# Macroeconomics A, EI056

## Class 8

## Policy in the New Keynesian model, Money and inflation

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November 14, 2023

# What you will get from today class

- Policy in the New Keynesian model.
  - Forward-looking nature of inflation. FORWARD GUID
  - **Trade-off** in monetary policy and a new gain of commitment.
- Recent **developments**: financial frictions, limit on interest rate, heterogeneous agents. ZERO LB
- **Money**: concepts, measures, the multiplier.
- Money and **inflation**, the Cagan model.

FLEX PRICE

# A question to start

$PY = MV$

*Inflation reflects money creation. If a new government is elected, who does not mind inflation, and they will replace the central bank in 5 years, inflation will increase in 5 years but not before.*

$E\,\tilde{\pi}_{t+1} \rightarrow \pi_t$

DEMAND $M$ vs $B$

$i^{NOM}_{t \to t+1} = r + \tilde{\pi}_{t \to t+1}$

$\uparrow \frac{M}{P}$

$M$ ASSET

$\frac{1}{P}$ : PRICE

Do you agree? Why or why not?

# NEW KEYNESIAN MODEL : REMINDER

# Two central equations for behavior

- Aggregate demand: Euler condition for the dynamics of consumption.
  - Consumption (= output as there is not investment) dynamic reflect the real interest rate.
  - Expected real interest rate is the nominal rate adjusted by expected inflation: $E_t(1+i_t)P_t/P_{t+1}$.

$\frac{Y_{t+1}}{Y_t}$ < −

$$(Y_t)^{-\sigma} = \beta(1+i_t)E_t\left[\frac{P_t}{P_{t+1}}(Y_{t+1})^{-\sigma}\right]$$

- Aggregate supply: optimal forward-looking price setting by firms.

NKPC

  - Rise prices today if a) we expect competitors to rise them tomorrow or b) costs are high today.
  - Output gap: output relative to the output under flexible prices $x_t = y_t - y_t^{flex}$.

$$\boxed{\pi_t = \beta E_t \pi_{t+1} + \kappa x_t} \quad ; \quad \kappa = \frac{(1-\omega\beta)(1-\omega)}{\omega}\frac{1+\eta+(\sigma-1)a}{a+(1-a)\theta}$$

# Policy: a third relation

- Aggregate supply: New Keynesian Phillips curve.
- Aggregate demand: Euler relation, expressed in terms of gaps:

$$
\begin{aligned}
y_t &= E_t y_{t+1} - \frac{1}{\sigma}\left(i_t - E_t \pi_{t+1}\right) \\
x_t &= E_t x_{t+1} - \frac{1}{\sigma}\tilde{r}_t
\end{aligned}
$$

- Policy rule for the interest rate (**Taylor rule**), with possible shocks:

$$
i_t = \delta_\pi \pi_t + \delta_x x_t + v_t \quad \text{SHOCK}
$$

- Output gap, inflation, and the interest rate are the endogenous variables.

# The forward looking nature of the results

- **NKPC** implies that inflation reflects expected future output gaps (key role of expectations in policy):

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t = \kappa \sum_{i=0}^{\infty} \beta^i E_t x_{t+i}$$

- Initial empirical tests point towards the usual backward looking Phillips curve. Better measures of output gap and marginal costs support the forward looking NKPC.
- Euler implies that the **output gap** reflects expected **future deviation from the natural interest rate**:

$$x_t = E_t x_{t+1} - \frac{1}{\sigma} \tilde{r}_t = -\frac{1}{\sigma} \sum_{i=0}^{\infty} E_t \tilde{r}_{t+i}$$

- Interest rates far in the future matter a lot (questionable, but refined in more recent papers).

