Money and Inflation
Roadmap to this Lecture

- Money: definitions and properties
- The Quantity Theory of Money
- Seignorage: the inflation tax
- Interest rates and the Fisher effect
- Money Demand: determinants and equilibrium
- Costs of inflation: hyperinflation
1923 Germany – 5 Trillion Marks
1993 Yugoslavia – 10 Billion Dinars
U.S. inflation: 1960-2003
Money: definition

Money is the stock of assets that can be readily used to make transactions.
Money: functions

1. **medium of exchange**
   *we use it to buy stuff*

2. **store of value**
   *transfers purchasing power from the present to the future*

3. **unit of account**
   *the common unit by which everyone measures prices and values*
Money: types

1. fiat money
   - has no intrinsic value
   - example: the paper currency we use

2. commodity money
   - has intrinsic value
   - examples: gold coins, cigarettes in P.O.W. camps
The money supply & monetary policy

- The **money supply** is the quantity of money available in the economy.
- **Monetary policy** is the control over the money supply.
The central bank

- Monetary policy is conducted by a country’s central bank.
- In the U.S., the central bank is called the Federal Reserve ("the Fed").

The Federal Reserve Building
Washington, DC
## Money supply measures, May 2004

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Assets included</th>
<th>Amount (billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Currency</td>
<td>$671.7</td>
</tr>
<tr>
<td>M1</td>
<td>C + demand deposits, travelers’ checks, other checkable deposits</td>
<td>1319.2</td>
</tr>
<tr>
<td>M2</td>
<td>M1 + small time deposits, savings deposits, money market mutual funds, money market deposit accounts</td>
<td>6268.9</td>
</tr>
<tr>
<td>M3</td>
<td>M2 + large time deposits, repurchase agreements, institutional money market mutual fund balances</td>
<td>9193.8</td>
</tr>
</tbody>
</table>
Money Stock

- To reduce the monetary base, the Federal Reserve sells short-term government bonds
- To increase the monetary base, the Federal Reserve buys short-term government bonds
- These transactions are called open market operations
Open Market Operations

To Increase the Monetary Base
- Federal Reserve: Buy bonds for cash

To Decrease the Monetary Base
- Federal Reserve: Sell bonds for cash
The Money Stock

- The Federal Reserve directly controls the monetary base
- The money stock is determined by the interaction of the monetary base with the banking sector
  - regulatory requirements
  - the incentive of financial institutions to have enough funds on hand to satisfy depositors’ demands
The Quantity Theory of Money

- A simple theory linking the inflation rate to the growth rate of the money supply.
- Begins with a concept called “velocity”…
Velocity

- **basic concept**: the rate at which money circulates
- **definition**: the number of times the average dollar bill changes hands in a given time period
- **example**: In 2003,
  - $500 billion in transactions
  - money supply = $100 billion
  - The average dollar is used in five transactions in 2003
  - So, velocity = 5
Velocity, cont.

- This suggests the following definition:

\[ V = \frac{T}{M} \]

where

- \( V \) = velocity
- \( T \) = value of all transactions
- \( M \) = money supply
Use nominal GDP as a proxy for total transactions.

Then,

\[ V = \frac{P \times Y}{M} \]

where

- \( P \) = price of output (GDP deflator)
- \( Y \) = quantity of output (real GDP)
- \( P \times Y \) = value of output (nominal GDP)
Velocity

Mean = 22

Mean = 1.5

Currency Velocity
M3 Velocity
The quantity equation

- The **quantity equation**
  \[ M \times V = P \times Y \]
  follows from the preceding definition of velocity.

- It is an *identity*: it holds by definition of the variables.
Money demand and the quantity equation

- \( \frac{M}{P} = \text{real money balances}, \) the purchasing power of the money supply.

- A simple money demand function:
  \[
  (\frac{M}{P})^d = kY
  \]
  where
  \( k = \) how much money people wish to hold for each dollar of income.
  \( (k \text{ is exogenous}) \)
Money demand and the quantity equation

- money demand: \((M/P)^d = kY\)
- quantity equation: \(M \times V = P \times Y\)
- The connection between them: \(k = 1/V\)
- When people hold lots of money relative to their incomes (\(k\) is high), money changes hands infrequently (\(V\) is low).
back to the Quantity Theory of Money

- starts with quantity equation
- assumes $V$ is constant & exogenous:
  $$V = \bar{V}$$
- With this assumption, the quantity equation can be written as
  $$M \times \bar{V} = P \times Y$$
The Quantity Theory of Money, cont.

\[ M \times \bar{V} = P \times Y \]

How the price level is determined:

- With \( V \) constant, the money supply determines nominal GDP \((P \times Y)\)
- Real GDP is determined by the economy’s supplies of \( K \) and \( L \) and the production function
- The price level is \( P = \frac{\text{(nominal GDP)}}{\text{(real GDP)}} \)
The Quantity Theory of Money, \textit{cont.}

- \textit{Recall:}
  
The growth rate of a product equals the sum of the growth rates.

