

Macroeconomics A, EI056

Class 3

Time (in) consistency

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What you will get from today class

OUTPUT

- When can money affect real variables?
- The time inconsistency problem, and remedies.
 - Based on Walsh ch. 7 (7.1-7.2, 7.3.2).
 - Policy insights, even though the model is simple and ad-hoc.
- Empirical evidence on the impact of central bank independence (Bodea and Hicks 2015).
 - Impact of central bank independence on inflation depends on political institutions.

A question to start

- ALTERNANCE vs L.T.
- POLITICS: S.P.
- KNOWLEDGE

COMMUNICAT.
FISCAL-MONET
COORDINATION
→ LEVEL

IN DEP. Central banks should be given a clear mission, and then be left alone to execute it without having to answer questions from
↓ politicians.

ACCOUNTABILITY
(FOR PREF.)

ARETIVE

MORAL
HAZARD

INFO SHARING ↔ C.R.D.

REALLY FEASIBLE?

Do you agree? Why or why not?

STRATEGIC

OPERATIONAL

When can policy affect output?

- Monetary policy can easily affect prices, but when can it have **real effects**?
- The central bank needs a **timing advantage**.
 - Expectations are **slow to catch up** (adaptive expectations).
 - The central bank acts with **more information** than private agents.
- Example of more information: price or wages are chosen **before** the central bank **acts**.
 - If **new information** is revealed in between, the central bank reacts to it before private agents can.
 - **Aggregate supply** with inflation surprises, $\pi_t - E_{t-1}\pi_t$.
- How much power does this really give when inflation are **forward looking**?
EXPECTATION

TIME (IN) CONSISTENCY

Time inconsistency problem

$\pi \neq \tilde{\pi}$

AS

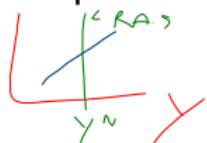
- An unexpected move in policy can affect real output.
 - Policy makers can be tempted to take advantage of this.
 - They can (at least temporarily) if people take time to figure it out.
- Different when expectations are forward looking and rational.
- Agents understand the temptation, and take it into account when forming their expectations.
- In equilibrium, the temptation leads to no benefit (cannot fool all people all the time).
 - A commitment to avoid the temptation is beneficial.
- We first consider a deterministic model, then introduce shocks.

A simple deterministic model

- One period model.
 - Agents set their expectations at the beginning of the period.
 - The central bank then moves, and output is determined by the policy.

- The economy is summarized by an AS curve linking output y to unexpected inflation, $\pi - \pi^e$:

π



~~LRAS~~

$$y = y^n + a(\pi - \pi^e)$$

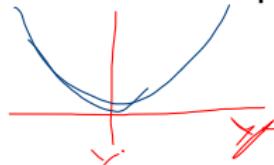
- y^n is the natural level of output, i.e. the one prevailing when expectations are right (notation of the textbook, corresponds to \bar{Y} last week).

Monetary policy

- The central bank sets the **monetary stance** m which drives **inflation** π .
- For simplicity we consider that the central bank has a precise control of **inflation**: $\pi = m$.
 - The technical appendix presents the case where there is a shock to the link between m and π .
- We consider two ways to conduct policy.
 - **Discretion**: the central bank does whatever it wants. However, this is **fully understood** by the public.
 - **Commitment**: the central bank **commits to a value of π** , and delivers it no matter what.

Policy objective

- The central bank wants to minimize a loss driven by inflation and the deviation of output around a target y^* (it is a loss: a high V is bad):



$$V = \frac{1}{2} [\lambda (y - y^*)^2 + \pi^2]$$

- The target output y^* is above the natural rate, so the central bank has an incentive to boost up output (for instance because of structural unemployment): .

$$y^* = y^n + k > y^n$$

- The central bank is thus tempted to engineer some surprise inflation to raise y above y^n .
 - Especially if it cares about output (λ is high) and its objective is substantially above the natural rate (k is high).
 - The temptation is an issue because the central bank moves (sets π) after the private agents (set π^e).