# Welfare

- Utility of the representative agent to assess alternative **policies**.
- Linear expansion of the utility useless: expectations of all variables (functions of the shocks) are zero. All pers $E_t C_{t+1} = 0$
- **Quadratic expansion** of the utility (more complex): loss function with the variance of the output gap and the variance of inflation (weights are functions of the model parameters):

$$L = \frac{1}{2}\left[\lambda (x_t)^2 + (\pi_t)^2\right]$$

- A loss of zero requires **full stabilization around the natural rate**: $x_t = \pi_t = 0$.
  RBC
- Optimal rule complex, so focus on simpler Taylor rule of the form:

$$i_t = \delta_\pi \pi_t + \delta_x x_t + v_t$$

# Taylor principle

- Simple model: NKPC and AD show no trade-off between the output gap and inflation.
- Reason: output gaps are the only cause of inflation:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t \qquad ; \qquad x_t = E_t x_{t+1} - \frac{1}{\sigma}\tilde{r}_t$$

- While $\pi = x = 0$ is an equilibrium, is it a **stable** one? The model is a dynamic system in two control variables $\pi$ and $x$.
- Taylor principle: stability if the central bank raises the real interest rate in response to inflation: $\delta_\pi > 1$.:

$\tilde{\pi}_t$ + 1%

$i_t$ + 1% ++>1%

$$\kappa(\delta_\pi - 1) + (1-\beta)\delta_x > 0$$

- A shock to the interest rate ($v_t > 0$) leads to a recession ($x < 0$) and negative inflation.

# Impulse response

- Impact of a tightening shock of monetary policy (higher interest rate).

$r = i - \pi^e$

SHOCK

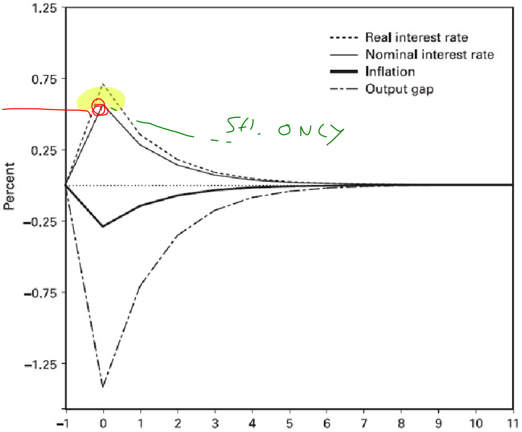



**Figure 8.1**
Response of output, inflation, and real interest rate to a policy shock in the new Keynesian model.

Walsh, chapter 8

# TRADE – OFF AND COMMITMENT

# Introducing a trade-off

- **Cost-push shock** $e_t$ to the NKPC: output gaps are not the only drivers of inflation:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + e_t$$

- $\pi = x = 0$ is not an equilibrium. $e > 0$ leads to positive inflation and / or a recession ($x < 0$).

$\frac{W}{P}$

- **Sticky wages** are a form of cost-push shocks.
  - No problem if wages **or** prices are flexible, policy can produce efficient movements in real wages.
  - Problem if wages **and** prices are sticky.
- Minimize the discounted value of inflation and output gaps:

$$E_t \sum_{i=0}^{\infty} \beta^i \left[\lambda x_{t+i}^2 + \pi_{t+i}^2\right]$$

- **No inflation bias** as the central bank aims for the natural rate of output. Yet, **commitment** is better.

# New value of commitment

- Shocks are persistent (impact on future, hence role of expectations), $e_{t+1} = \rho e_t + \varepsilon_{t+1}$. Consider an inflationary shock $\varepsilon_t > 0$.
- **Discretion** vs. simple **commitment** rule of the form $x_t = -\xi e_t$ that the central bank follows (the optimal policy is more complex). ▸ Details of analysis
- Discretion: policy cannot commit to future inflation → no impact on expectation. Inflation or some recession, the NKPC effectively boils down to:

t POLICY ↛ E t+1

POLICY

$$\pi_t = \kappa x_t + e_t + E_t \pi_{t+1}$$

↓ 0.5 ↓ 0.5

- Commitment: policy can promise negative future output gaps → affects future inflation: $E_t\pi_{t+1} < 0$. Output gap adjustment can be smoothed (commitment leads to a lower net present value of the loss):

EXTRA TOOL

t POLICY → E t+1

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + e_t < \kappa x_t + e_t$$

↓ 0.5 ↓ 0.2 ↓ 0.3

# Intuition for the gain of commitment

NEW TOOL : $E_t \pi_{t+1}$

- Under commitment, the central bank **inflates by less than under discretion** (but gets a more negative output gap).
- Commitment leads to a higher welfare, as future policy affects the current gap and inflation.
- Smoothing the negative output gap after an inflationary shock, the central bank keeps **future output gaps (hence marginal cost) low**.
- Low future marginal costs moderate current price increases, improving the inflation - output trade off.
- Commitment allows to **spread the adjustment**, which is always a good idea with quadratic losses as large movements are particularly costly.

