

# Money, Inflation, and the LM Curve

## Session 7 – Introduction to Macroeconomics

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## Recap: Session 6

**Answer the questions individually.**

1. What is **money**? What are its **functions** and **types**? What about **Bitcoins**?
2. How do central banks **define** and **affect** the money supply?
3. Explain the role of **banks** in the money supply. For a given amount of deposit, will the money increase or decrease when the **reserve ratio increases**?
4. What is **capital**, **leverage**, and why do we need **capital requirements**? What are **bank runs**?
5. We saw that  $M = m \times B$ . What are these variables? On what does  $m$  depend? How can the central bank increase  $B$  or the reserve–deposit ratio?

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- ▶ **Fiat money**: accepted as money without intrinsic commodity value.

**Bitcoin**: a crypto-asset used for some payments. Limited acceptance and volatile purchasing power restrict its monetary functions.

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  - ▶ Euro-area M1: currency and overnight deposits.
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- ▶ **Monetary aggregates** group assets by liquidity.
  - ▶ Euro-area M1: currency and overnight deposits.
  - ▶ M2 adds specified short-term deposits; M3 adds some marketable instruments.
- ▶ **Policy tools**: asset purchases and sales, lending to banks, reserve requirements, and interest on reserve balances.
- ▶ The central bank controls the **monetary base** in our model. Bank behavior and public currency preferences also affect broad money.

## Recap: Banks and Money Creation

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3. Explain the role of **banks** in the money supply. For a given amount of deposit, will the money increase or decrease when the **reserve ratio increases**?

- ▶ Bank lending creates deposits; the borrower also incurs a debt.
- ▶ In the fractional-reserve example, banks keep a fraction of deposits as reserves, and successive rounds of lending expand deposits.
- ▶ A higher reserve–deposit ratio,  $rr = R/D$ , supports **less deposit expansion** from the initial deposit.
- ▶ In the model  $M = mB$ , holding  $B$  and the currency–deposit ratio fixed:

$$rr \uparrow \Rightarrow m \downarrow \Rightarrow M \downarrow .$$

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- ▶ **Capital**: owners' equity, equal to assets minus liabilities.
- ▶ **Leverage**: financing assets with borrowed funds.

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- ▶ **Capital requirements**: an equity cushion to absorb losses.
- ▶ **Bank runs**: many depositors withdraw at once.
  - ▶ A solvent bank may need emergency liquidity from the central bank.
  - ▶ An insolvent bank needs recapitalization or resolution.
  - ▶ Deposit insurance reduces incentives to withdraw in a panic.

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$$M = C_u + D, \quad B = C_u + R, \quad M = \underbrace{\frac{1 + cr}{rr + cr}}_m B.$$

- ▶  $M$ : money supply;  $B$ : monetary base;  $m$ : money multiplier.
- ▶  $rr = R/D$ : banks' reserve–deposit ratio;  $cr = C_u/D$ : the public's currency–deposit ratio.

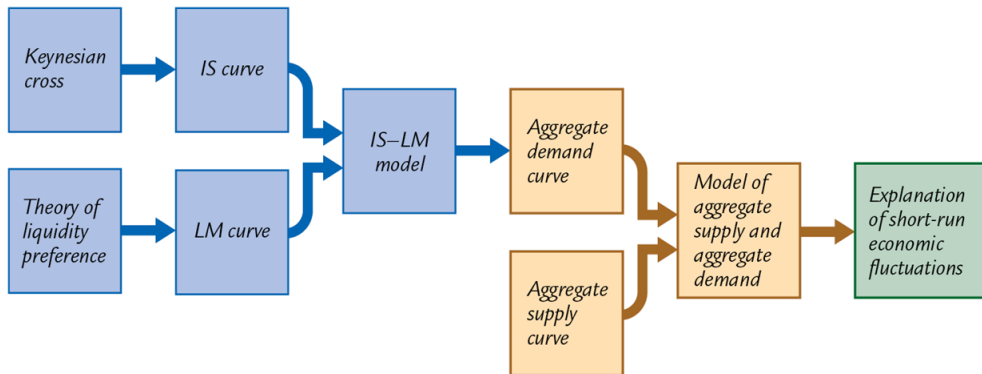
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- ▶  $rr = R/D$ : banks' reserve–deposit ratio;  $cr = C_u/D$ : the public's currency–deposit ratio.
- ▶ **Increase**  $B$ : purchase assets or supply more central-bank lending.
- ▶ **Encourage higher**  $rr$ : raise reserve requirements or the return on reserves. Actual holdings also depend on banks' choices.