Policy under discretion

- The central bank takes the expectations π^e as given. The loss is rewritten as:

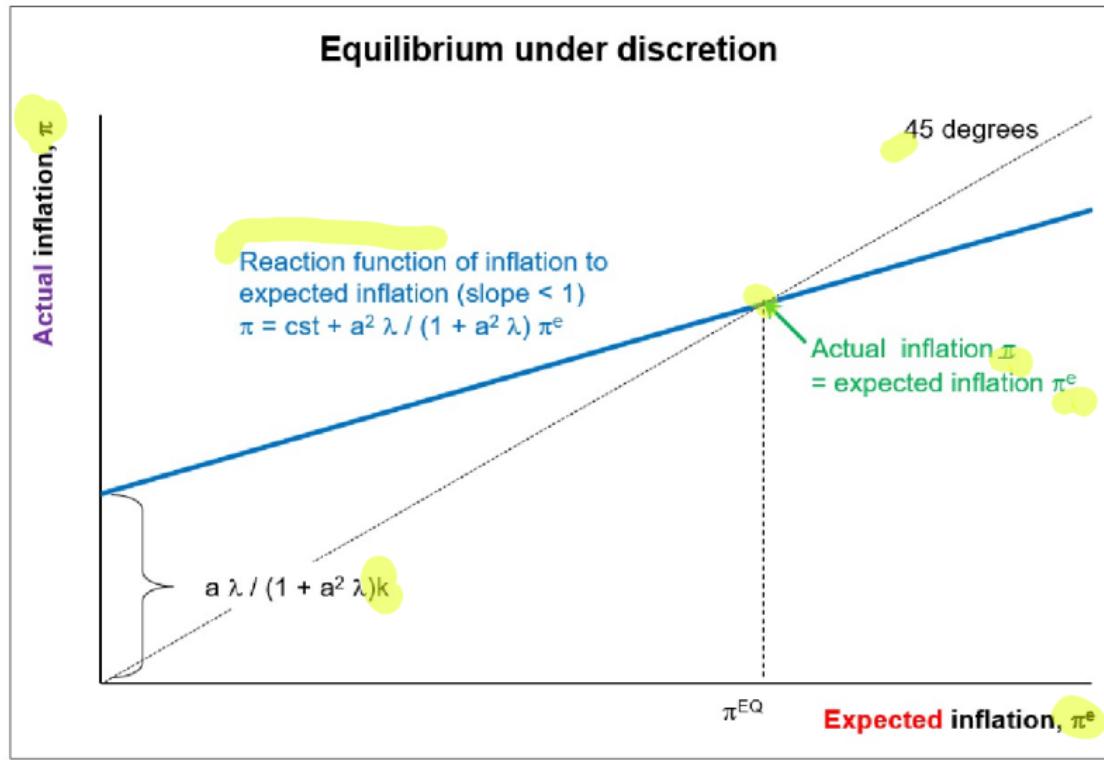
$$\begin{aligned}V &= \frac{1}{2} \left[\lambda (y - y^*)^2 + \pi^2 \right] \\V &= \frac{1}{2} \left[\lambda \underbrace{(a(\pi - \pi^e) + y^n - y^*)^2}_{AS} + \pi^2 \right] \\V &= \frac{1}{2} \left[\lambda (a(\pi - \pi^e) - k)^2 + \pi^2 \right]\end{aligned}$$

- The central bank sets π to minimize it. The first-order condition gives a reaction function of actual inflation to expected inflation, with a slope smaller than 1:

$$\pi = \frac{\lambda a^2}{1 + \lambda a^2} \pi^e + \frac{\lambda a}{1 + \lambda a^2} k$$

Visual representation of the reaction

- In equilibrium, inflation is expected: $\pi = \pi^e$. It is positive



Equilibrium inflation

- Agents figure out the model, and thus understand the central bank's reaction function.
- The form their expectations accordingly. To solve, take expectation of the reaction function ($E\pi = E\pi^e = \pi^e$) → ANY EXP.

$$E\pi = \frac{\lambda a^2}{1 + \lambda a^2} \pi^e + \frac{\lambda a}{1 + \lambda a^2} k$$
$$E\pi = \lambda a k > 0$$

- Expected and actual inflation is positive. There is an inflation bias because of:
 - the extra output objective of the central bank k .
 - its utility weight on output λ .
 - the impact of inflation on output a . AS