# LIMITS AND RECENT DEVELOPMENTS

# All is well?

- Dynamic Stochastic General Equilibrium (DSGE) models with price rigidities to analyze the design of optimal monetary policy.
  - Simple versions to get the intuition behind the transmission of policy.
- Two broad lines of criticism emerged with the crisis.
- Excessive **"mathiness"**. Too much emphasis on the internal coherence and sophistication, at the expense of relevant aspects.
  - What if we are away from the steady state, because of a crisis?
- Neglect of financial factors.
  - What about banks and financial intermediaries?

# Recent lines of research

- Models have been (and are being) expanded along many lines
  - JEP 2018 articles by Gali, Christiano-Eichenbaum-Trabandt, and Kaplan-Violante.
- **Banking sector amplifies** shocks, and is itself a source of shocks.
- Richer characteristics leading to more realism (habits in consumption, cost of adjusting capital).
- Introduction of **heterogeneous agents**: HANK, TANK, RANK (Heterogenous Agent New Keynesian, or Two Agents New Keynesian, instead of Representative Agent New Keynesian).
  - Keep track of the cross-section distribution of variables (can be hard).
  - Simpler versions with two agents go a long way (some agents do intertemporal optimization, others don't).
- Inclusion of **Zero Lower Bound on interest rate**. This makes commitment particularly useful. OCCASIONNALY BINDING
  - Recent advance make the magnitude of the channel more realistic.

# Use in policy

- Criticism that policy makers have focused on DSGE at the expense of other useful simpler frameworks.
- Central banks have developed DSGE and use them in formulating policy.
- Models used in specific ways (Gürkaynak and Tille 2017).
    - Develop internally coherent models for **"what if" policy scenario** analysis.
    - Support forecasting.
- Central banks hardly rely only on DSGE for policy making (and shouldn't).
    - Broad range of inputs from economic indicators, financial markets.

# WHAT IS MONEY?

# Roles of money

- Money plays three roles:
  - **Medium of exchange**, no need for double coincidence of wants (barter economy).
  - Unit of **account** (efficiency gain from coordination).
  - **Store of value** to transfer resources through time.
- One standard avoids the uncertainty from multiple currencies (U.S. before the "Greenback" dollar, Switzerland in most of the 19th century).
- Move from commodity money (intrinsically valuable, i.e. gold) to **fiat** money (backed only by confidence in the government and central bank).

# Various measures of money

$M2 \ni M1 \not\ni M0$

- M0 (monetary base) consists of currency (coins and notes) and reserves held by banks at the central bank.
  - Under fiat money the central bank plays a key role.
  - Its balance sheet is essentially made of securities on the asset side, and M0 on the liability side.
- M1 (liquid, directly useful for payment) consists of currency and bank accounts used for transactions.
- M2 (less liquid) consists of M1 and accounts held for savings more than transactions (saving accounts, money market accounts).
- The higher the number on M#, the less liquid the assets, even though the difference is never 100% sharp.

- Example: the Federal Reserve.

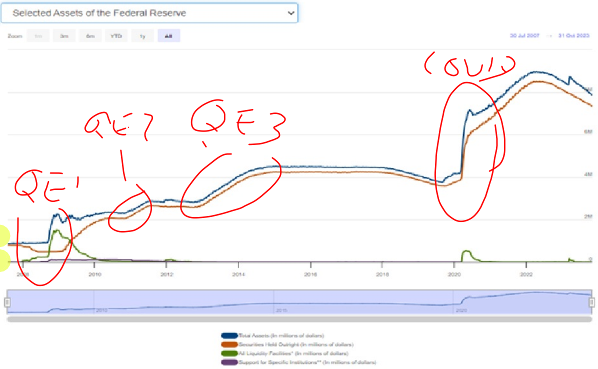
**Table 1. Assets, liabilities, and capital of the Federal Reserve System**
**($ billions)**