# The Overall Plan



**Today:** money, inflation, and the money-market building block of aggregate demand.

# Session 7: Outline

## **Long run: flexible prices**

### **1. The Quantity Theory of Money**

Velocity, money demand, and the long-run price level.

### **2. Inflation and Interest Rates**

Seigniorage, the Fisher effect, and monetary neutrality.

## **Short run: sticky prices**

### **3. Liquidity Preference**

Money-market equilibrium when prices are sticky.

### **4. The LM Curve and IS–LM**

From the money market to short-run output and interest rates.

## 1. The Quantity Theory of Money

How does money relate to nominal spending and prices?

# The Quantity Equation: Transactions

- ▶ People hold money to **pay for goods and services**.

$$\underbrace{M \times V_T}_{\text{money used for payments}} \equiv \underbrace{P \times T}_{\text{value of transactions}} .$$

- ▶  $T$ : number of transactions per year;  $P$ : average price per transaction.
- ▶  $M$ : money stock;  $V_T$ : **velocity of money**.
  - ▶ Average number of times each unit of money is used per year.
- ▶ This is an **accounting identity**: if one variable changes, at least one other must adjust.

## How Often Is Money Used?

- ▶ Suppose the only transactions are **60 loaves of bread per year**, at **\$0.50 per loaf**.
- ▶ The annual value of transactions is  $PT = \$30$ .
- ▶ The money stock is \$10. The same dollars can be spent repeatedly.

**How often must the average dollar change hands?**

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**How often must the average dollar change hands?**

$$V_T = \frac{PT}{M} = \frac{\$30 \text{ per year}}{\$10} = 3 \text{ times per year.}$$

**Transactions velocity** measures how frequently money is used for payments.

# From Transactions to Income

- ▶ Total transactions are difficult to measure. We instead use **nominal GDP**, the value of current final output and total income.
- ▶ The sale of a **used car** is a transaction, but adds no current output. Transactions and GDP are related, but different.

$$MV \equiv PY, \quad V \equiv \frac{PY}{M}.$$

- ▶  $Y$ : real GDP per year;  $P$ : price level;  $PY$ : nominal GDP per year.
- ▶  $V$  is **income velocity**: nominal income generated per unit of money per year. We use this version from now on.

# Money Demand: The Balances People Want to Hold

- ▶ **Real money balances**,  $M/P$ , measure money's purchasing power.
  - ▶ If the quantity of money is \$10 and bread costs \$0.50 per loaf, real money balances are **20 loaves**.
- ▶ A **money demand function** tells us the quantity of real money balances people wish to hold:

$$\left(\frac{M}{P}\right)^d = kY, \quad k > 0.$$

- ▶  $k$  is the desired ratio of real balances to annual real income. For now, take  $k$  as fixed and exogenous.
- ▶ Higher income means more purchases: people want to hold more money to make those payments.

## Money Demand and Velocity

**How is the amount of money people hold related to its velocity?**

# Money Demand and Velocity

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$$\begin{aligned}\text{Money-market equilibrium: } \quad \frac{M}{P} &= kY, \\ M &= kPY, \\ V = \frac{PY}{M} &= \frac{1}{k}.\end{aligned}$$

- ▶ A **larger**  $k$  means more money held relative to income.
- ▶ That corresponds to **lower velocity**: each unit finances less spending per period.
- ▶ Conversely, when people hold **less money per dollar of income**, they must use each unit more often:  $k$  falls and  $V$  rises.

## From an Identity to a Long-Run Theory

- ▶ We now have a theory of what determines the economy's **overall price level**.
- 1. **Real output comes from the supply side:**  $Y = \bar{Y}$ , given capital, labor, and technology.
- 2. **The money supply determines nominal GDP:** with  $V = \bar{V}$ ,  $PY = M\bar{V}$ .
  - ▶ Constant velocity is a simplification: changes in money demand can change  $V$ .
- 3. **Flexible prices adjust:** the price level equals nominal GDP divided by real GDP.

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$$M\bar{V} = P\bar{Y} \quad \implies \quad P = \frac{M\bar{V}}{\bar{Y}}.$$

With  $\bar{V}$  and  $\bar{Y}$  unchanged, a 10% larger money stock implies a 10% higher price level.

## From the Price Level to Inflation

**Write  $MV = PY$  in percentage changes over the same period:**

$$\underbrace{\% \text{ change in } M}_{g_M} + \underbrace{\% \text{ change in } V}_{g_V} \approx \underbrace{\% \text{ change in } P}_{\pi} + \underbrace{\% \text{ change in } Y}_{g_Y}.$$

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$$\pi \approx g_M - g_Y.$$

## From the Price Level to Inflation

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- ▶ With constant velocity,  $g_V = 0$ :

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- ▶ Money growth of 6% and real GDP growth of 2% imply inflation of approximately 4%.
- ▶ Holding output growth fixed, one percentage point more money growth implies approximately one percentage point more inflation.