Output under discretion

- Output follows from the AS relation. It is not affected by the systematic bias k (as inflation is expected, there is no surprise):

$$y = y^n$$

- The policy does not lead to a systematic increase in output ($y = y^n$), but leads to higher inflation.
 - All pain, no gain.
- The value of the loss function is ($disc$ denotes discretion):

$$V^{disc} = \frac{1}{2} (1 + \lambda a^2) \lambda k^2$$

Policy under commitment

- The central bank **commits to deliver π** (and actually does so: it is **credible**). Expectations reflect this ($\pi^e = \pi$), so there is no surprise and output is at the natural level: $y = y^n$. $\bar{Y} = Y^N + k$
- The loss function is (*strict* denotes strict commitment):

$$V^{strict} = \frac{1}{2} [\lambda k^2 + \pi^2]$$

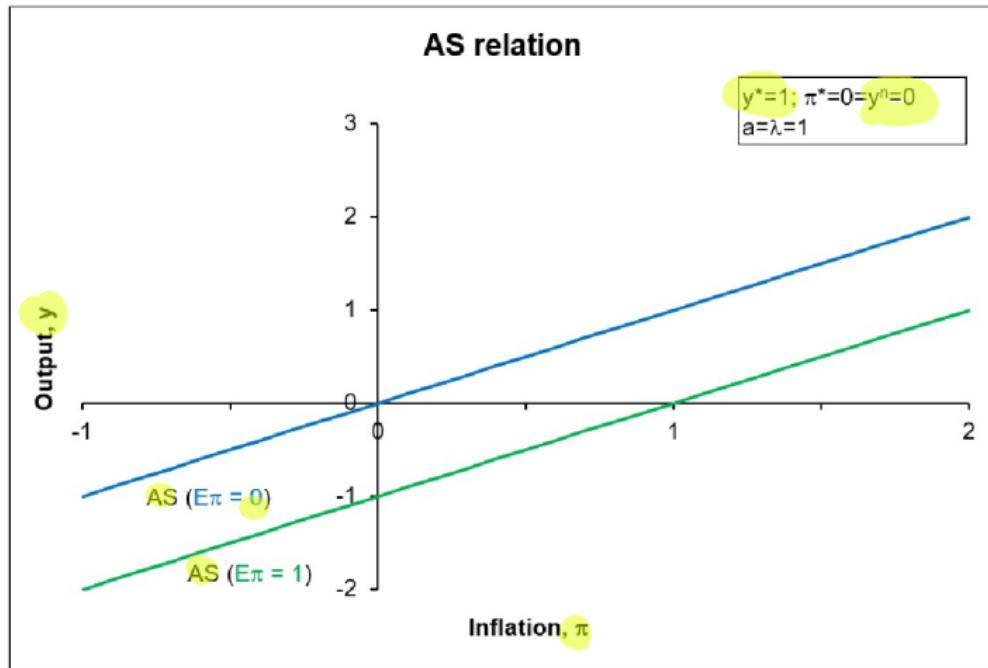
- The central bank minimizes it. Inflation enters only the second term, and is thus set at $\pi = 0$.
- The central bank understand that it cannot systematically affect output, and thus commits to **not even try**.

$$V^{strict} = \frac{1}{2} \lambda k^2 < V^{disc}$$

- Not trying to exploit inflation avoids a costly bias.