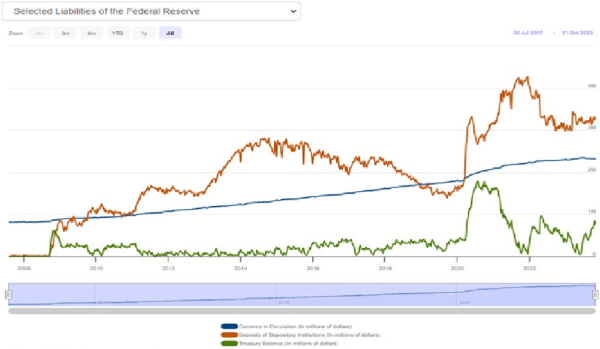
| Item | September 28, 2022 | March 29, 2023 | Change from September 28, 2022 |
|---|---|---|---|
| **Total assets** | **8,796** | **8,706** | **-90** |
| Securities held outright | 8,372 | 7,926 | -446 |
| U.S. Treasury securities | 5,672 | 5,329 | -343 |
| Federal agency debt securities | 2 | 2 | 0 |
| Agency mortgage-backed securities | 2,698 | 2,594 | -104 |
| Repurchase agreements | 0 | 55 | 55 |
| Foreign official | 0 | 55 | 55 |
| Other | 0 | 0 | 0 |
| Loans | 21 | 343 | 322 |
| Discount window | 6 | 88 | 82 |
| Bank Term Funding Program | 0 | 64 | 64 |
| Other credit extensions | 0 | 180 | 180 |
| Paycheck Protection Program Liquidity Facility | 14 | 10 | -4 |
| Other loans | 0 | 0 | 0 |
| Net portfolio holdings of Corporate Credit Facility LLC | 0 | 0 | 0 |
| Net portfolio holdings of Main Street Facilities LLC | 26 | 22 | -4 |
| Net portfolio holdings of Municipal Liquidity Facility LLC | 6 | 6 | 0 |
| Net portfolio holdings of Term Asset-Backed Securities Loan Facility II LLC | 2 | 2 | 0 |
| Central bank liquidity swaps | 0 | 1 | 1 |
| Other assets | 369 | 352 | -17 |
| | | | |
| **Total liabilities** | **8,754** | **8,664** | **-90** |
| Federal Reserve notes | 2,229 | 2,273 | 44 |
| Deposits held by depository institutions other than term deposits | 2,983 | 3,402 | 419 |
| Reverse repurchase agreements | 2,638 | 2,633 | -5 |
| Foreign official and international accounts | 271 | 368 | 97 |
| Others | 2,367 | 2,265 | -102 |
| U.S. Treasury, General Account | 662 | 163 | -499 |
| Treasury contributions to credit facilities | 18 | 15 | -3 |
| Other liabilities | 224 | 178 | -46 |
| **Total capital** | **42** | **42** | **0** |

Note: Rounded to billions.
Source: Federal Reserve Board.

Federal Reserve balance sheet developments, May 2023
https://www.federalreserve.gov/publications/files/balance_sheet_developments_report_202305.pdf

- Evolution since the global crisis.

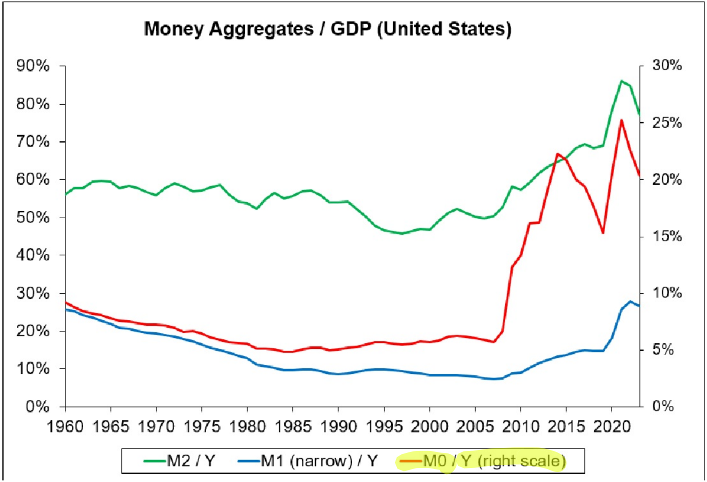



https://www.federalreserve.gov/monetarypolicy/bst_recenttrends.htm

# Money aggregates in the US

- Sharp increase relative to GDP.