- The quantity equation in growth rates:
  \[
  \frac{\Delta M}{M} + \frac{\Delta V}{V} = \frac{\Delta P}{P} + \frac{\Delta Y}{Y}
  \]
  
The quantity theory of money assumes $V$ is constant, so $\frac{\Delta V}{V} = 0$. 

Let \( \pi \) (Greek letter “pi”) denote the inflation rate:

\[
\pi = \frac{\Delta P}{P}
\]

The result from the preceding slide was:

\[
\frac{\Delta M}{M} = \frac{\Delta P}{P} + \frac{\Delta Y}{Y}
\]

Solve this result for \( \pi \) to get:

\[
\pi = \frac{\Delta M}{M} - \frac{\Delta Y}{Y}
\]
The Quantity Theory of Money, *cont.*

\[ \pi = \frac{\Delta M}{M} - \frac{\Delta Y}{Y} \]

- Normal economic growth requires a certain amount of money supply growth to facilitate the growth in transactions.

- Money growth in excess of this amount leads to inflation.
The Quantity Theory of Money, cont.

\[ \pi = \frac{\Delta M}{M} - \frac{\Delta Y}{Y} \]

\( \Delta Y/Y \) depends on growth in the factors of production and on technological progress (all of which we take as given, for now).

\textit{Hence, the Quantity Theory of Money predicts a one-for-one relation between changes in the money growth rate and changes in the inflation rate.}
International data on inflation and money growth

<table>
<thead>
<tr>
<th>Country</th>
<th>Inflation Rate (percent, logarithmic scale)</th>
<th>Money Supply Growth (percent, logarithmic scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicaragua</td>
<td>1,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Angola</td>
<td>100</td>
<td>1,000</td>
</tr>
<tr>
<td>Brazil</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Georgia</td>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>Kuwait</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>USA</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Oman</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Japan</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Canada</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Germany</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Democratic Repub of Congo</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>
U.S. data on inflation and money growth

Inflation rate (percent) vs. Growth in money supply (percent)

Inflation rate

Inflation rate trend

Inflation rate trend

Inflation rate

Inflation rate vs. M2 growth rate trend

- Inflation rate
- M2 growth rate
- Inflation rate trend
- M2 growth rate trend
Seigniorage

- To spend more without raising taxes or selling bonds, the govt can print money.

- The “revenue” raised from printing money is called **seigniorage**.

- The **inflation tax**: Printing money to raise revenue causes inflation. Inflation is like a tax on people who hold money.
Seignorage: An example

Suppose $M_s$ doubles from $100$ billion to $200$ billion. From the QTM we know the price level will double, e.g. $1/\text{loaf}$ to $2/\text{loaf}$

What is the real value of the extra purchases the government can make?

$50$ billion of the original dollars. Why?

Govt. printed $100$ billion but prices are now double ($2/\text{loaf}$)

A real life example: Bolivia, 1980-1985 had $\pi = 500\%$ and seignorage of $6\%$ of GNP
Inflation and interest rates

- When a borrower and a lender agree on a nominal interest rate on a loan, they do not know what the future rate of $\pi$ will be.
- Nominal interest rate: $i$
- Real interest rate, $r$
  \[ r = i - \pi \]
Two real interest rates

- $\pi =$ actual inflation rate
  (not known until after it has occurred)

- $\pi^e =$ expected inflation rate

- $i - \pi^e =$ \textit{ex ante} real interest rate:
  the real interest rate people expect
  at the time they buy a bond or take out a loan

- $i - \pi =$ \textit{ex post} real interest rate:
  the real interest rate people actually end up
  earning on their bond or paying on their loan
The Fisher Effect

- The Fisher equation: \( i = r + \pi^e \)
- Hence, an increase in \( \pi \) causes an equal increase in \( i \).
- This one-for-one relationship is called the Fisher effect.
U.S. inflation and nominal interest rates, since 1954

Nominal interest rate

Inflation rate
Inflation and nominal interest rates across countries

- Inflation rate (percent, logarithmic scale)
- Nominal interest rate (percent, logarithmic scale)

Countries included:
- Kenya
- Kazakhstan
- Armenia
- Nigeria
- Uruguay
- United Kingdom
- United States
- Singapore
- Germany
- Japan
- France
- Italy
- Hungary

Graph showing the relationship between inflation and nominal interest rates for various countries.
Exercise:

Suppose $V$ is constant, $M$ is growing 5% per year, $Y$ is growing 2% per year, and $r = 4$.

a. Solve for $i$ (the nominal interest rate).

