Reputation and the Credibility of Inflation Plans

Rumen Kostadinov
McMaster

Francisco Roldán
IMF

IMF Western Hemisphere Department seminar
March 2024

What is credibility?

- 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

  … borrowing insights from game-theory literature on reputation
- Application in a (modernized) Barro-Gordon setup

What is credibility?

- 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

  … borrowing insights from game-theory literature on reputation
- Application in a (modernized) Barro-Gordon setup

Our approach

- Reputation is other agents' belief about my commitments

  … conceptualize commitment with private-information behavioral types

- Discipline (rational expectations)

  … can only have reputation for possible things

  … reputation changes through Bayes' rule after actions and announcements

- Setup
  - Initial announcement of inflation targets

    … collapses the set of reputations
  - Continuation equilibrium *given a plan*

    … Crucial assumption: government action observed imperfectly

    … Dynamics of reputation

Our approach

- Reputation is other agents' belief about my commitments

  … conceptualize commitment with private-information behavioral types

- Discipline (rational expectations)

  … can only have reputation for possible things

  … reputation changes through Bayes' rule after actions and announcements

- Setup
  - Initial announcement of inflation targets

    … collapses the set of reputations
  - Continuation equilibrium *given a plan*

    … Crucial assumption: government action observed imperfectly

    … Dynamics of reputation

Our approach

- Reputation is other agents' belief about my commitments

  … conceptualize commitment with private-information behavioral types

- Discipline (rational expectations)

  … can only have reputation for possible things

  … reputation changes through Bayes' rule after actions and announcements

- Setup
  - Initial announcement of inflation targets

    … collapses the set of reputations
  - Continuation equilibrium *given a plan*

    … Crucial assumption: government action observed imperfectly

    … Dynamics of reputation

Main results

1. Compare continuation equilibria of different plans
   - … Larger deviations are **easier** to detect
   - … 'More time-inconsistent' plans have a more negative average drift of reputation
   - … Tradeoff between credibility and promised outcomes

2. Main result   choose a back-loaded plan with gradual disinflation
   - … Gradualism helps incentives and slows down reputation losses
   - … despite no inertia or other *real* reasons for gradualism

3. Take the limit as *initial reputation* vanishes to zero
   - … Gradualism result is preserved

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
- Plans
- Initial announcement
- Concluding remarks

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 (initial reputation)
  - Conditional on behavioral, probability ν over $\mathcal{C}$
- Private sector knows z and ν
  - Does *inference* over the government's type
  - Uses announcements and inflation observations

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 (initial reputation)
  - Conditional on behavioral, probability ν over $\mathcal{C}$
- Private sector knows z and ν
  - Does *inference* over the government's type
  - Uses announcements and inflation observations

Behavioral types

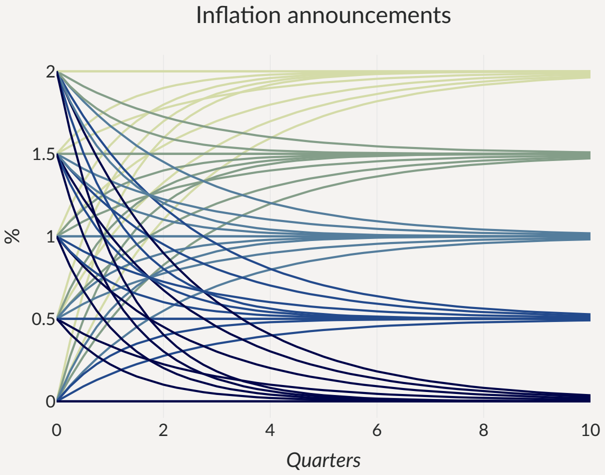
- What is the set $\mathcal{C}$?
  - $\cdots$ and associated possible ϕ_c functions
- Consider $\{a_t\}_t$ paths characterized by
  - Starting point a_0
  - Decay rate ω
  - Asymptote χ