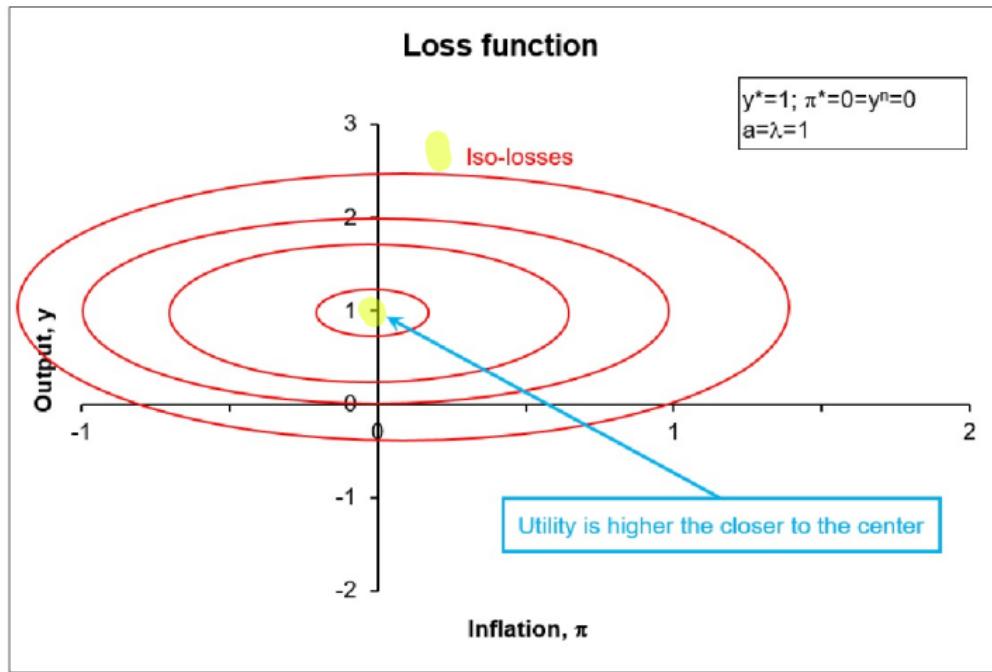
Graphical illustration

- Draw AS in a chart with inflation π and output y . AS relation depends on expected inflation.



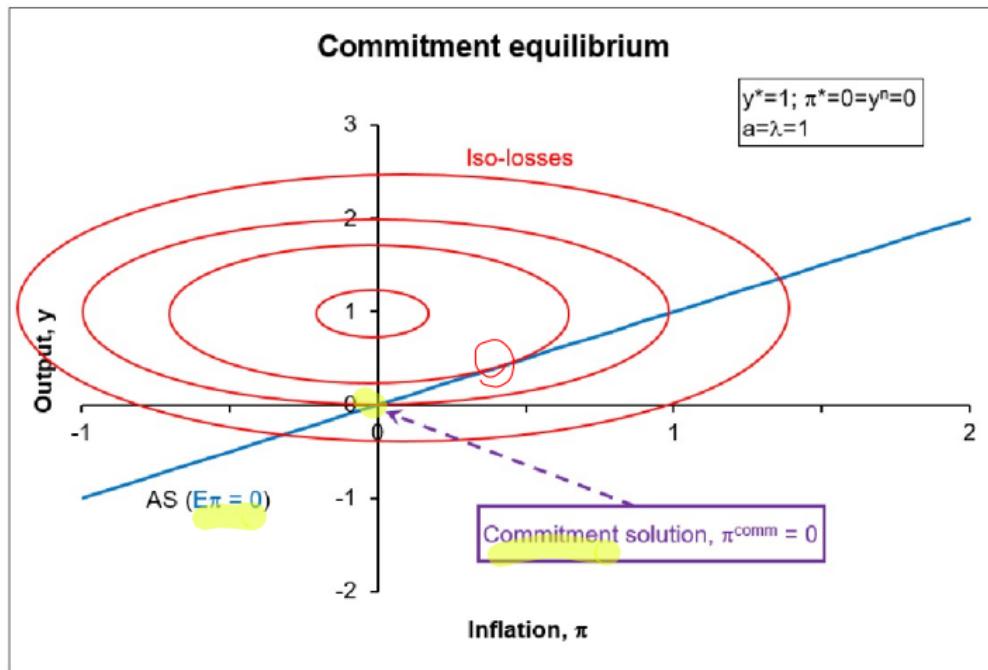
Objective: iso-losses

- Combinations of output and inflation that give the same loss V . Indifference curves, the closer to the center the better.