# How banks create money

- Most of M1 consists of accounts at banks. The central bank is not the only creator of money. **Most of it** is created by private banks.
    - When my bank grants me a loan, it increases both its assets (it is my creditor) and its liabilities (the amount of the loan raises the balance of my bank account).
- The loans are used by borrowers to pay other agents, who in turn deposit the money. This initiates a new round of money creation.
- **Fractional** reserve banking.
    - Banks must hold a fraction $r$ of deposits $D$ as required reserves.
    - They may want to hold a fraction $e$ of deposits as additional reserves beyond that requirement. Reserves are thus: $R = (r + e) D$.

PART M0

# Money multiplier

- Agents hold cash as a proportion $c$ of their deposits: $C = cD$.
- **Monetary base** $M_0$ and the **broader aggregate** $M_1$ are:

$$
\begin{aligned}
M_1 &= \text{Cash} + \text{Deposits} = C + D = (1 + c)\, D = \frac{1 + c}{r + e} R \\
M_0 &= \text{Cash} + \text{Reserves} = C + R = (c + r + e)\, D = \frac{c + r + e}{r + e} R
\end{aligned}
$$

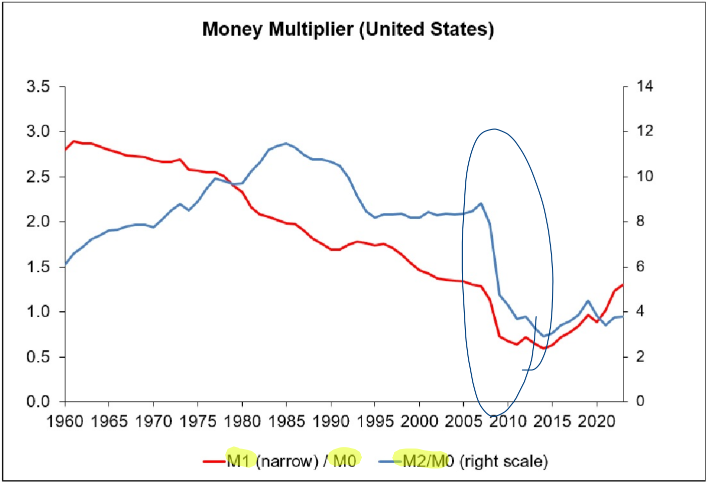
- Ratio of aggregates is larger the more agents use the banking sector (the lower $c$) and the lower the reserve ratio $r + e$:

$$
\frac{M_1}{M_0} = \frac{1 + c}{c + r + e} \qquad \frac{\partial\,(M_1 / M_0)}{\partial c} < 0 \qquad \frac{\partial\,(M_1 / M_0)}{\partial\,(r + e)} < 0
$$

- In the 2008 crisis central banks increased $M_0$. Broader aggregates ($M_1$ and $M_2$) have increased by less.
  - Hoarding of liquidity by the public and banks (higher $c$ and $e$).
  - In contrast, aggregates moved in proportion during the Covid crisis.

# US money multiplier

- Drop after 2008, recent increase.



# Narrow banking, private money

- The fact that most money is created by banks through fractional banking has led to two forms of objections.
- Should we prohibit this, and instead force banks to hold only cash ($r = 1$)?
  - **"Narrow banking"** view. Banks hold only safe assets, risky lending to firms and investment done by other intermediaries that do not issue deposits.
  - Could merely push the risk into a "shadow banking" sector (Lehman Brothers).
- Should we create **other types of money**?
  - WIR money. Created by WIR bank in Switzerland in the 1930's, focused on payments between firms.
  - Local currencies (Léman, Farinet). Limited size, and merely substitute one form of cash for another.

