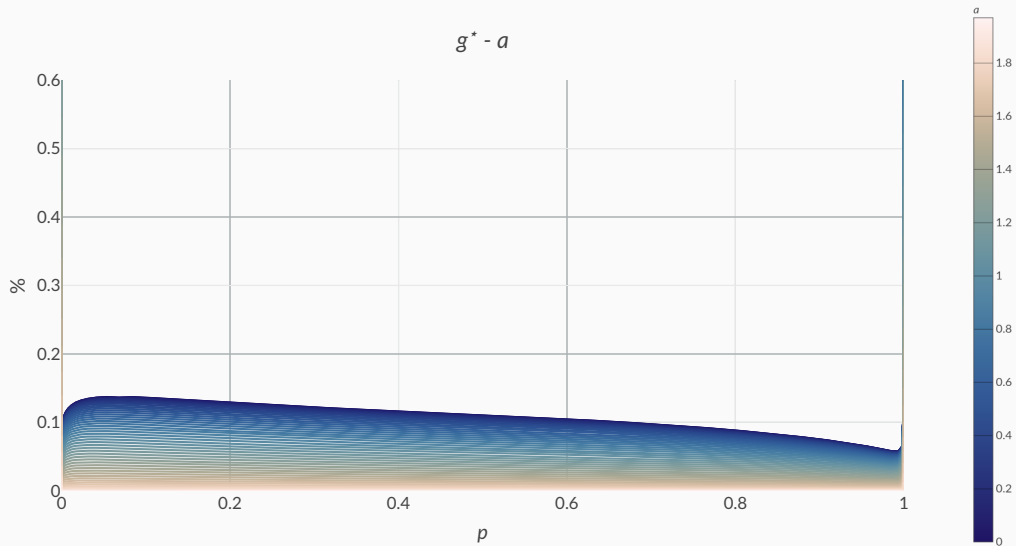


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# Equilibrium Deviations



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

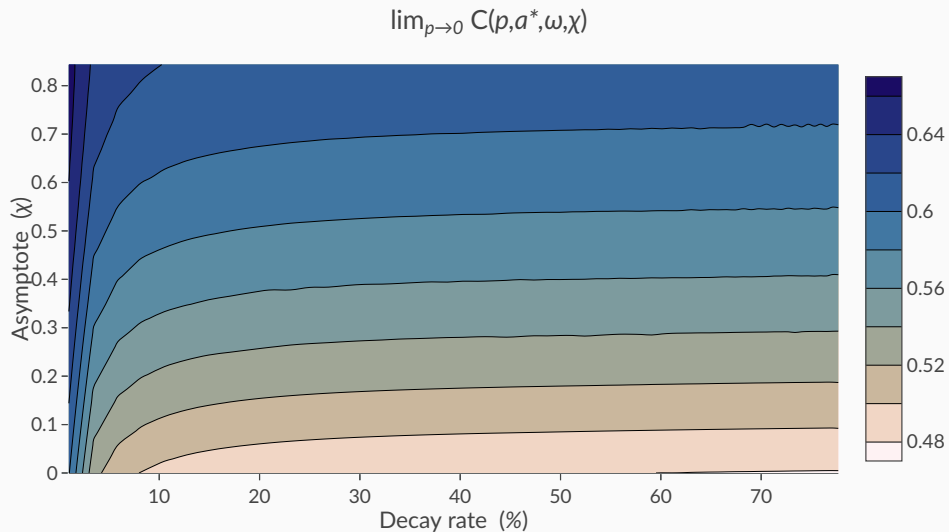
$$\forall c \in \mathcal{C} : \quad g_c^*(p, a) \leq \pi^N$$

- 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

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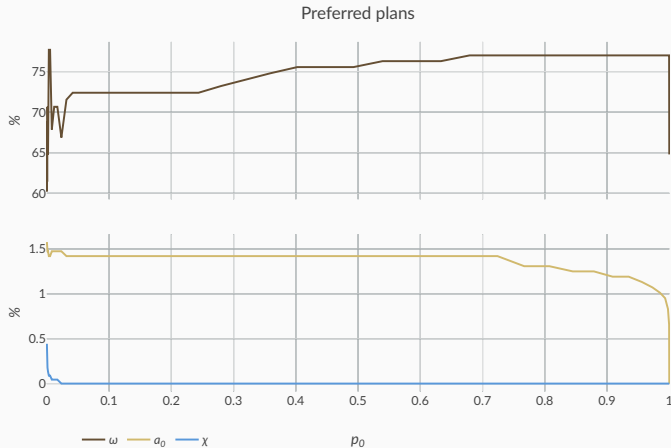