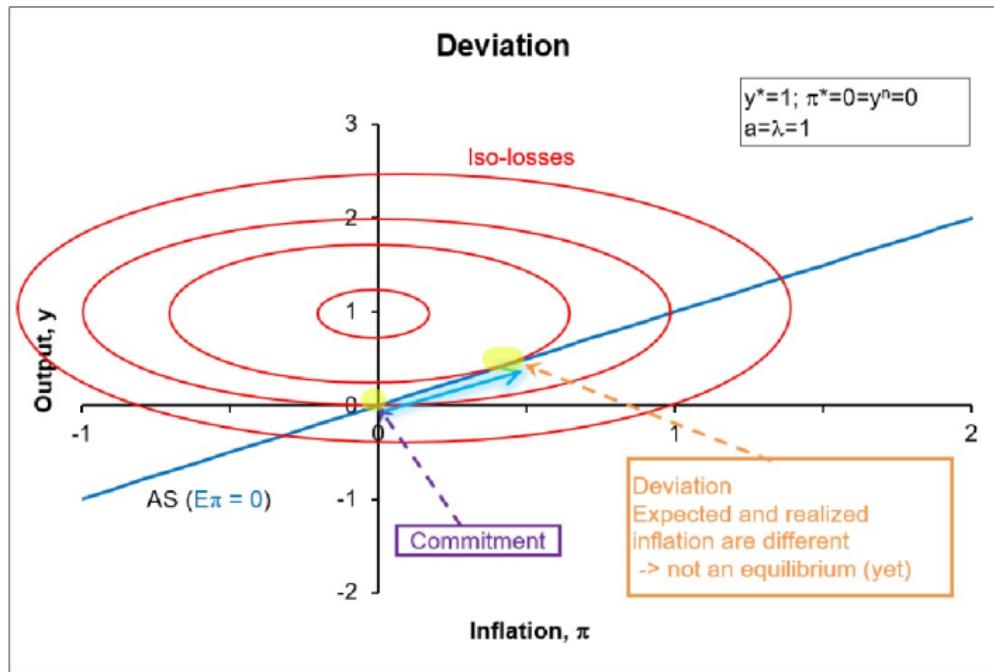
Commitment equilibrium

- Do not play the inflation game, accept some loss ($y^* > y^n$, and that's it).



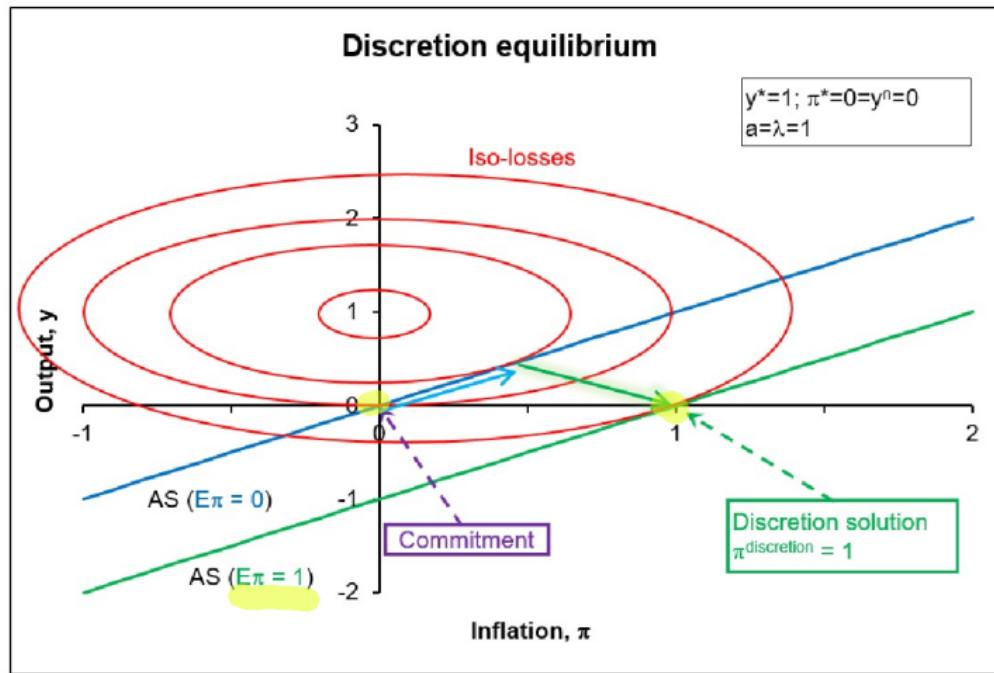
Temptation

- Given AS, starting from commitment one could move along AS and be better off.



Ultimate cost

- But then AS adjusts, and we end up in a discretion equilibrium with higher loss.



