ECON 101B: 00 - 06

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Chapter 1

00 - Measurement

1.1 Gross Domestic Product (GDP)

Definition 1.1.1: GDP

Market value of all final goods and services produced within a country in a given period of time.

Key Elements:

- *Market Value*: use prices for cross-good comparisons
- *Final*: no intermediate goods
- *Goods & Services*: foods and haircuts...
- *Produced*: no re-sales counted
- *Within a country*: Toyota plant in US is US GDP

$$GDP_t = P_{1,t}\,Q_{1,t} + P_{2,t}\,Q_{2,t} + \cdots + P_{N,t}\,Q_{N,t} = \sum_{j=1}^{N} P_{j,t}\,Q_{j,t}$$

GDP is also the sum of the incomes in the economy during a given period, including

- *labor* income
- *capital* income
- *indirect taxes*

But GDP can go up when either prices or output rise, so we can construct another measure that reflects only production changes: real GDP.

- ***Nominal GDP*** is GDP measures in current dollars
- ***Real GDP*** is GDP measures in constant dollars

Lemma 1.1.2: Computing Real GDP

1. Pick a base year (say 1996).
2. Calculate nominal GDP that year: $GDP_{1996,1996} = \sum_{j=1}^{N} P_{1996,j}\, Q_{1996,j}$
3. Calculate GDP for other years using 1996 prices:

$$GDP_{1997,1996} = \sum_{j=1}^{N} P_{1996,j}\, Q_{1997,j}$$

$$GDP_{1998,1996} = \sum_{j=1}^{N} P_{1996,j}\, Q_{1998,j}$$

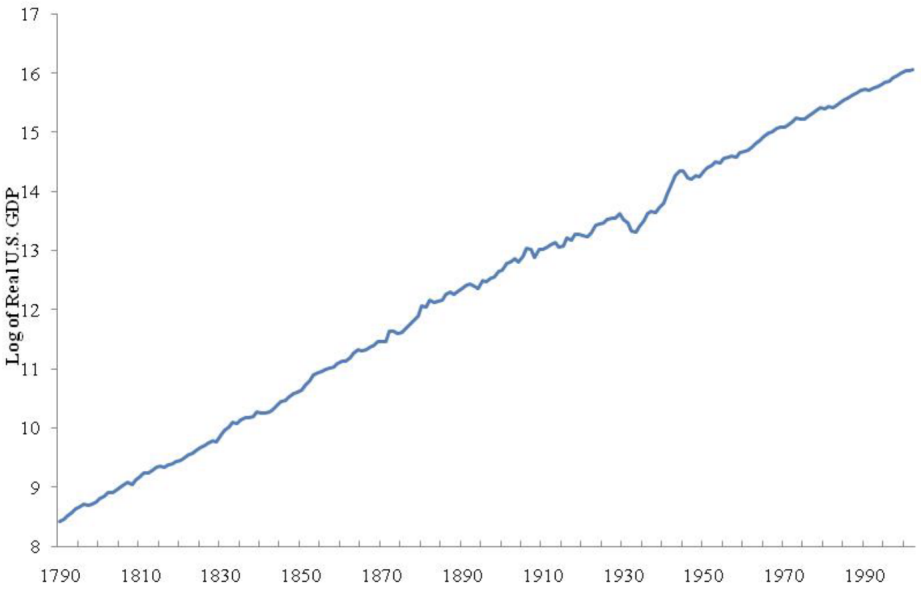


Figure 1.1: Historical U.S. Real GDP

1. **Growth Theory** addresses the fact that Real GDP keeps going up over time:
   - Average annual growth rate: 3.6% a year, 2% of which is population
   - Income today is more than **30 times** higher than in 1790.
2. **Business Cycle** analysis addresses the cyclical fluctuations in Real GDP about the long-run trend.

1.2 Unemployment

The *labor force* is the total number of workers, including both the employed and the unemployed.

The *unemployment rate* is calculated as the percentage of the labor force that is unemployed:

$$\text{Unemployment rate} = \frac{\text{Number unemployed}}{\text{Labor Force}} \times 100$$

1.2.1 Employment-Population Ratio

If we are concerned about *discouraged workers* leaving the labor force and affecting unemployment rates, we look at the employment-population ratios.