The growth-rate sum is exact for log changes; it is an approximation for ordinary percentage changes.

# The Central Bank and Long-Run Inflation

- ▶ In this theory, the central bank controls  $M$ . With **constant velocity** and **given real output growth**, it therefore determines long-run inflation.
- ▶ If real output is unchanged, a **stable money stock** keeps the price level stable.

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- ▶ If real output is unchanged, a **stable money stock** keeps the price level stable.
- ▶ If real output grows, stable prices require money to grow at the same rate:  
 $g_M = g_Y$ .
- ▶ **Rapid money growth relative to output growth** produces rapid inflation:  
 $\pi \approx g_M - g_Y$ .

# A Higher Money Stock or Faster Money Growth?

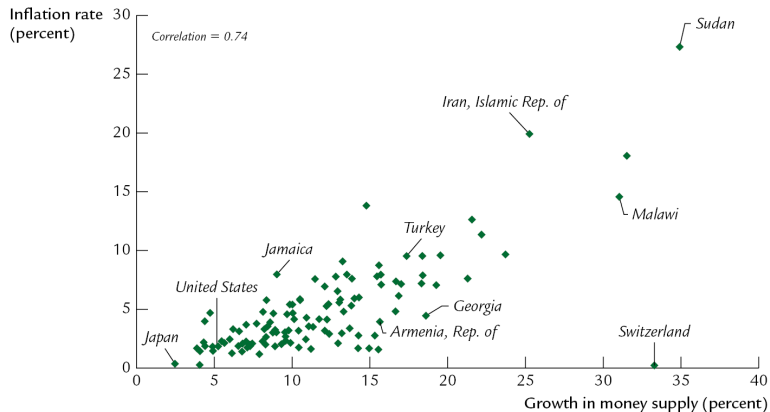
## A one-off increase in $M$

- ▶ The stock of money rises once and then follows its previous growth rate.
- ▶ With velocity and output fixed, the price level rises proportionally.
- ▶ Inflation rises during adjustment, without remaining permanently higher.

## A permanent increase in $g_M$

- ▶ Money grows faster every period.
- ▶ With stable velocity and unchanged output growth, the inflation rate is persistently higher.
- ▶ This is the experiment used in the long-run Fisher effect.

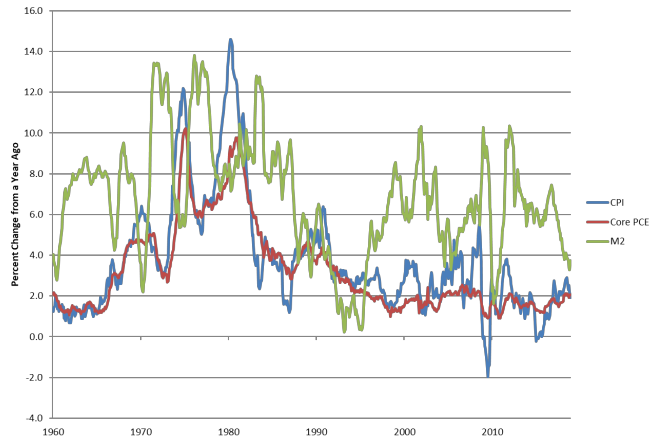
# Money Growth and Inflation Across Countries



Higher money growth is associated with higher inflation in this sample. The scatter alone does not establish causation.

Source: Mankiw, *Macroeconomics*, 12th edition.

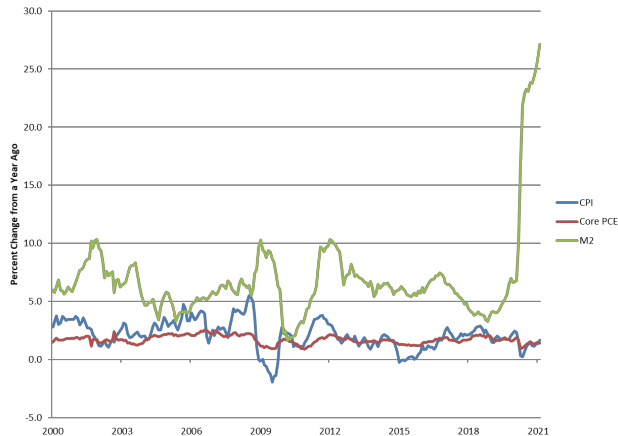
# US Money Growth and Inflation, 1960–2019



CPI: Consumer Price Index. Core PCE: Personal Consumption Expenditures price index excluding food and energy. M2: US broad money.