- For each  $c \in \mathcal{C}$ , find  $\mathcal{L}^c(p, a), g_c^*(p, a)$ .
- Generates big matrix  $\mathcal{L}(p, a; \omega, \chi)$
- First pass: preferred plan **at each  $p$**



# Plans

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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

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

- 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

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

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  - For given  $p_0$ , plans that minimize  $\mathcal{L}$  should be played *often*

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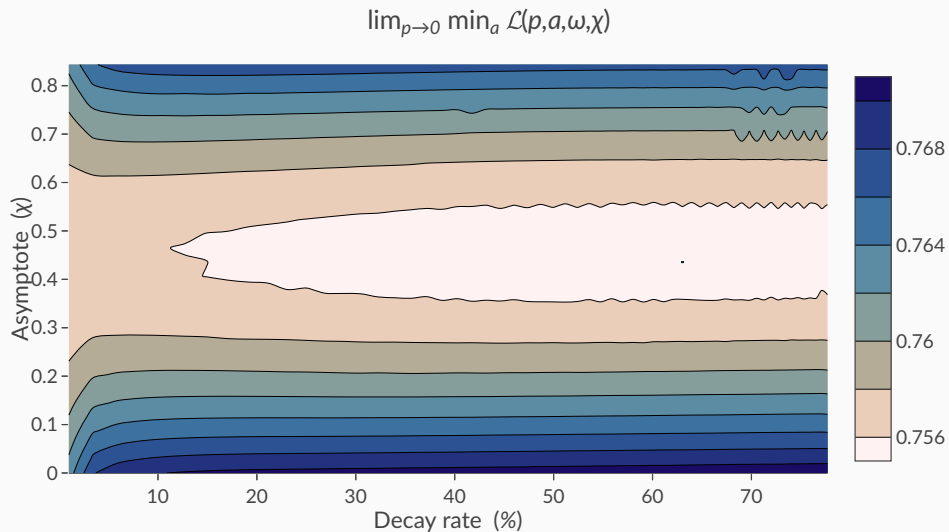
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## Equilibrium for given $z$

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

$$\int_C \mu(c) = 1$$

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

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

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

- We do

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

- Partition states

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

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

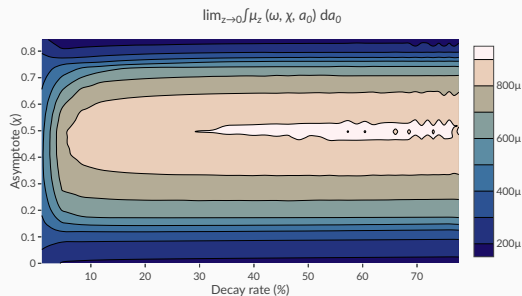
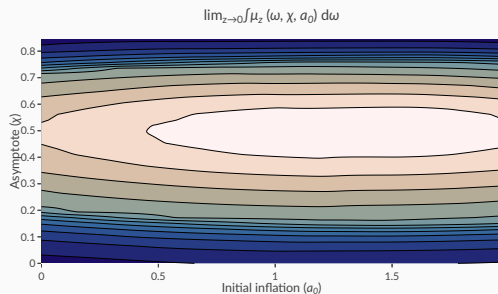
- In second case find  $\mu(c)$  such that

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

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

- Set  $\mu(c) = \mathcal{B}^{-1}(p_0(c); \nu, z)$  if unset
- Check whether  $\int_C \mu(c) = 1$

# Equilibrium distribution of announcements



- Gradualism:  $\mathbb{P}(a_0 > \chi) = 71.3\%$ .  $\mathbb{P}(a_0 > 5\chi) = 18\%$ .  $\mathbb{P}(\text{decay} \leq 10\%) = 6.17\%$ .
- Imperfect credibility:  $\mathbb{P}(\chi = 0) = 0.73\%$ .