1.3 Measuring Prices

1. Approach 1: ***GDP Deflator***
   Tells us what portion of the rise in nominal GDP is attributable to a rise in prices rather than a rise in the quantities produced.

   $$\text{GDP deflator} = \frac{\text{Nominal GDP}}{\text{Real GDP}} \times 100$$

   The only problem with calculating with GDP Deflator is that prices change each period, so old prices will become outdated.

2. Approach 2: ***Consume Price Index (CPI)***

   Definition 1.3.1: CPI

   A measure of the overall cost of the goods and services bought by a typical consumer.

   Methodology:

   (a) *Fix the basket.* Determine what prices are most important to the typical consumer.

   (b) *Find the prices.* Find the prices of each of the goods and services in the basket for each point in time.

   (c) *Compute the basket's cost.* Use the data on prices to calculate the cost of the basket of goods and services at different times.

   (d) Choose a base year and compute the index.

   $$\text{CPI} = \frac{\text{Price of basket of goods and services}}{\text{Price of basket in base year}} \times 100$$

1.3.1 National Income Accounting Identity

Lemma 1.3.2: Computing GDP (Y)

In computing GDP itself, we use the common, well-known formula:

$$Y = C + I + G + NX$$

where

- Y is GDP
- C is Consumption
- I is Investment
- G is Government
- NX is Net Exports

1.4 Business Cycle

What is a business cycle?

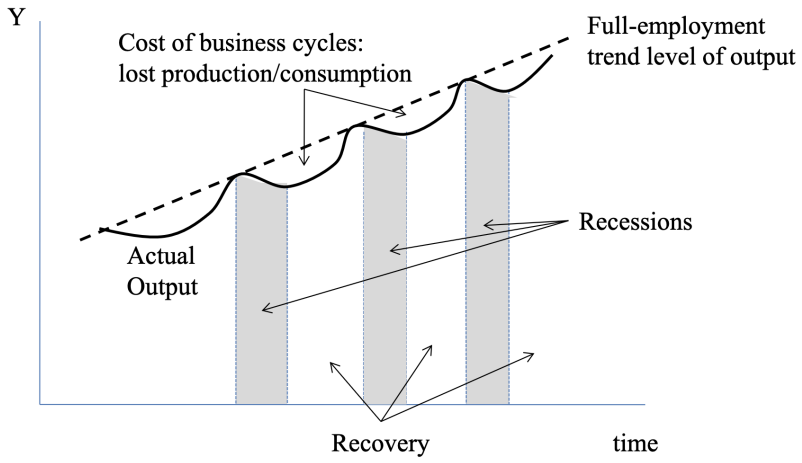


Figure 1.2: A traditional business cycle

1.5 Recessions

How the National Bureau of Economic Research (NBER) identifies U.S. recessions:

"We identify a month when the economy reached a peak of activity and a later month when the economy reached a trough. The time in between is a recession, a period when the economy is contracting. The following period is a expansion. Economic activity is below

normal or diminished for some part of the recession and for some part of the following expansion as well."

Some Simple Stylized Facts:

- Recessions are varied in length and depth.
- Recessions are unpredictable.
- Recessions are becoming less frequent.

What happens during a recession?
By averaging across all post-WWII recessions, we identity several variables:
Key things to look for:

- Co-movement of variables (pro-cyclical vs. counter-cyclical)
- Lead-lag patterns

Key variables we care about:

- Real GDP
- Prices
- Unemployment
- Consumption & Investment
- Interest Rates
- Real wages

Visually, we can see this "pattern" reflected in GDP, CPI, industrial production, etc.:

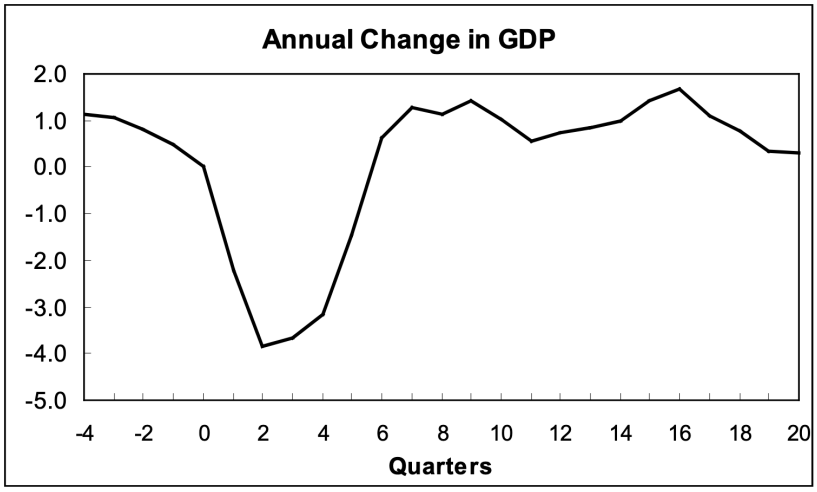


Figure 1.3: Growth rate of GDP relative to growth rate at time 0 (start of recession)

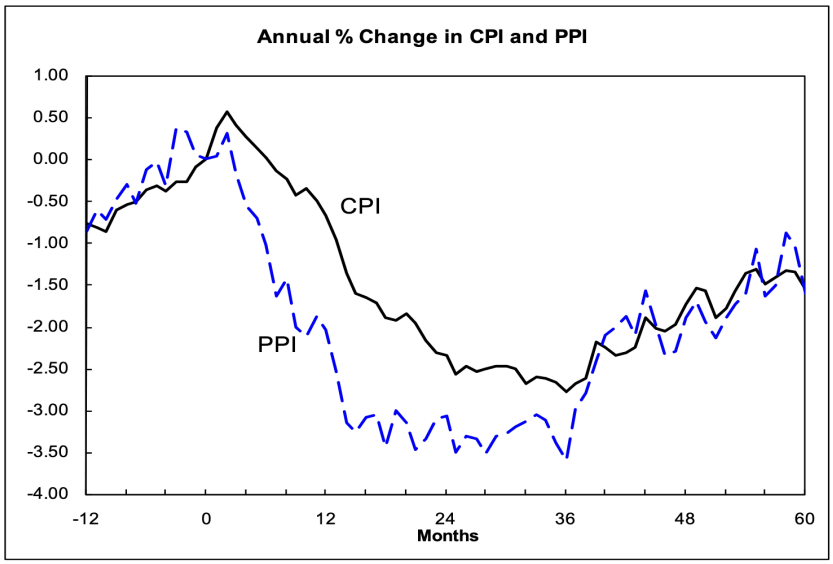


Figure 1.5: Growth rate of Prices relative to growth rate at time 0 (start of recession)

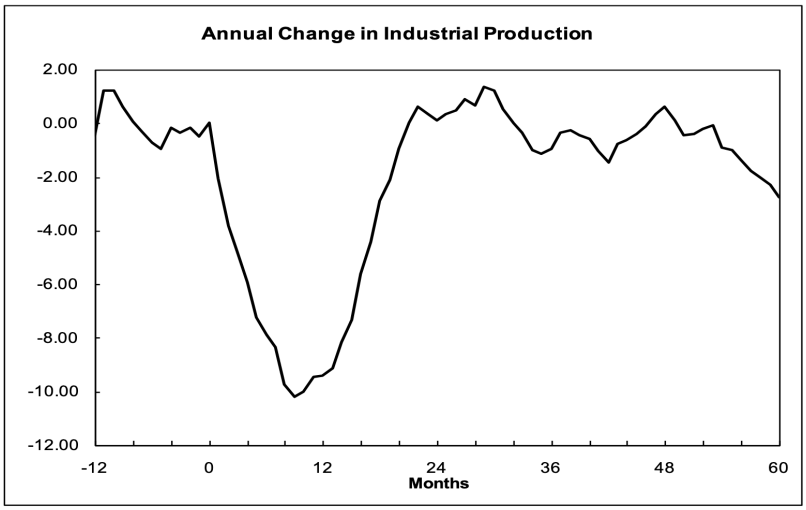


Figure 1.4: Growth rate of Industrial Production relative to growth rate at time 0 (start of recession)

Ultimately, during a recession, the following occurs:

1. Real GDP growth declines.
2. Inflation is rising before recessions, but falls rapidly during recessions.
3. Consumption and investment decline. The decline in consumption is particularly due to durables. The decline in investment begins with the residential sector.
4. Interest rates rise before the recession, but fall rapidly during a recession.
5. Unemployment goes up about 2 percentage points, and declines slowly.