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

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

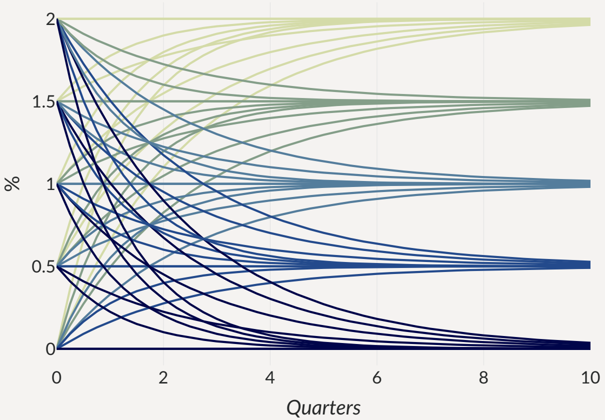
$$a_t = \chi + (a_0 - \chi)e^{-\omega t}$$
$$\phi(a) = \chi + e^{-\omega}(a - \chi)$$



Gameplay

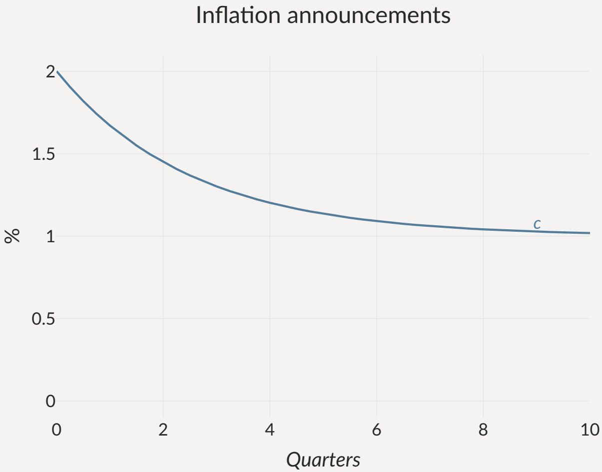
- At $t = 0$, inflation targets are announced
  - Type $c \in \mathcal{C}$ says c
  - Rational type **strategizes** announces r possibly $\in \mathcal{C}$
- At time $t \geq 0$, the government sets inflation
  - Behavioral type $c \in \mathcal{C}$ implements $g_t = a_t^c$
  - Rational type acts strategically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

Inflation announcements



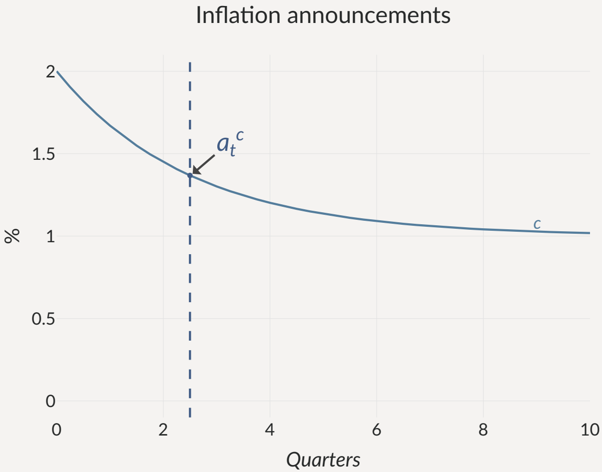
Gameplay

- 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 $g_t \lessgtr a_t^c$



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 $g_t \lesseqgtr a_t^c$



Continuation equilibria

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

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

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

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

Reputation and Outcomes

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

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

- Private sector solves a **signal extraction** problem to update beliefs

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

Reputation and Outcomes

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

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

- Private sector solves a **signal extraction** problem to update beliefs

$$p_{t+1} = \frac{p_t \cdot f_\epsilon(\pi_t - a^c_t)}{p_t \cdot f_\epsilon(\pi_t - a^c_t) + (1 - p_t) \cdot f_\epsilon(\pi_t - g^\star_t)}$$