## Discussion

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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

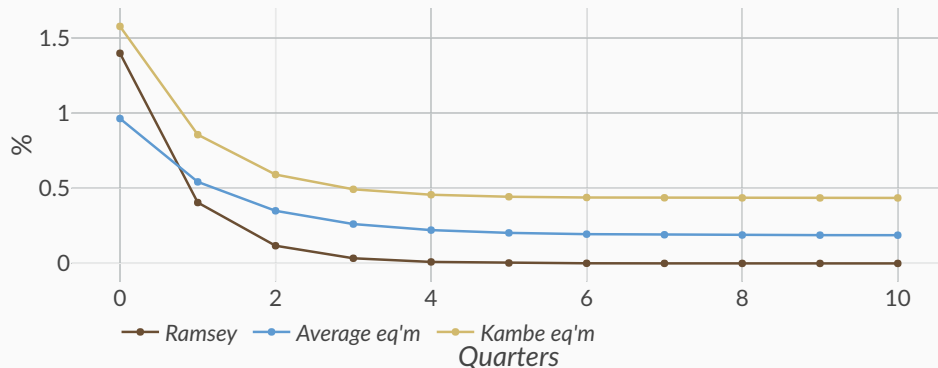
$$v^{FB}(\theta) = \max_{\theta'} \min_{y, \pi} (y - y^*)^2 + \gamma \pi^2 + \theta'(\pi - \kappa y) - \theta \pi + \beta v^{FB}(\theta')$$

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

# A Planning Problem

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

Plans



## Decentralization

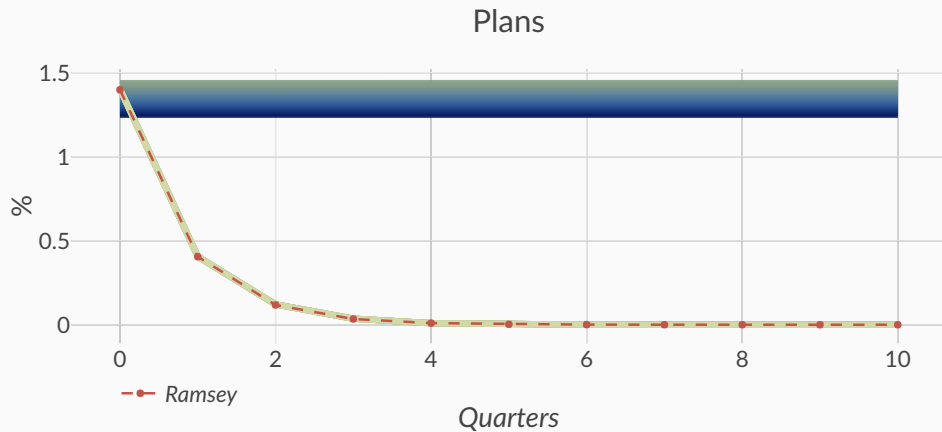
- Perfect control of inflation
- Private sector 'threatens' to expect  $\xi$  after deviations

$$\begin{aligned} v^\xi(p, a) &= \min_{y, \pi, a'} (y - y^*)^2 + \gamma \pi^2 + \beta v^\xi(p', a') \\ \text{subject to } \pi &= \kappa y + \beta (p' g_\pi^\xi(1, a') + (1 - p') \xi) \\ p' &= \begin{cases} 1 & \text{if } \pi = a \\ 0 & \text{otherwise} \end{cases} \end{aligned}$$

- Use  $p$  to denote whether the government has deviated

[► Is this Reputation?](#)