- ▶ Rates are year-on-year percentage changes.
- ▶ Inflation and money growth do not move one-for-one each year.
- ▶ Output growth and velocity can vary.

# US Money Growth and Inflation, 2000–2021



- ▶ M2 growth jumps near the end of this historical sample.
- ▶ Inflation does not rise proportionally at the same time.
- ▶ Constant velocity is an assumption to assess, especially over short horizons.

## 2. Inflation and Interest Rates

What does inflation change, and what remains real?

## Seigniorage and the Inflation Tax

- ▶ A government can finance spending through **taxes**, **borrowing** by selling bonds, or **printing money**. Revenue from printing money is called **seigniorage**.
- ▶ **What happens to prices as we print more money?**

# Seigniorage and the Inflation Tax

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  - ▶ **Who pays for this tax?**
- ▶ **We do, as holders of money.**
  - ▶ The purchasing-power loss is larger for people holding more non-interest-bearing money.
- ▶ Money creation can finance government spending when the institutional framework permits monetary financing.

## When Money Financing Becomes Extreme

- ▶ **Hyperinflation** is extremely rapid inflation; a common convention is inflation above 50% per month.
- ▶ Persistent fiscal deficits financed through money creation can generate very high money growth and inflation.
- ▶ As people try to spend money quickly, real money demand falls and velocity rises.
- ▶ Prices become poor signals, contracts are harder to write, and holding money becomes costly.
- ▶ Stabilization requires a credible end to persistent monetary financing, supported by fiscal adjustment.

# Nominal and Real Interest Rates

- ▶ **Nominal interest rate**,  $i$ : the percentage return in money over a period.
- ▶ **Real interest rate**,  $r$ : the return measured in purchasing power over the same period.
- ▶ **Inflation**,  $\pi$ : the percentage increase in the price level over that period.

$$1 + r = \frac{1 + i}{1 + \pi}, \quad r \approx i - \pi.$$

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$$1 + r = \frac{1 + i}{1 + \pi}, \quad r \approx i - \pi.$$

- ▶ Rearranging gives the approximate **Fisher equation**:

$$i \approx r + \pi.$$

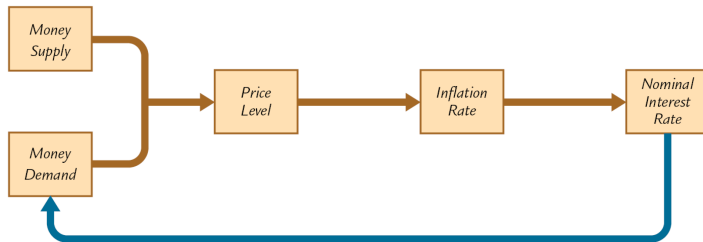
# The Fisher Effect

- ▶ In the long run, saving and investment determine the **real interest rate**,  $r$ .
- ▶ With output growth and velocity unchanged, faster money growth raises inflation.
- ▶ With  $r$  unchanged:  $i \approx r + \pi \Rightarrow \Delta i \approx \Delta \pi$ .

# The Fisher Effect

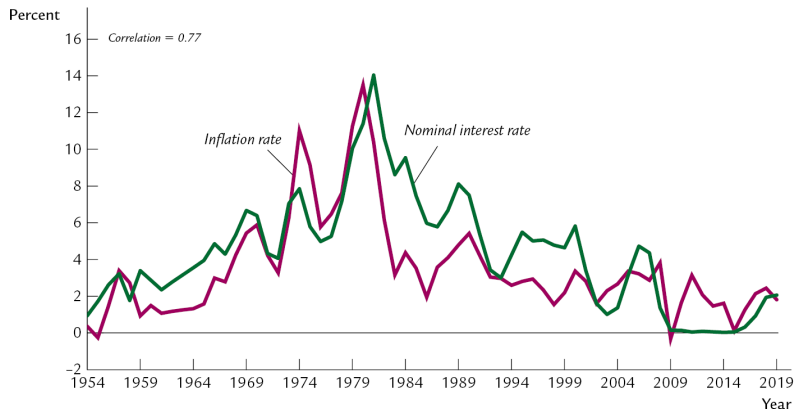
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**The Fisher effect:** a one-percentage-point rise in inflation raises the nominal interest rate by approximately one percentage point.



