Macroeconomics A, EI056

Class 3

Time (in) consistency

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What you will get from today class

- 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

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

Do you agree? Why or why not?

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 expectations are forward looking?

TIME (IN) CONSISTENCY

Time inconsistency problem

- 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, $\pi - \pi^e$:

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

- 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):

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

- 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:

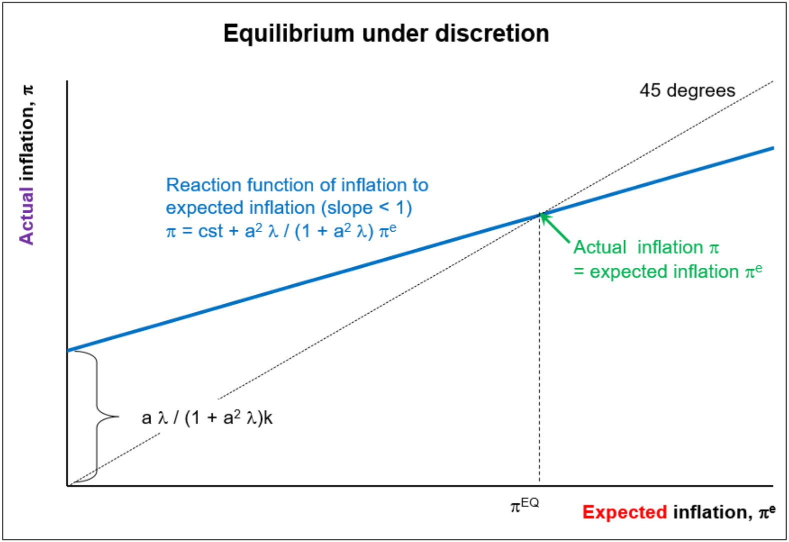
$$\begin{aligned} V &= \frac{1}{2}\left[\lambda\left(y-y^*\right)^2+\pi^2\right] \\ V &= \frac{1}{2}\left[\lambda\left(a\left(\pi-\pi^e\right)+y^n-y^*\right)^2+\pi^2\right] \\ V &= \frac{1}{2}\left[\lambda\left(a\left(\pi-\pi^e\right)-k\right)^2+\pi^2\right] \end{aligned}$$

- 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 ($E\pi = E\pi^e = \pi^e$):

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

- 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.

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):

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

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: $y = y^n$.
- The loss function is (*strict* denotes strict commitment):

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

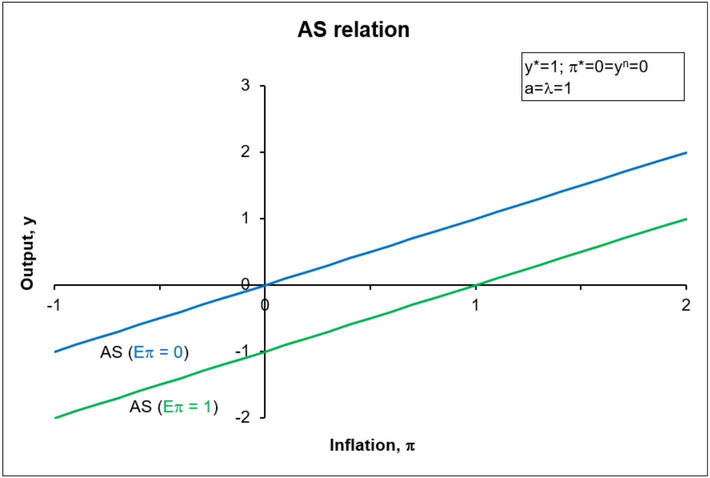
- The central bank minimizes it. Inflation enters only the second term, and is thus set at $\pi = 0$.
- The central bank understand that it cannot systematically affect output, and thus commits to not even try.

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

- Not trying to exploit inflation avoids a costly bias.