Rational type's problem

Given an announcement c,

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

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

- 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

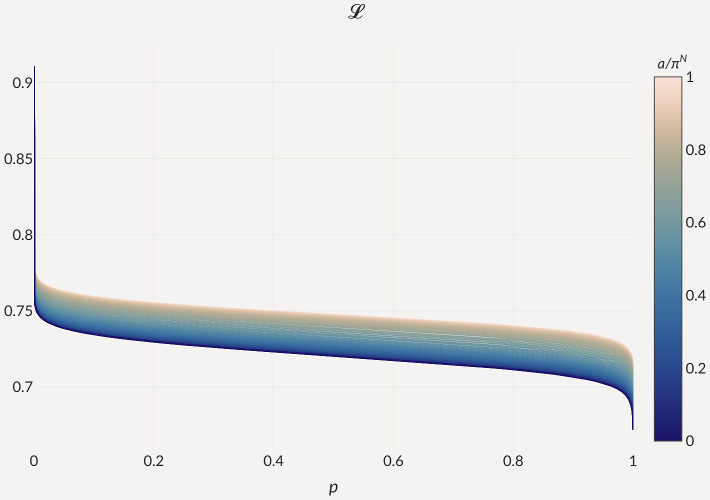
$$c = (a_0, \chi, \omega)$$

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

$(\mathcal{L}, g^\star)$ is a continuation equilibrium for (a, χ, ω) $\iff$ $(\mathcal{L}, g^\star)$ is a continuation equilibrium for (b, χ, ω)

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

The Value Function



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

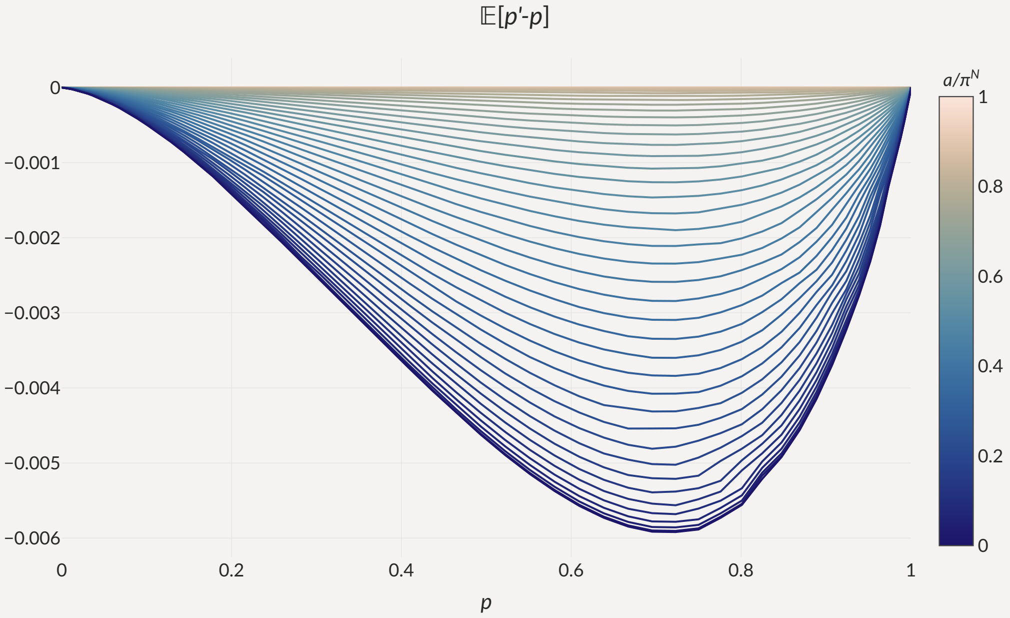
Lemma 1 Idea

In any continuation equilibrium,

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

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

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

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

Incentives

From the Phillips curve

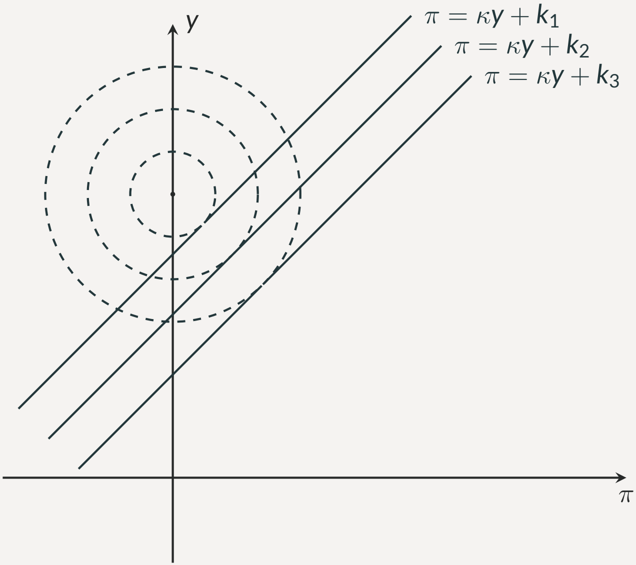
$$\frac{\partial y}{\partial \pi} = \frac{1}{\kappa}\left[1 - \beta\frac{\partial p'}{\partial \pi}\left(\phi_c(a) - g^\star(p', \phi_c(a)) + (1-p')\frac{\partial g^\star(p', \phi_c(a))}{\partial p'}\right)\right]$$