Mankiw, Macroeconomics, 11e, © 2022 Worth Publishers

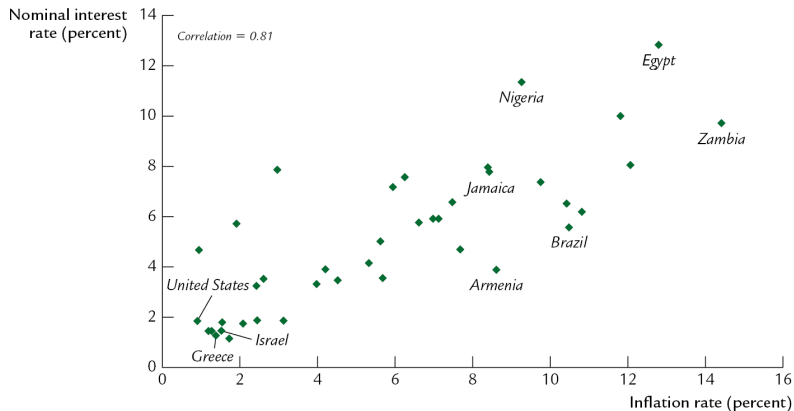
# US Inflation and Nominal Interest Rates, 1955–2020



The series move together over long horizons. Real rates and inflation expectations also change, so the relationship is not exact.

Source: Mankiw, *Macroeconomics*, 12th edition.

# Inflation and Nominal Interest Rates in 48 Countries



Higher inflation is associated with higher nominal rates. The graph uses observed inflation; the Fisher relation concerns expected inflation.

Source: Mankiw, *Macroeconomics*, 12th edition.

# Classical Dichotomy and Monetary Neutrality

## Real variables

- ▶ Output and employment.
- ▶ Real wage: goods purchasable with an hour's earnings.
- ▶ Real interest rate: return in purchasing power.

## Nominal variables

- ▶ Money stock and price level.
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# Classical Dichotomy and Monetary Neutrality

## Real variables

- ▶ Output and employment.
- ▶ Real wage: goods purchasable with an hour's earnings.
- ▶ Real interest rate: return in purchasing power.
- ▶ **Classical dichotomy**: the classical model separates the determination of real variables from nominal variables.
- ▶ **Monetary neutrality**: in the long run, flexible prices adjust to changes in the money supply, leaving real variables unchanged.

## Nominal variables

- ▶ Money stock and price level.
- ▶ Nominal wage: money earned per hour.
- ▶ Nominal interest rate: return in money.

**We now go back to the short run.**

### 3. Liquidity Preference

How does the money market determine the interest rate in the short run?

# The Opportunity Cost of Holding Money

- ▶ We began with  $(M/P)^d = kY$ : desired real money balances depend on income.
- ▶ Money makes payments convenient. But holding non-interest-bearing money means giving up the return on an interest-bearing asset, such as a bond.

# The Opportunity Cost of Holding Money

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- ▶ Money makes payments convenient. But holding non-interest-bearing money means giving up the return on an interest-bearing asset, such as a bond.
- ▶ The **nominal interest rate**,  $i$ , is therefore the **opportunity cost of holding money**.
- ▶ Both the real interest rate and **expected inflation**,  $E\pi$ , affect this cost:

$$i \approx r + E\pi.$$

## A More General Money Demand Function

- ▶ Let desired real money balances depend on income and the cost of holding money:

$$\left(\frac{M}{P}\right)^d = L(i, Y).$$

- ▶ **Higher income**  $Y$ : more purchases and payments, so people want to hold more money.
- ▶ **Higher nominal interest rate**  $i$ : interest-bearing assets become more attractive, so people want to hold less money.

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- ▶ At a given real rate, higher expected inflation raises  $i$  and reduces desired real money balances.

# The Short-Run Money Market

- ▶ Keynes's **theory of liquidity preference** uses money supply and money demand to explain the interest rate in the short run.
- ▶ **Sticky prices:** take the price level as fixed,  $P = \bar{P}$ .
  - ▶ A constant price level means zero inflation over the period.
  - ▶ Also assume zero expected inflation,  $E\pi = 0$ , so  $i = r$ .
- ▶ Take the money supply as **exogenous**,  $M = \bar{M}$ .

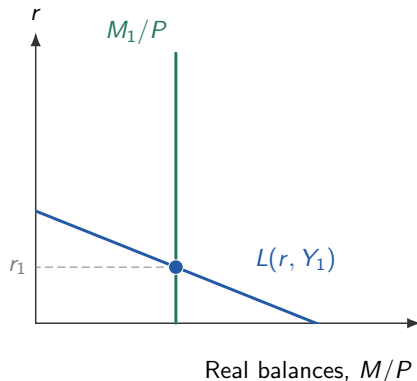
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  - ▶ Also assume zero expected inflation,  $E\pi = 0$ , so  $i = r$ .
- ▶ Take the money supply as **exogenous**,  $M = \bar{M}$ .
- ▶ First hold income  $Y$  fixed. With  $i = r$ , write money demand as  $L(r, Y)$ ; the interest rate adjusts to clear the money market.