First, notice $\pi = 5\% - 2\% = 3\%$
and $i = r + \pi = 4\% + 3\% = 7\%$.

b. If the Fed increases the money growth rate by 2 percentage points per year, find $\Delta i$.

$\Delta i = 2$, same as the increase in the money growth rate.
**Exercise (cont.)**

Suppose \( V \) is constant, \( M \) is growing 5\% per year, \( Y \) is growing 2\% per year, and \( r = 4 \).

c. Suppose the growth rate of \( Y \) falls to 1\% per year.

- What will happen to \( \pi \)?
  - If the Fed does nothing, \( \Delta \pi = 1 \)
- What must the Fed do if it wishes to keep \( \pi \) constant?
  - To prevent inflation from rising, Fed must reduce the money growth rate by 1 percentage point per year.
Money demand and the nominal interest rate

- The Quantity Theory of Money assumes that the demand for real money balances depends only on real income $Y$.
- We now consider another determinant of money demand: the nominal interest rate.
- The nominal interest rate $i$ is the opportunity cost of holding money (instead of bonds or other interest-earning assets).
- Hence, $i \uparrow \Rightarrow i \downarrow$ in money demand.
The money demand function

\[(M/P)^d = L(i, Y)\]

\[(M/P)^d\] = real money demand, depends

- negatively on \(i\)
  - \(i\) is the opp. cost of holding money
- positively on \(Y\)
  - higher \(Y\) ⇒ more spending
  - ⇒ so, need more money

(\(L\) is used for the money demand function because money is the most liquid asset.)
The money demand function

\[(M/P)^d = L(i, Y)\]

\[= L(r + \pi^e, Y)\]

When people are deciding whether to hold money or bonds, they don’t know what inflation will turn out to be.

Hence, the nominal interest rate relevant for money demand is \( r + \pi^e \).
Equilibrium

\[ \frac{M}{P} = \frac{L(r + \pi^e, Y)}{Y} \]

The supply of real money balances

Real money demand
What determines what

\[
\frac{M}{P} = L(r + \pi^e, Y)
\]

variable how determined (in the long run)

\begin{align*}
M & \quad \text{exogenous (the Fed)} \\
r & \quad \text{adjusts to make } S = I \\
Y & \quad \bar{Y} = F(\bar{K}, \bar{L}) \\
P & \quad \text{adjusts to make } \frac{M}{P} = L(i, Y)
\end{align*}
How $P$ responds to $\Delta M$

\[
\frac{M}{P} = L(r + \pi^e, Y)
\]

- For given values of $r$, $Y$, and $\pi^e$, a change in $M$ causes $P$ to change by the same percentage --- just like in the Quantity Theory of Money.
What about expected inflation?

- Over the long run, people don’t consistently over- or under-forecast inflation, so $\pi^e = \pi$ on average.

- In the short run, $\pi^e$ may change when people get new information.

- EX: Suppose Fed announces it will increase $M$ next year. People will expect next year’s $P$ to be higher, so $\pi^e$ rises.

- This will affect $P$ now, even though $M$ hasn’t changed yet.

*(continued...)*
How $P$ responds to $\Delta \pi^e$

\[ \frac{M}{P} = L(r + \pi^e, Y) \]

- For given values of $r$, $Y$, and $M$,
  \[ \uparrow \pi^e \Rightarrow \uparrow i \text{ (the Fisher effect)} \]
  \[ \Rightarrow \downarrow (M/P)^d \]
  \[ \Rightarrow \uparrow P \text{ to make } (M/P) \text{ fall} \]
  to re-establish eq'm
Now using Calculus

\[ \frac{M_s}{P} = L(i + \pi^e, Y) \]

\[ - \frac{M_s}{P^2} \frac{dP}{d\pi^e} = L_i d\pi^e \]

\[ \frac{dP}{d\pi^e} = -L_i \frac{P^2}{M_s} > 0 \]

- Consider what happens to the price level when \( \pi^e \) increase
- Taking total differentiation on both sides with respect to \( P \) and \( \pi^e \)
Discussion Question

Why is inflation bad?

- What costs does inflation impose on society? List all the ones you can think of.
- Focus on the long run.
- Think like an economist.
A common misperception

- Common misperception: 
  *inflation reduces real wages*

- This is true only in the short run, when nominal wages are fixed by contracts.

- In the long run, the *real* wage is determined by labor supply and the marginal product of labor, *not the price level or inflation rate*.

- Consider the data...
Average hourly earnings & the CPI, 1964-2004

Hourly earnings in 2004 dollars

Average hourly earnings (nominal)

Consumer Price Index
The classical view of inflation

- The classical view:
  A change in the price level is merely a change in the units of measurement.