INTRODUCING SHOCKS

Supply shock

$$e = \pi^e$$

- We add a shock e to the AS curve (the expected value of the shock is zero $Ee = 0$):

$$y = y^n + a(\pi - \pi^e) + e$$

- Policy **should react** to shocks: **unexpected inflation** movements can be **warranted**.
- We consider three ways to conduct policy.
 - Discretion**: the central bank does whatever it wants, but this is understood by the public (as before).
 - Strict commitment**: the central bank commits to a **value of π** and delivers it no matter what (as before).
 - Flexible commitment**: the central bank commits to a **rule giving π** as a function of the shock e .

Policy under discretion

- The central bank moves **after the shock** has happened and minimizes the ex-post loss:

$$\begin{aligned}V &= \frac{1}{2} [\lambda(y - y^*)^2 + \pi^2] \\V &= \frac{1}{2} [\lambda(a(\pi - \pi^e) + e + y^n - y^*)^2 + \pi^2] \\V &= \frac{1}{2} [\lambda(a(\pi - \pi^e) + e - k)^2 + \pi^2]\end{aligned}$$

AS

- The reaction function of actual inflation now includes the **shock**:

$$\pi = \frac{\lambda a^2}{1 + \lambda a^2} \pi^e + \frac{\lambda a}{1 + \lambda a^2} k - \frac{\lambda a}{1 + \lambda a^2} e$$

Equilibrium under discretion

- Expected inflation includes the bias: $\pi^e = \lambda a k$. Actual inflation also reflects shocks, with the central bank tightening (lower π) following a positive shock:

$$\pi = \lambda a k - \frac{\lambda a}{1 + \lambda a^2} e$$

- Output also reflects the shock:

< |

$$y = y^n + \frac{1}{1 + \lambda a^2} e$$

- Expected ex-ante value of the loss function includes the shock volatility:

$$EV^{disc} = \frac{1}{2} \left[(1 + \lambda a^2) \lambda k^2 + \frac{\lambda}{1 + \lambda a^2} E(e^2) \right]$$

Policy under strict commitment

- The central bank delivers π regardless of the shocks.
- Ex-ante (expected) loss function (*strict* denotes strict commitment):

$$EV^{strict} = \frac{1}{2} \left[\lambda E(e - k)^2 + \cancel{E}(\pi^2) \right]$$

- Inflation enters only the second term, so the central bank sets $\pi = 0$. This implies:

$$EV^{strict} = \frac{1}{2} [\lambda k^2 + \cancel{\lambda E}(e^2)]$$

- The first term is smaller under commitment: not trying to exploit inflation avoids a costly bias.
- The second term is larger under commitment: the central bank foregoes a needed reaction to shocks.

Can't we get the best of both worlds?

- Yes. The central bank **commits to a rule** that links inflation to the shock (b_0 and b_1 are parameters to be set):

$$\pi = b_0 + b_1 e \Rightarrow \pi^e = b_0$$

A S

- Ex-post output** is $y = y^n + ab_1 e + e$. The ex-ante loss function is then (*flexible* denotes flexible commitment):

$$EV^{\text{flexible}} = \frac{1}{2} E \left[\lambda ((1 + ab_1) e - k)^2 + (b_0 + b_1 e)^2 \right]$$

- b_0 only enters the last term and it is thus best to set it to **zero**. b_1 enters both terms and there is a trade-off. We minimize the loss ($\partial EV^{\text{flexible}} / \partial b_1 = 0$).
- The optimal policy implies **no inflation bias** and a **reaction to shocks**:

$$\pi = -\frac{\lambda a}{1 + \lambda a^2} e ; \quad \pi^e = E\pi = 0$$

Comparing policies: inflation and output

- Inflation entails a bias ($\pi^e > 0$) only under discretion. It reacts to shocks under both discretion and flexible commitment:

$$\pi^{disc} = \lambda a k - \frac{\lambda a}{1 + \lambda a^2} e ; \quad \pi^{strict} = 0 ; \quad \pi^{flex} = -\frac{\lambda a}{1 + \lambda a^2} e$$

- Output is less affected by shocks under discretion and a flexible commitment:

$$y^{disc} = y^{flex} = y^n + \frac{1}{1 + \lambda a^2} e ; \quad y^{strict} = y^n + e$$

- Both discretion and flexible commitment absorb some of the shock e through inflation, thus stabilizing output.
 - Discretion does so at the cost of positive expected inflation.