# Supply and Demand for Real Money Balances

**Assume money pays no interest.** More generally, the relevant cost is the return on alternative assets minus the return on money.

- ▶ **Supply:**  $(M/P)^s = \bar{M}/\bar{P}$ . It is vertical because it does not depend on  $r$ .
- ▶ **Demand:**  $(M/P)^d = L(r, Y)$ .
- ▶ Holding  $Y$  fixed, a higher rate raises the opportunity cost of holding money and reduces desired balances.

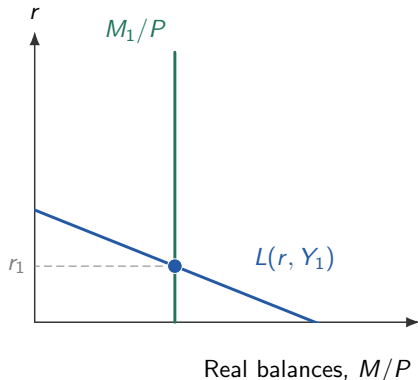


# Money-Market Equilibrium

**Bond prices and yields move in opposite directions.** A bond paying \$110 in one year yields 10% at a price of \$100; a lower price means a higher yield.

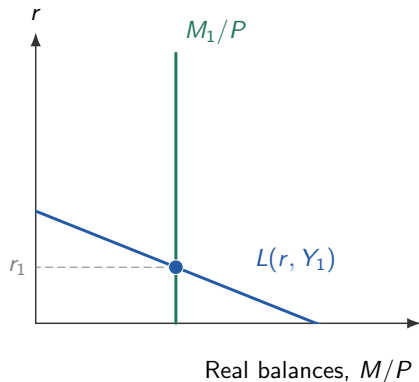
$$\frac{\bar{M}}{\bar{P}} = L(r, Y).$$

- ▶ At  $r_1$ , people want to hold the available real balances.
- ▶ If  $r$  is too low, money demand exceeds supply. People try to sell bonds; bond prices fall and yields rise.
- ▶ If  $r$  is too high, people try to buy bonds; bond prices rise and yields fall.



## A Fall in the Money Supply

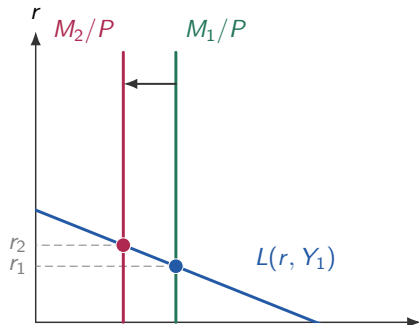
Hold income and the price level fixed. Reduce money from  $M_1$  to  $M_2$ .



# A Fall in the Money Supply

Hold income and the price level fixed. Reduce money from  $M_1$  to  $M_2$ .

- ▶ The supply of real balances shifts left.
- ▶ At the old interest rate, desired balances exceed the smaller supply.
- ▶ The interest rate rises from  $r_1$  to  $r_2$ , reducing money demand.



$$M \downarrow, \quad P = \bar{P} \quad \Rightarrow \quad M/P \downarrow \quad \Rightarrow \quad r \uparrow.$$

# Does Monetary Tightening Raise or Lower Rates?

**The answer depends on the horizon and the policy experiment.**

---

|            | <b>Short run</b>                        | <b>Long run</b>                                  |
|------------|-----------------------------------------|--------------------------------------------------|
| Model      | Liquidity preference                    | Quantity theory and Fisher effect                |
| Prices     | Sticky                                  | Flexible                                         |
| Experiment | Lower $M$ at given $P$ and $Y$          | Persistently slower money growth                 |
| Mechanism  | Scarcer real balances raise $r$ and $i$ | Lower expected inflation reduces $i$ , given $r$ |

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A one-off reduction in  $M$  alone does not imply permanently lower inflation or nominal interest rates.

# The Volcker Disinflation

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- ▶ **How do you think this policy change would affect nominal interest rates?**

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## Three-month US Treasury bill yields (annualized)

| Before Oct. 1979 | 1980  | 1981  | 1986 |
|------------------|-------|-------|------|
| 10.3%            | 11.4% | 14.0% | 6.0% |

- ▶ **Initially:** real money balances fell and interest rates rose, as liquidity preference predicts.
- ▶ **Later:** lower inflation and inflation expectations brought nominal rates down, as the Fisher effect predicts.