## Sustainable plans with expectations as threats



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

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

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

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

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

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

$$\text{subject to } \pi = \kappa y + \beta \xi$$

## Sustainable plans with reverting triggers (cont'd)

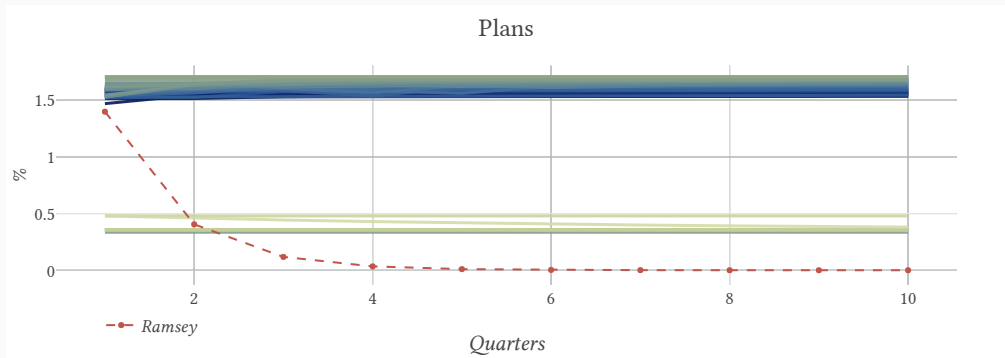
$$v^{GP}(p, a) = \min_{g, a'} \mathbb{E} \left[ (y - y^*)^2 + \gamma \pi^2 + \beta \left( v^{GP}(p', a') \right) \right]$$

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

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

$$p' = \begin{cases} \begin{cases} 1 & \text{if } \frac{|\pi - a|}{a} < D \\ 0 & \text{otherwise} \end{cases} & \text{if } p = 1 \\ \begin{cases} 1 & \text{with prob } \theta \\ 0 & \text{with prob } 1 - \theta \end{cases} & \text{if } p = 0 \end{cases}$$

# Sustainable plans with reverting triggers





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

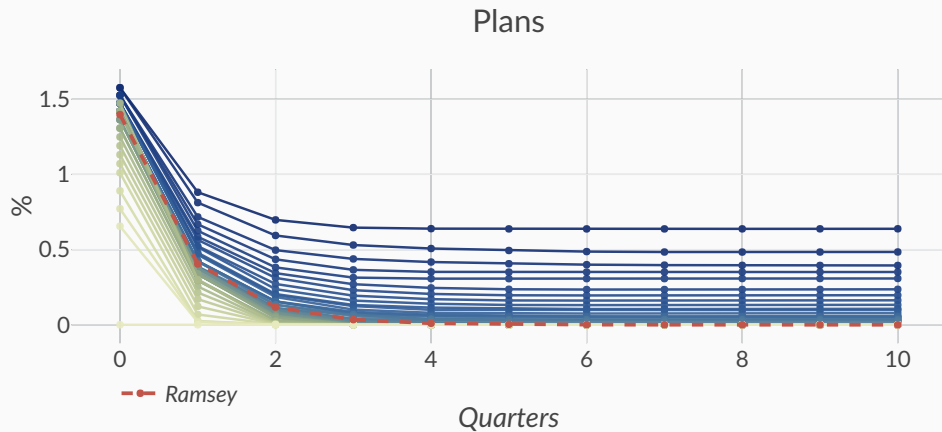
$$v^R(p, a) = \min_{g, a'} \mathbb{E} \left[ (y - y^*)^2 + \gamma \pi^2 + \beta v^R(p', a') \right]$$

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

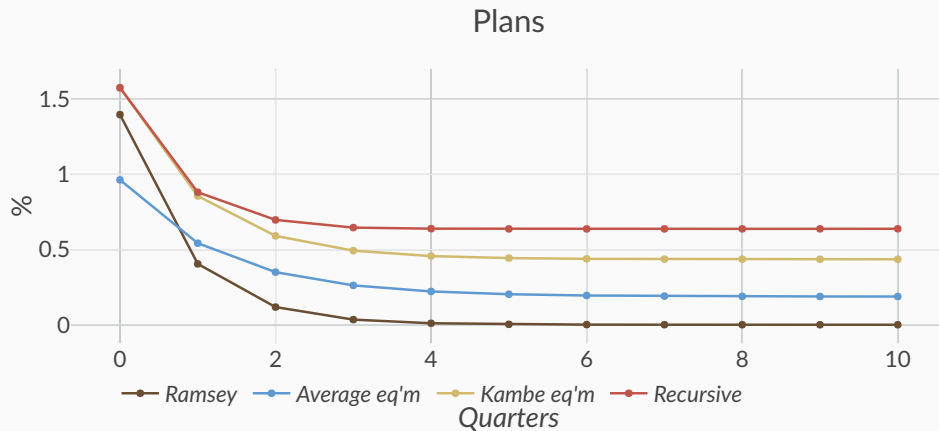
$$\pi = \kappa y + \beta (p' a' + (1 - p') g^R(p', a'))$$