- 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

Phillips curves

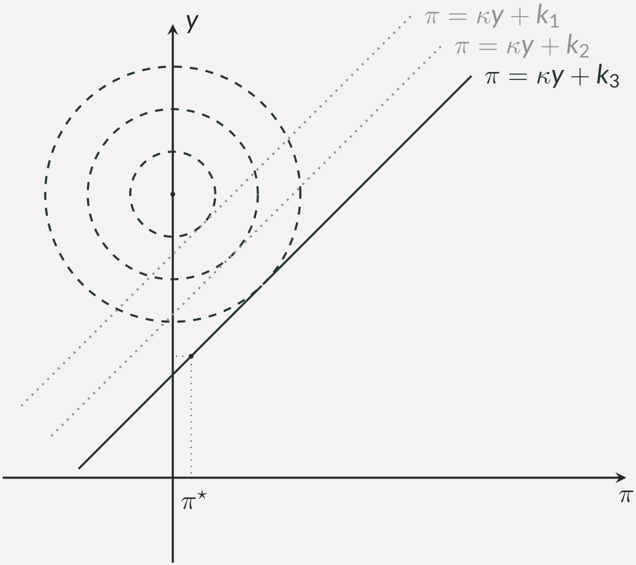
Bayes



- 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 straight PC
- If $g^\star(p, a) > a$ $\implies \frac{\partial p'}{\partial \pi}$ matters

Phillips curves

Bayes



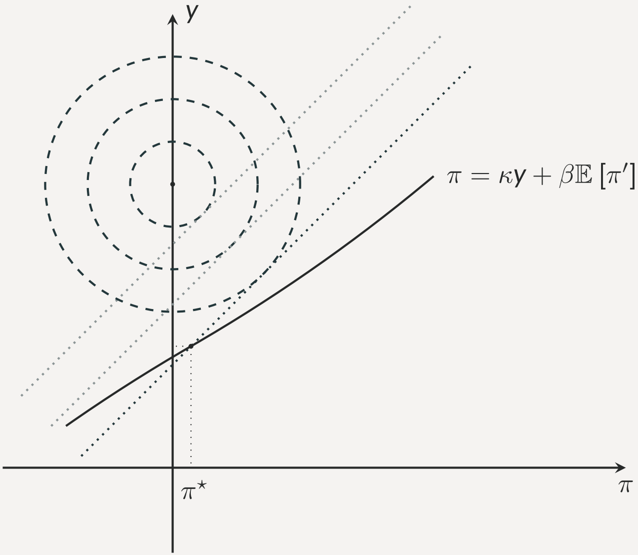
- Without reputation:
  if $\beta \mathbb{E}[\pi'] = k_j$
  choose point on jth PC

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

- If $g^\star(p, a) > a$
  $\implies \frac{\partial p'}{\partial \pi}$ matters

Phillips curves

Bayes

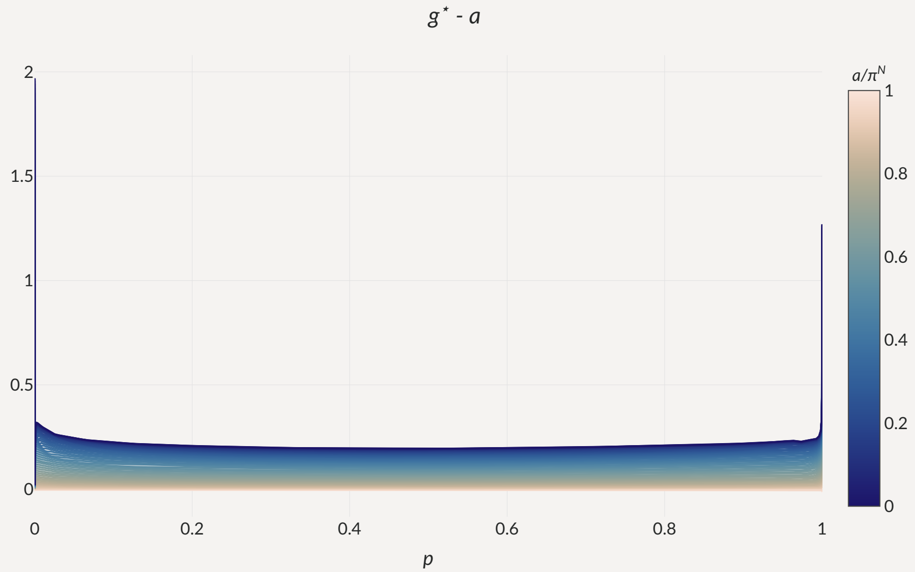


- Without reputation:
  if $\beta \mathbb{E}[\pi'] = k_j$
  choose point on jth PC