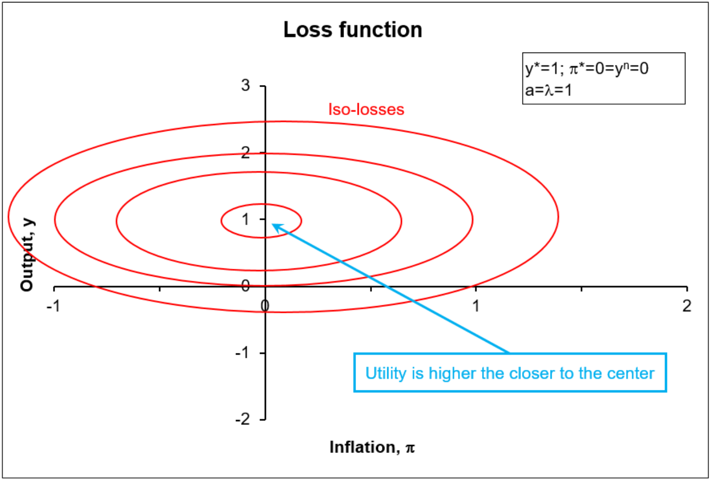
Graphical illustration

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

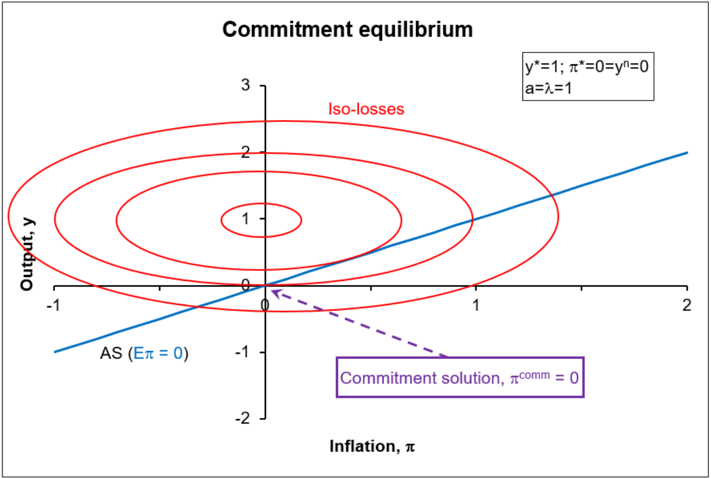


Objective: iso-losses

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

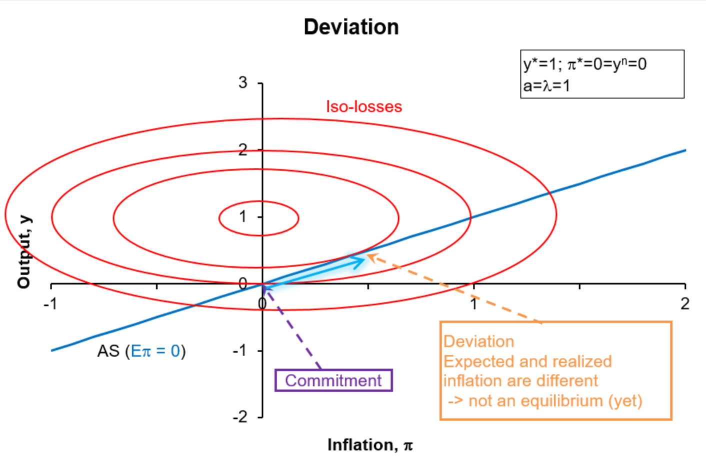


- Do not play the inflation game, accept some loss ($y^* > y^n$, and that's it).



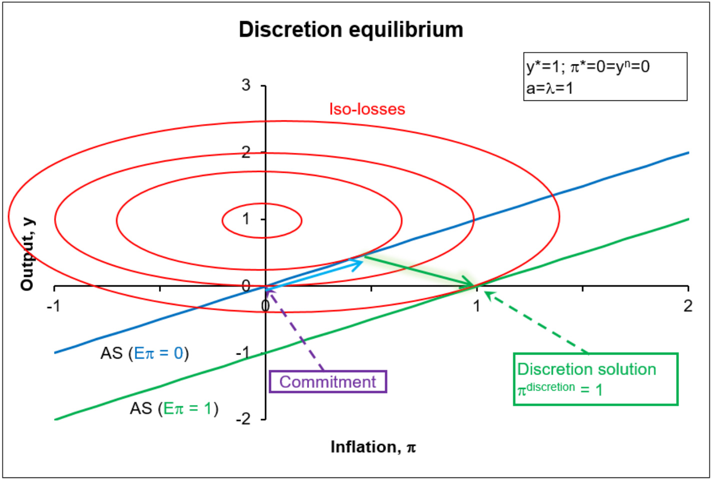
Temptation

- **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

- 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:

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

- 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**:

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

Policy under strict commitment

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

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

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

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

- 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):

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

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

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

- 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 ($\partial EV^{flexible} / \partial b_1 = 0$).
- The optimal policy implies **no inflation bias** and a **reaction to shocks:**

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

Comparing policies: inflation and output

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

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

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

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

- 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, $E\left(e^2\right)$:

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

- 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:

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

- 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

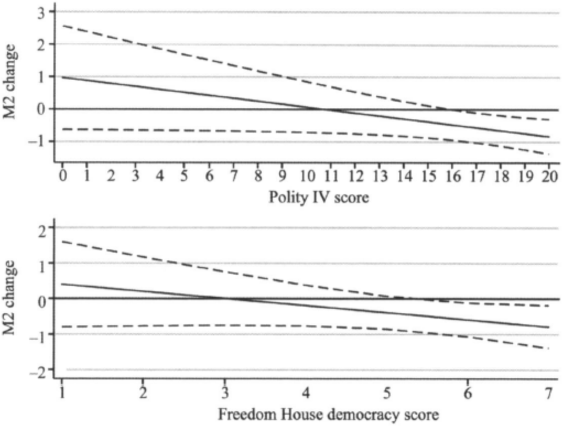
- Higher CBI reduces the money growth rate.
- The effect is stronger with more political constraints (prevents the government from pressuring the central bank).

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

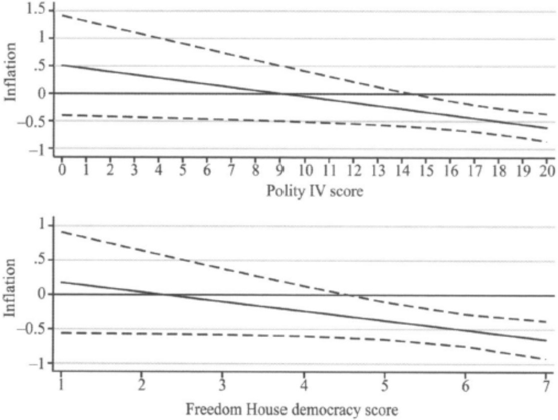
- Higher CBI reduces inflation, controlling for the money growth rate.
- The effect is stronger with more democracy (polity index).

<u>**Regression of inflation on CBI**</u>

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.