Comparing policies: loss function

- The loss function reflects the **gap** between natural and desired output, k , and the **volatility** of the shock, $E(e^2)$:

$$\begin{aligned}EV^{disc} &= \frac{1}{2} \left[(1 + \lambda a^2) \lambda k^2 + \frac{\lambda}{1 + \lambda a^2} E(e^2) \right] \\EV^{strict} &= \frac{1}{2} [\lambda k^2 + \lambda E(e^2)] > \\EV^{flexible} &= \frac{1}{2} \left[\lambda k^2 + \frac{\lambda}{1 + \lambda a^2} E(e^2) \right]\end{aligned}$$

The handwritten annotations highlight the terms involving λ and $E(e^2)$ in each equation, comparing them directly.

- The gap leads to a larger loss under discretion, as under both commitments the central bank does not try to exploit it.
- The volatility leads to a larger loss under strict commitment, as under the other two policies the central bank absorbs the shock through output and inflation.
- Flexible commitment always dominate.** Discretion is better than strict commitment if shocks are volatile.

Delegation to a conservative central bank

- An alternative to rules is to delegate policy to a central banker who puts **more weight on inflation** than society does:

$$V^{\text{bank}} = \frac{1}{2} \left[\lambda (y - y^n - k)^2 + (1 + \delta) \pi^2 \right] ; \quad \delta > 0$$

- The conservative central banker operates under discretion:

$$\pi = \frac{a\lambda}{1 + \delta} k - \frac{a\lambda}{1 + \delta + a^2\lambda} e$$

- The **bias is reduced** compared to the initial discretion case, but so is the **reactivity** to shocks.
 - An infinite δ shuts down the bias, but also the reactivity (similar to a strict commitment).
 - A conservative central banker cannot deliver flexible commitment.
- An alternative is to give the central bank a conservative inflation objective, penalize it for any deviation, and let it operate under discretion.

DOES IT WORK EMPIRICALLY?

Testable hypotheses

- The theory implies that more central bank independence lowers inflation, as the central bank can truly be committed.
 - Earlier literature lacked robustness.
- Test about a broad sample (78 advanced and emerging countries, from 1973 to 2008).
- Measure of central bank independence (CBI) drawing from a range (16) of organizational and legal indicators.
 - Discipline: does CBI reduce money issuance?
 - Credibility: given money issuance, does CBI reduce inflation (i.e. do agents expect the central bank to ultimately do the right think)?
- CBI can be in the law, but what if the law is only good on paper, and not actually implemented?
 - CBI should work better in countries with rule of law and freedom to object. Use polity measures of democracy and freedom.

Effect on money growth

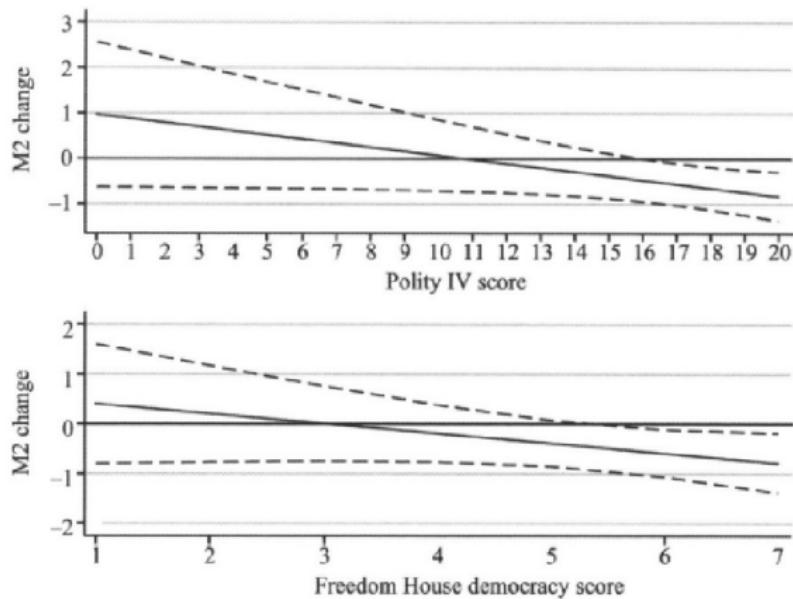
- Higher CBI reduces the money growth rate.
- The effect is stronger with more political constraints (prevents the government from pressuring the central bank).