# Digital money

- **Distributed-ledger**: money that does not rely on bookkeeping by a centralized entity.
  - Bitcoin, and many others.
  - Time/energy cost of verification of transactions, hard to scale up. Volatile value.
- **Stable coins**: electronic money anchored to an official one (dollar, euro, Swiss franc, basket...)
  - Similar to a currency board with 100% backing by anchor money reserves. Need to ensure the backing is there.
- Central bank digital currencies (**CBDC**). Stable coin issued by central banks.
  - Individual accounts at the central bank (Know Your Customer legal issues), anonymous electronic token, retail vs. large value payments.
  - Fast paced innovation, with new BIS innovation hubs.

# MONEY AND INFLATION

# The quantity "theory"

- The **value of transactions** can be viewed from two angles.
  - Price level $P$ times the quantities of transactions (real GDP) $Y$.
  - Amount of money $M$ times the number of times it is used (velocity $V$):

$$PY = MV$$

- In the **long run**, the ratio of money to nominal GDP is steady, hence velocity is (roughly) constant. If real GDP is driven by real factors (productivity, labor supply), real balances are steady. Money affects the price level:

$$P = M\frac{V}{Y}$$

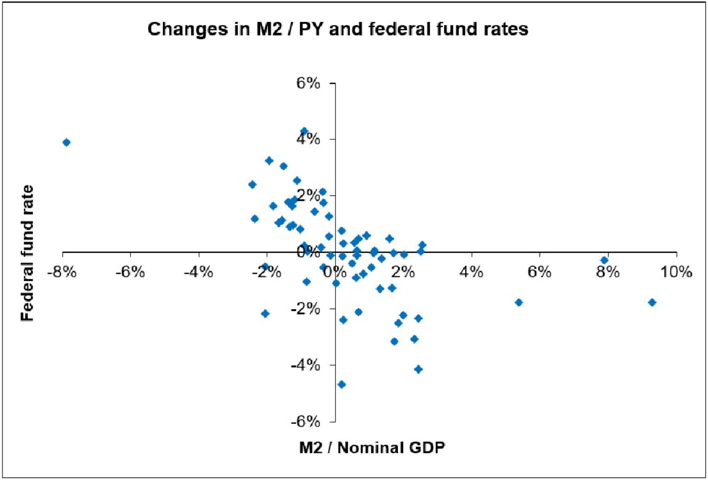
- In the **short run** $V$ is not set. It has fallen in the current crisis as banks focus on de-leveraging and strengthening their balance sheet.
  - Central banks have reacted by increasing $M$ (higher balance sheets).

# Bringing money in macro models

- Three broad ways to generate a money demand.
- Real balances in the **utility function** (even with a small weight).
  - Trade off between money, which gives utility, and bonds, which give interest.
  - Generates a money demand where real balances are linked to consumption and the nominal interest rate.
  - $M/(PY) = 1/V$ inversely related to interest rate.
- **Cash in advance**: one needs to hold real balances to make purchases. Links money and consumption.
- **Shopping technology**: household splits time between work, leisure and shopping.
  - Shopping time is an increasing function of consumption and a decreasing function of money.
  - Generates a money demand relation between real balances, consumption and the interest rate.

# Money and the interest rate

- Ratio of money to GDP inversely correlated with the interest rate.



# Cagan model of inflation

- Go beyond the $PY = MV$ to be more specific on the demand for real balances.
- Nominal interest rate is equal to the real rate plus inflation expectations: $i_t = r + \pi_{t+1}^e$.
  - Focus on the nominal variables and take the real rate $r$ to be constant (and zero for simplicity).
  - Higher expected **inflation reduces the demand** for money (inflation acts as a tax reducing the real value of cash).
- Money demand is given by:

$$m_t - p_t = -\gamma \pi_{t+1}^e = -\gamma \left( p_{t+1}^e - p_t \right)$$

- Dynamic relation between the current price and future expected prices. Iterating forward, the price reflects **future expected money**:

$$p_t = \frac{1}{1+\gamma} \sum_{s=0}^{\infty} \left( \frac{\gamma}{1+\gamma} \right)^s m_{t+s}^e$$