So why, then, is inflation a social problem?
The social costs of inflation

...fall into two categories:

1. costs when inflation is expected
2. additional costs when inflation is different than people had expected.
The costs of expected inflation: 1. shoeleather cost

- def: the costs and inconveniences of reducing money balances to avoid the inflation tax.

- $\pi \uparrow \Rightarrow i \uparrow$  
  $\Rightarrow \downarrow$ real money balances

- Remember: In long run, inflation doesn’t affect real income or real spending.

- So, same monthly spending but lower average money holdings means more frequent trips to the bank to withdraw smaller amounts of cash.
The costs of expected inflation: 2. menu costs

- def: The costs of changing prices.

- Examples:
  - print new menus
  - print & mail new catalogs

- The higher is inflation, the more frequently firms must change their prices and incur these costs.
The costs of expected inflation: 3. relative price distortions

- Firms facing menu costs change prices infrequently.

- Example:
  Suppose a firm issues a new catalog each January. As the general price level rises throughout the year, the firm’s relative price will fall.

- Different firms change their prices at different times, leading to relative price distortions...

- ...which cause microeconomic inefficiencies in the allocation of resources.
The costs of expected inflation: 4. unfair tax treatment

Some taxes are not adjusted to account for inflation, such as the capital gains tax.

Example:

- Jan 1: you bought $10,000 worth of Starbucks stock
- Dec 31: you sold the stock for $11,000, so your nominal capital gain was $1000 (10%).
- Suppose $\pi = 10\%$ during the year. Your real capital gain is $0$.
- But the govt requires you to pay taxes on your $1000 nominal gain!!
The costs of expected inflation:

5. General inconvenience

- Inflation makes it harder to compare nominal values from different time periods.
- This complicates long-range financial planning.
Additional cost of *unexpected* inflation: arbitrary redistributions of purchasing power

- Many long-term contracts not indexed, but based on $\pi^e$.
- If $\pi$ turns out different from $\pi^e$, then some gain at others’ expense.

Example: borrowers & lenders
- If $\pi > \pi^e$, then $(i - \pi) < (i - \pi^e)$ and purchasing power is transferred from lenders to borrowers.
- If $\pi < \pi^e$, then purchasing power is transferred from borrowers to lenders.
**Additional cost of high inflation: increased uncertainty**

- When inflation is high, it’s more variable and unpredictable: \( \pi \) turns out different from \( \pi^e \) more often, and the differences tend to be larger *(though not systematically positive or negative)*

- Arbitrary redistributions of wealth become more likely.

- This creates higher uncertainty, which makes risk averse people worse off.
One benefit of inflation

- Nominal wages are rarely reduced, even when the equilibrium real wage falls.
- Inflation allows the real wages to reach equilibrium levels without nominal wage cuts.
- Therefore, moderate inflation improves the functioning of labor markets.
Hyperinflation

- def: $\pi \geq 50\%$ per month
- All the costs of moderate inflation described above become **HUGE** under hyperinflation.
- Money ceases to function as a store of value, and may not serve its other functions (unit of account, medium of exchange).
- People may conduct transactions with barter or a stable foreign currency.
What causes hyperinflation?

- Hyperinflation is caused by excessive money supply growth:
- When the central bank prints money, the price level rises.
- If it prints money rapidly enough, the result is hyperinflation.
Recent episodes of hyperinflation

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Percent Growth</th>
<th>Inflation</th>
<th>Growth of Money Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Israel</td>
<td>1983-85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>1989-90</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Brazil</td>
<td>1987-94</td>
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</tr>
<tr>
<td>Argentina</td>
<td>1988-90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peru</td>
<td>1988-90</td>
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</tr>
<tr>
<td>Nicaragua</td>
<td>1987-91</td>
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<tr>
<td>Bolivia</td>
<td>1984-85</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Why governments create hyperinflation

- When a government cannot raise taxes or sell bonds,
- it must finance spending increases by printing money.
- In theory, the solution to hyperinflation is simple: stop printing money.
- In the real world, this requires drastic and painful fiscal restraint.
The Classical Dichotomy

**Real variables** are measured in physical units: quantities and relative prices, e.g.
- quantity of output produced
- real wage: output earned per hour of work
- real interest rate: output earned in the future by lending one unit of output today

**Nominal variables**: measured in money units, e.g.
- nominal wage: dollars per hour of work
- nominal interest rate: dollars earned in future by lending one dollar today
- the price level: the amount of dollars needed to buy a representative basket of goods
The Classical Dichotomy

- **Note**: Real variables were explained in Chap 3, nominal ones in Chap 4.

- **Classical Dichotomy**: the theoretical separation of real and nominal variables in the classical model, which implies nominal variables do not affect real variables.

- **Neutrality of Money**: Changes in the money supply do not affect real variables. In the real world, money is approximately neutral in the long run.