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

- If $g^\star(p, a) > a$
  $\implies \frac{\partial p'}{\partial \pi}$ matters

Equilibrium Deviations



Credibility

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

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

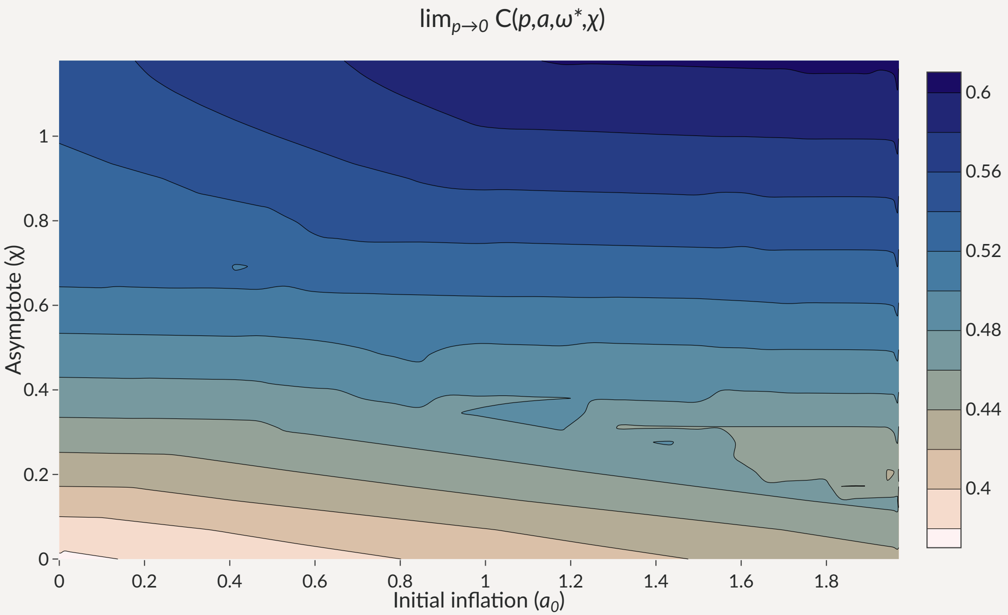
- Define the *remaining credibility* of a plan as