6. Real wages decline.

Chapter 2

01 - Consumption Theory

2.1 Consumer's Problem

The objective is to maximize utility subject to constraints.

$$U(c_1, c_2) = \mu(c_1) + \beta\mu(c_2)$$

where

- c_t is consumption at time t
- β is the discount factor
- $\mu(c)$ is the instantaneous utility from consuming c.
- $U(c_1, c_2)$ is total utility.
- Only two periods
- Endowments (income) y_1 and y_2
- Borrow/lend freely at interest rate $1 + r$

More consumption is always better: $c_1 > c_2 \Leftrightarrow \mu(c_1) > \mu(c_2)$.
We move on to the diminishing marginal utility of consumption: $MU(c)$.

Definition 2.1.1: $MU(c)$

$MU(c)$ is the extra utility from one more unity of consumption, or $\frac{du(c)}{dc}$.

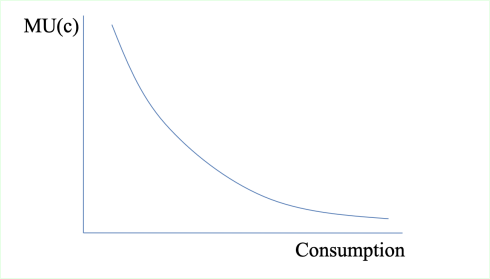


Figure 2.1: $MU(c)$ compared to Consumption

Implications of Diminishing $MU(c)$: Suppose you have three choices:

1. 2 large pizzas for lunch, none for dinner
2. 1 large pizza for lunch, one for dinner
3. Nothing for lunch, 2 large pizzas for dinner

Typically, consumers will choose 2, since consumers generally prefer mixes. How do we solve this problem?

2.1.1 Solving the Maximization Problem

1. ***Tangency Condition***
   (a) Consume one more unit at time 1 yields
   $$MU(c_1)$$
   (b) Save that unit, earn interest and consume at time 2 yields
   $$\beta(1+r)\cdot MU(c_2)$$
   $$MU(c_1) = \beta(1+r)MU(c_2)$$
2. ***Intertemporal budget constraint (ITBC)***
   Two budget constraints
   $$t = 1 : c_1 + s_1 = y_1 \tag{2.1}$$
   $$t = 2 : c_2 = y_2 + s_1(1+r) \tag{2.2}$$
   These collapse to the *Intertemporal Budget Constraint*
   $$c_1 + \frac{c_2}{1+r} = y_1 + \frac{y_2}{1+r}$$

However, the present discounted sum of consumption must equal the present discounted sum of income.

2.1.2 Solving for the Consumption Function

- Assume $MU(c) = \frac{1}{c}$
- The tangency condition reduces to

$$c_2 = \beta(1+r)c_1$$

- Plugging this into the ITBC yields the ***consumption function***

$$c_1 = \frac{1}{1+\beta}(y_1 + \frac{y_2}{1+r})$$

- If $\beta = 1$, then this simplifies to

$$c_1 = \frac{1}{2}(y_1 + \frac{y_2}{1+r})$$

2.1.3 Solving for the Saving Function

- Consumer's saving in the first period is

$$s_1 = y_1 - c_1$$

- The ***saving function*** is therefore

$$s_1 = y_1 - \frac{1}{1+\beta}(y_1 + \frac{y_2}{1+r}) \tag{2.3}$$
$$= \frac{\beta}{1+\beta}y_1 - (\frac{1}{1+\beta})\frac{y_2}{1+r} \tag{2.4}$$

Note that

$$r \uparrow \Rightarrow s \uparrow \tag{2.5}$$
$$y_1 \uparrow \Rightarrow s \uparrow \tag{2.6}$$
$$y_2 \uparrow \Rightarrow s \downarrow \tag{2.7}$$

Example.