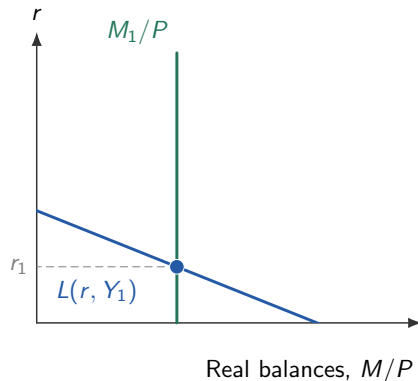
## 4. The LM Curve and IS–LM

How do income and interest rates clear both markets?

# Income Also Affects Money Demand

**What happens to real money demand when income rises from  $Y_1$  to  $Y_2$ ?**

Keep  $\bar{M}/\bar{P}$  fixed and consider the initial interest rate first.

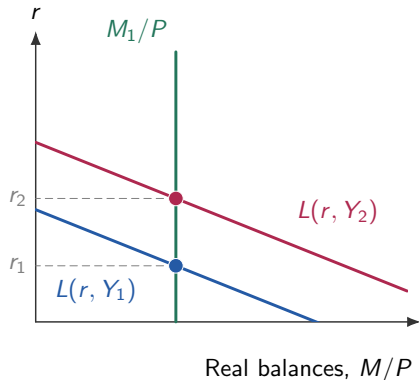


# Income Also Affects Money Demand

**What happens to real money demand when income rises from  $Y_1$  to  $Y_2$ ?**

Keep  $\bar{M}/\bar{P}$  fixed and consider the initial interest rate first.

- ▶ Higher income means more purchases and payments: people want to hold more real money balances.
- ▶ Money demand shifts up/right. At the old interest rate, demand exceeds the fixed supply.
- ▶ The interest rate rises from  $r_1$  to  $r_2$ , reducing desired balances and restoring equilibrium.



# What Is the LM Curve?

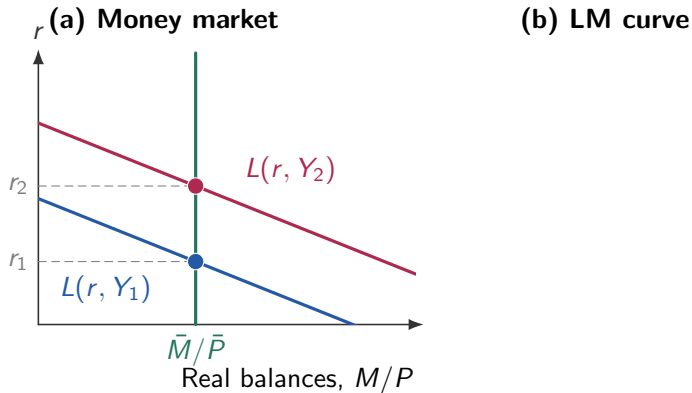
- ▶ The **LM curve** collects combinations of income  $Y$  and interest rate  $r$  that clear the market for real money balances.
- ▶ LM refers to **liquidity preference and money supply**.
- ▶ Its equilibrium condition is

$$\frac{\bar{M}}{\bar{P}} = L(r, Y).$$

The curve holds the money supply, price level, and money-demand behavior fixed.

## Deriving the LM Curve

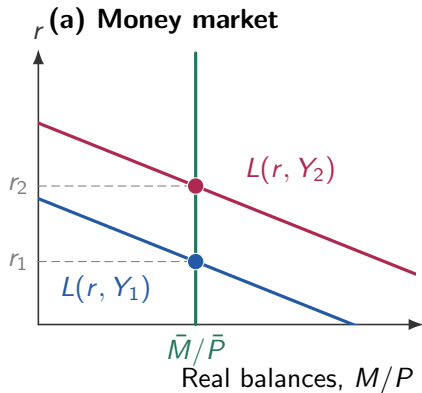
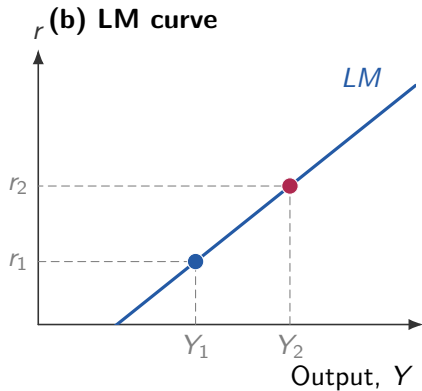
Raise income from  $Y_1$  to  $Y_2$ , holding  $\bar{M}/\bar{P}$  fixed.



Higher income shifts money demand right. The equilibrium interest rate rises.

## Deriving the LM Curve

Raise income from  $Y_1$  to  $Y_2$ , holding  $\bar{M}/\bar{P}$  fixed.