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

- If $0 \leq g^\star(p, a) \leq \pi^N$ always, then $C_c \in [0, 1]$

Plans

Credibility

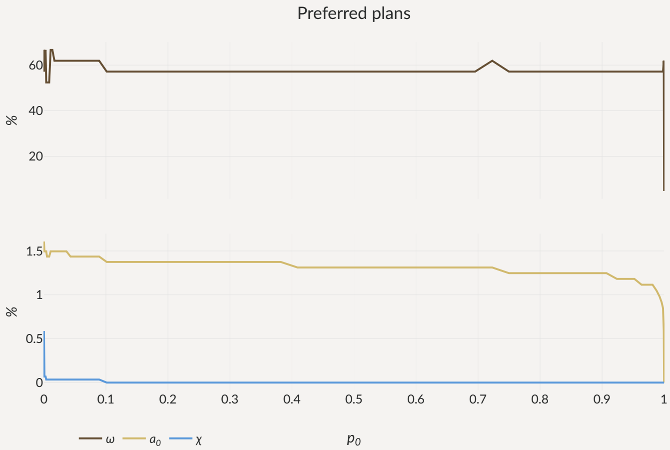


Plans

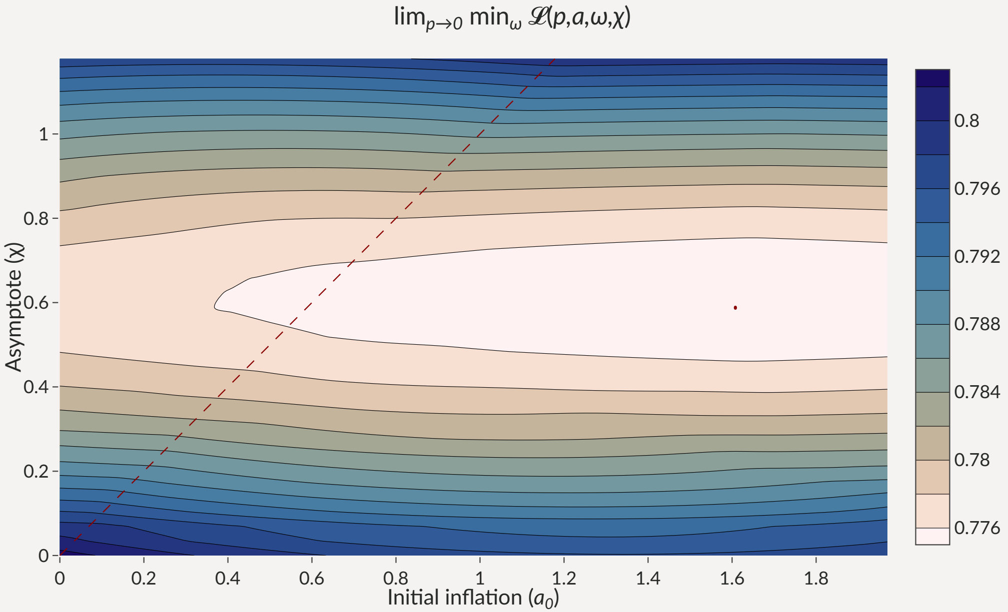
- For each $c \in \mathcal{C}$, find $\mathcal{L}^c(p, a), g_c^\star(p, a)$.
- Generates big matrix $\mathcal{L}(p, a; \omega, \chi)$
- First pass: preferred plan at each p

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



K-equilibrium



Initial announcement

What plan to choose?

Back to the initial announcement: two notions

- 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*

- 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

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

- Need to find equilibrium μ

What plan to choose?

Back to the initial announcement: two notions

- 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*

- 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

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

- Need to find equilibrium μ

What plan to choose?

Back to the initial announcement: two notions

- 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*

- 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

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

- Need to find equilibrium μ

What plan to choose?

Back to the initial announcement: two notions

- 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*

- 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

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

- Need to find equilibrium μ

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

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

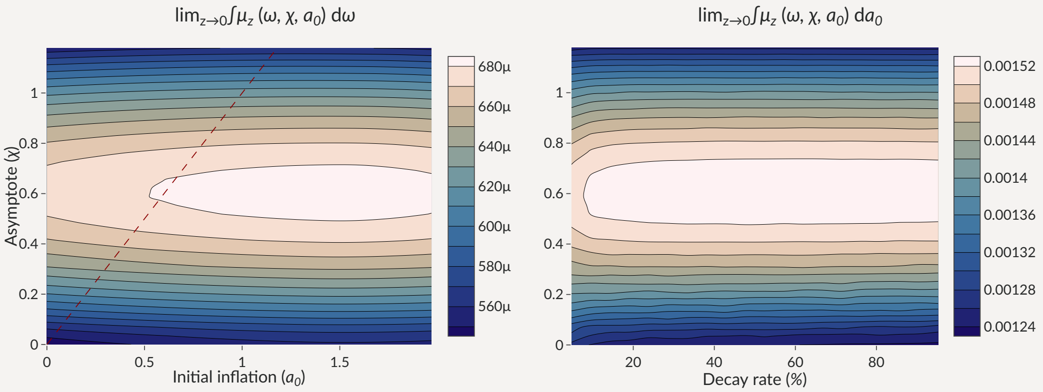
$$\mathcal{L}(1, c) < k$$

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

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

    This is possible if $k \leq$ 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: $\mathbb{P}(a_0 > \chi) = 65\%$. $\mathbb{P}(a_0 > 5\chi) = 16.7\%$. $\mathbb{P}(\text{decay} \leq 10\%) = 9.97\%$.
- Imperfect credibility: $\mathbb{P}(\chi = 0) = 2.49\%$.

Concluding remarks

Concluding remarks

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

- Credibility dynamics concerns influence choice of policy
    - Tradeoff between **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

Scan to find the paper