Regression of money growth on CBI

| | | | | |
|--------------------------------|------------------|------------------|-------------------|------------------|
| CBI | -0.584** (0.279) | -0.832** (0.323) | -1.394*** (0.497) | -0.741** (0.339) |
| POLITY 2 | 0.002 (0.011) | 0.036* (0.021) | | |
| CBI × POLITY 2 | | -0.090 (0.054) | | |
| POLITICAL CONSTRAINTS | | | 1.097* (0.566) | |
| CBI × POLITICAL CONSTRAINTS | | | | -2.615** (1.076) |
| FREEDOM OF PRESS | | | | 0.082 (0.180) |
| CBI × PRESS | | | | -0.332 (0.299) |
| LAG LOG INFLATION | | | | |
| LAG LOG CHANGE IN M2 | 0.297*** (0.056) | 0.292*** (0.057) | 0.292*** (0.057) | 0.273*** (0.059) |

Marginal effect on money growth

- CBI has a significantly negative effect only at high value of the polity measure of democracy.



Note: 90 percent confidence intervals.

Effect on inflation

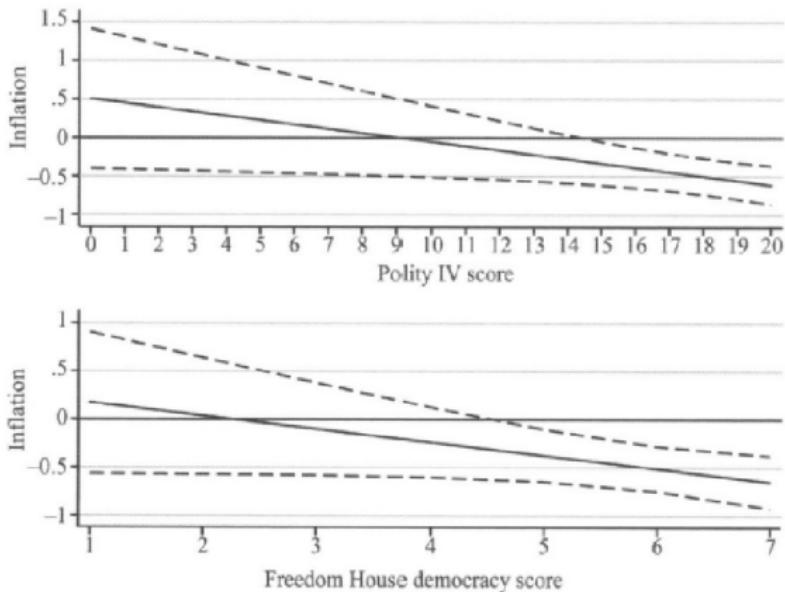
- Higher CBI reduces inflation, controlling for the money growth rate.
- The effect is stronger with more democracy (polity index).

Regression of inflation on CBI

| | | | | |
|--------------------------------|-------------------|-------------------|-------------------|-------------------|
| CBI | -0.465*** (0.143) | -0.612*** (0.150) | -0.690*** (0.251) | -0.646*** (0.149) |
| POLITY 2 | -0.003 (0.004) | 0.019* (0.011) | | |
| CBI × POLITY 2 | | -0.056* (0.029) | | |
| POLITICAL CONSTRAINTS | | | 0.164 (0.285) | |
| CBI × POLITICAL CONSTRAINTS | | | -0.816 (0.559) | |
| FREEDOM OF PRESS | | | | 0.145 (0.091) |
| CBI × PRESS | | | | -0.369** (0.145) |
| LAG LOG INFLATION | 0.615*** (0.041) | 0.609*** (0.042) | 0.621*** (0.043) | 0.614*** (0.043) |
| LAG LOG CHANGE IN M2 | 0.125*** (0.024) | 0.124*** (0.024) | 0.127*** (0.025) | 0.120*** (0.023) |

Marginal effect on inflation

- Here also, the benefit of CBI requires higher democracy.



Note: 90 percent confidence intervals.