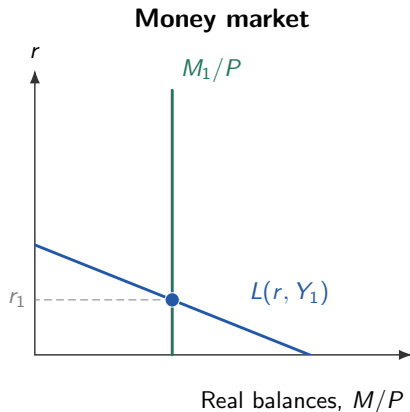
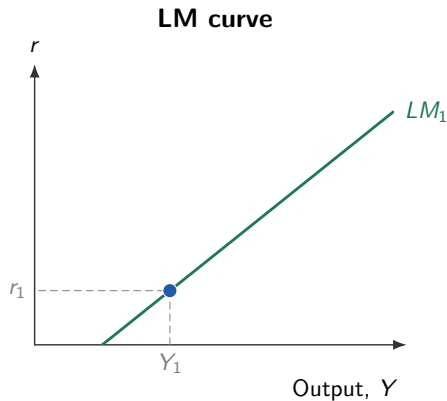


Plot  $(Y_1, r_1)$  and  $(Y_2, r_2)$ : the LM curve is upward sloping.

**Why upward sloping?** Higher income raises money demand, so a higher interest rate is needed to restore equilibrium.

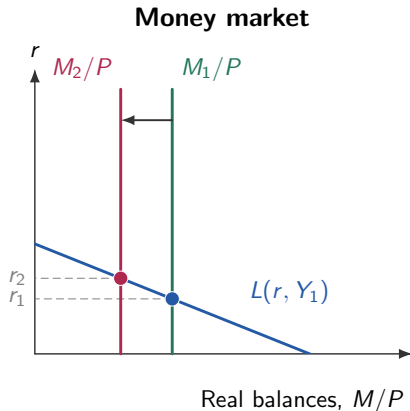
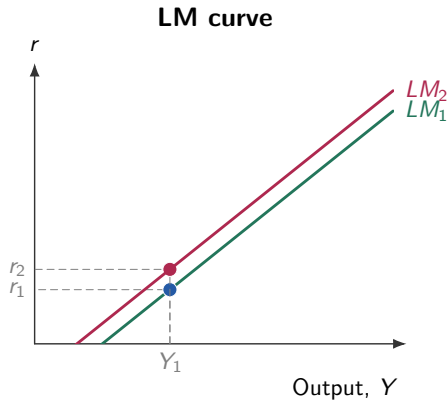
# How a Fall in Money Shifts LM

Keep  $P$  fixed. Compare the interest rate at the same income,  $Y_1$ .



# How a Fall in Money Shifts LM

Keep  $P$  fixed. Compare the interest rate at the same income,  $Y_1$ .



$M \downarrow$  raises the equilibrium rate at every given  $Y$ : **LM shifts up/left**. An increase in money shifts LM down/right.

# Short-Run Equilibrium in IS-LM

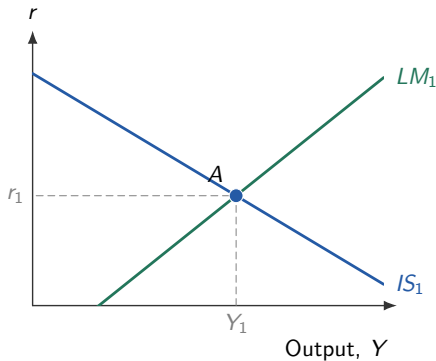
**Goods market:**

$$Y = C(Y - \bar{T}) + I(r) + \bar{G}.$$

**Money market:**

$$\frac{\bar{M}}{\bar{P}} = L(r, Y).$$

- ▶ The intersection determines  $Y$  and  $r$  jointly.
- ▶  $\bar{G}$ ,  $\bar{T}$ ,  $\bar{M}$ , and  $\bar{P}$  are given.  $T$  is taxes net of transfers.
- ▶ Closed economy; expected inflation is zero.



## What to Remember

- ▶ **The quantity equation is an identity.** Constant velocity and supply-determined output turn it into a long-run theory of prices.
- ▶ **Persistent money growth matters for inflation.** With stable velocity,  $\pi \approx g_M - g_Y$ .
- ▶ **The Fisher effect links inflation and nominal rates.** Given the real rate, higher (expected) inflation raises the nominal rate.
- ▶ **Sticky prices change the adjustment.** In liquidity preference, money supply and demand determine the interest rate at a given income.
- ▶ **LM collects money-market equilibria.** It slopes upward; IS and LM jointly determine short-run output and the interest rate.

**Next session:** fiscal and monetary policy in IS–LM, and the aggregate demand curve.