# Constant money growth rate

- Constant growth rate of money: $m_t - m_{t-1} = \mu$. Inflation is constant and equal to $\mu$:

$$\begin{aligned} m_{t+1} - p_{t+1} &= -\gamma\pi \quad ; \quad m_t - p_t = -\gamma\pi \\ (p_{t+1} - p_t) &= (m_{t+1} - m_t) = \mu \end{aligned}$$

- Higher price level when money grows at a fast rate:

$$\begin{aligned} m_t - p_t &= -\gamma\pi \\ p_t &= m_t + \gamma\mu \end{aligned}$$

- Higher growth rate **reduces the demand for real balances**, as money looses its value fast:

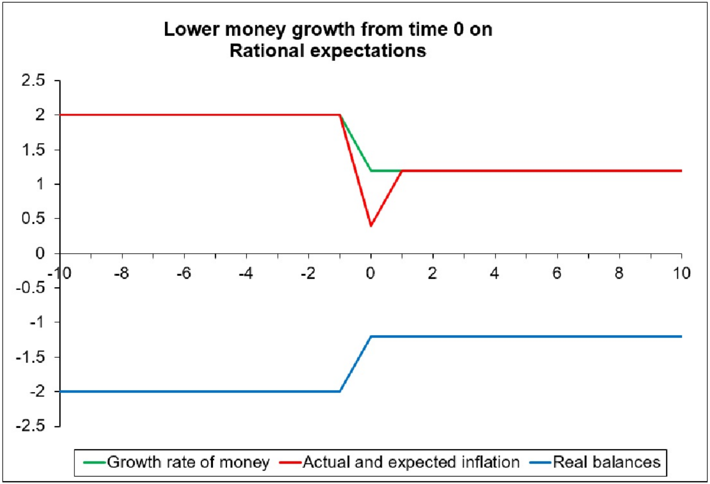
$$m_t - p_t = -\gamma\mu$$

- A lower $\mu$ lowers inflation. The transition depends on expectations.

# Disinflation: rational expectations

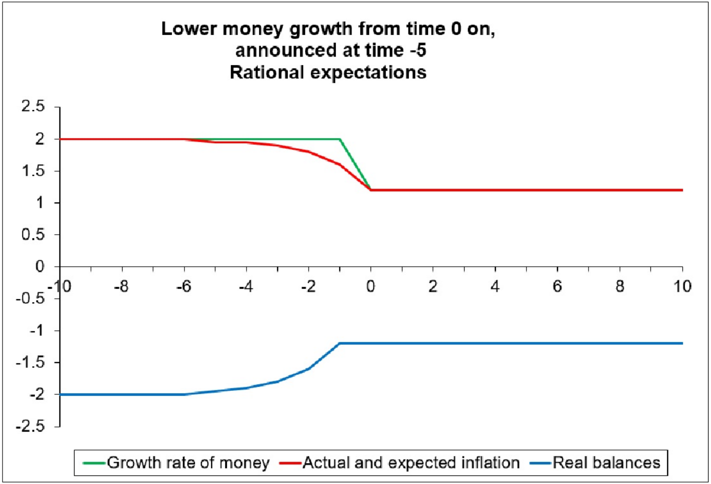
- Agents immediately understand the new regime at time $T+1$. Inflation **drops** from $\mu_0$ to $\mu_1$.
- At the period of transition, inflation **undershoots** for one period.
  - Lower money growth leads to a positive **jump in the demand** for real balances $m - p$.
  - Nominal balances $m$ do not jump up (they only grow at a slower rate). So the **price** $p$ **has to jump** down, a one-shot low inflation
- If the regime is announced before implementation, real balances react right away.

- Lower money growth starting at time 0, Rational expectations.



# Dynamics with news under rational expectations

- Lower money growth starting at time 0, announced at time $-5$, rational expectations.