$$p' = p + p(1 - p) \frac{f_\epsilon(\pi - a) - f_\epsilon(\pi - g^R(p, a))}{p f_\epsilon(\pi - a) + (1 - p) f_\epsilon(\pi - g^R(p, a))}$$

## 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

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Table 1: Inflation plans

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

# Conclusion

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## Concluding Remarks

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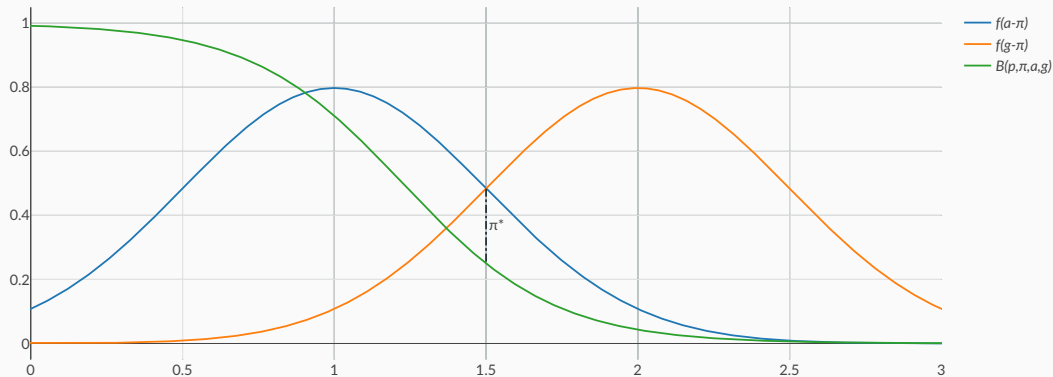
- Model of reputational dynamics and policy
  - Simple environment
  - Focus on low reputation limit
- Credibility-dynamics concerns influence choice of policy
  - Tradeoff between literal **promises** and **incentives**
  - Gradual plans boost reputation-building incentives for **future** decision-makers
- 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



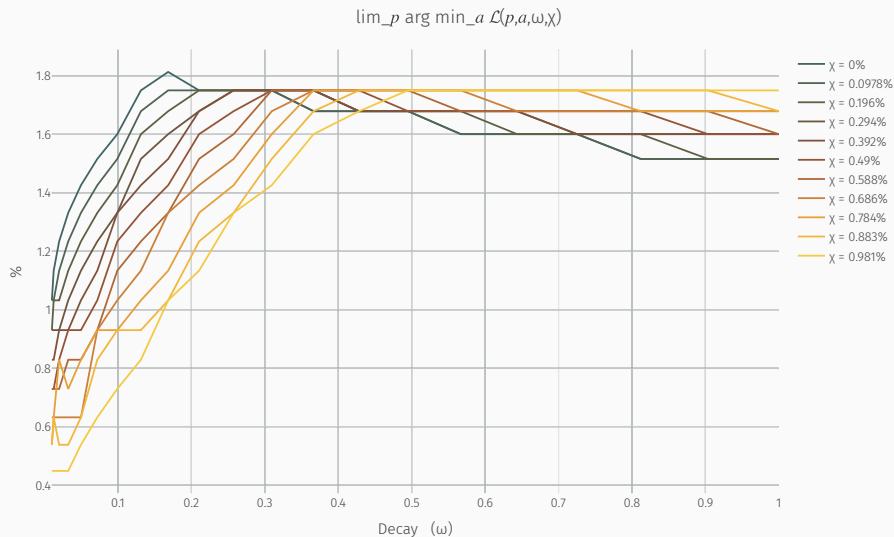
# Bayes' Law

[◀ to Lemma](#)[◀ to Phillips curves](#)

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



# Results

[◀ 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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