# Disinflation: adaptive expectations

- Until $T$ money grows at a high rate: $m_T - m_{T-1} = \mu_0$. Starting at $T+1$ money grows at a **slower rate**: $m_{T+1} - m_T = \mu_1 < \mu_0$.
- Start with adaptive inflation expectations:

$$\pi^e_{t+1} - \pi^e_t = \delta \left( \pi_t - \pi^e_t \right)$$

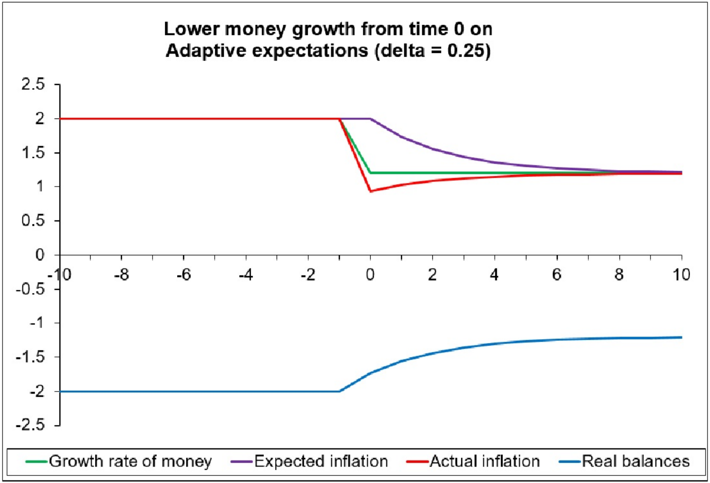
- Inflation expectations come down only gradually:

$$\begin{aligned} \pi^e_{T+s} &= \mu_1 + \left( 1 - \frac{\delta}{1-\gamma\delta} \right)^{s-1} \left( \mu_0 - \mu_1 \right) \\ \pi_{T+s} &= \mu_1 - \frac{\gamma\delta}{1-\gamma\delta} \left( 1 - \frac{\delta}{1-\gamma\delta} \right)^{s-1} \left( \mu_0 - \mu_1 \right) \end{aligned}$$

- Money demand **increases slowly** as agents realize lower inflation is here to stay.

# Dynamics under adaptive expectations

- Lower money growth starting at time 0, adaptive expectations ($\delta = 0.25$).



# Cost of inflation

- Inflation is costly, especially hyperinflation:
  - **"Shoe-leather** cost": agents don't want to hold cash for long, **menu** cost: firms change prices often.
  - **Volatility** and uncertainty: inflation is more volatile when it's high, making long-term decisions such as investment harder.
- Low inflation can have some benefits: '**grease** in the wheels'.
  - Prices and wages are most sticky downwards than upwards.
  - Moderate inflation allows adjustments in relative prices (such as real wages) without needing an actual decrease in one price.
- Current discussion of whether inflation targets should be higher (4% instead of 2%).

# EXTRA : GAIN FROM COMMITMENT

# Allocation under discretion

- Under discretion the central bank minimizes the one period loss taking expectations as given:

$$\min\left[\lambda x_t^2 + \pi_t^2\right] \qquad \text{subject to} \qquad \pi_t = \kappa x_t + \left(\beta E_t \pi_{t+1} + e_t\right)$$

- The solution under discretion is:

$$x_t^{\text{disc}} = \frac{-\kappa}{\lambda\left(1-\beta\rho\right)+\kappa^2} e_t \qquad ; \qquad \pi_t^{\text{disc}} = \frac{\lambda}{\lambda\left(1-\beta\rho\right)+\kappa^2} e_t$$

- There is a trade-off following a cost push shocks. Policy tightens, leading to a small pickup in inflation and a recession (a negative output gap).

# Allocation under commitment

- The central bank is committed to a rule linking the output gap and shocks: $x_t = -\xi u_t$. Conditional on this rule we can solve for the output gap and inflation.
- The central bank chooses $\omega$ to minimize:

$$\frac{1}{2} E_t \sum_{i=0}^{\infty} \beta^i \left( \lambda x_{t+i}^2 + \pi_{t+i}^2 \right)$$

- Compared to discretion, inflation reacts by less to the shock, while the output gap reacts by more (the overall loss is reduced): Return

$$x_t^{\text{comm}} = \frac{-\kappa}{\lambda \left(1 - \beta\rho\right)^2 + \kappa^2} e_t \quad ; \quad \pi_t^{\text{comm}} = \frac{\lambda \left(1 - \beta\rho\right)}{\lambda \left(1 - \beta\rho\right)^2 + \kappa^2} e_t$$