> Endowment: $y_1 = 1, y_2 = 0$. Discount factor $\beta = 1$. Interest rate $1 + r = 1$. $MU(c) = \frac{1}{c}$.
> This means that the tangency condition is $c_2 = \beta(1 + r)c_1 = c_1$.
> The ITBC, therefore, is $c_1 + \frac{c_2}{1+r} = y_1 + \frac{y_2}{1+r} \Rightarrow c_1 + c_2 = 1$
> Combining them and solving for consumption
>
> $$c_1 = c_2 = \frac{1}{2}$$
>
> The consume allocates consumption evenly over the two periods: this is also known as ***consumption smoothing***.

2.2 Permanent Income Hypothesis

Suppose income has two components:

- *permanent* component y^p
- *cyclical* (or transitory) component y_t^c.

This means that income at time t is given by

$$y_t = y^p + y_t^c$$

Then, the consumption function becomes

$$c_1 = y^p + \frac{1}{T}[y_1^c + y_2^c + \cdots + y_T^c]$$

An increase in permanent income rises consumption *one-for-one*: ***the marginal propensity to consume (mpc) out of a change in permanent is one.***
A temporary increase in income raises consumption very little: ***the marginal propensity to consume (mpc) out of a transitory change in income is very small(***$\frac{1}{T}$.

2.2.1 Aggregating Across Consumers

- Two types of agents: A and B
- Number of agents: N_A and N_B
- Endowments: (y_1^A, y_2^A) and (y_1^B, y_2^B)
- Total income each period: $Y_1 = N_A\, y_1^A + N_B\, y_1^B$
- Agent i has consumption function:

$$c_1^i = \frac{1}{1+\beta}(y_1^i + \frac{y_2^i}{1+r}$$

- Therefore, the ***aggregate consumption function*** is:

$$C = N_A\, c_1^A + N_B\, c_1^B = \frac{1}{1+\beta}(Y_1 + \frac{Y_2}{1+r})$$

2.2.2 Implications of Permanent Income Hypo.: Effect of tax cuts

Suppose consumers have to pay taxes τ_t each period.
The ITBC (same assumptions as for PIH $(1 + r = 1)$) is then:

$$c_1 + c_2 + \cdots + c_T = (y_1 - \tau_1) + (y_2 - \tau_2) + \cdots + (y_T - \tau_T)$$

Given same tangency condition ($\beta = 1, 1 + r = 1$, this yields:

$$c_1 = \frac{1}{T}[(y_1 - \tau_1) + (y_2 - \tau_2) + \cdots + (y_T - \tau_T)]$$

- Consider a ***temporary*** decrease in taxes of $\Delta\tau_1 < 0$, then:

$$\Delta c_1 = -\frac{1}{T}\Delta\tau_1$$

- Consider a ***permanent*** decrease in taxes of $\Delta\tau_1 < 0$ for all periods, then:

$$\Delta c_1 = \frac{1}{T}[-\Delta\tau - \Delta\tau - \cdots - \Delta\tau] = -\Delta\tau$$

2.3 Random Walk Hypothesis

Let's add uncertainty to the model:

- Income next period is a random variable, so second period consumption is not known with certainty.
- Utility is given by
$$U(c_1, c_2) = \mu(c_1) + \beta E[\mu(c_2)]$$
where $E(x)$ is the ***expected value*** of x.
- So the tangency condition is now:

$$MU(c_1) = \beta(1 + r)E[MU(c_2)]$$

- Suppose $MU(c) = \frac{1}{c}$, then the tangency condition is:

$$\frac{1}{c_1} = \beta(1 + r)E[\frac{1}{c_2}]$$

- For simplicity, let $\beta(1 + r) = 1$. Then,

$$\frac{1}{c_1} = E[\frac{1}{c_2}]$$

which is approximately:

$$E[c_2 - c_1] \approx 0$$

Changes in consumption should be completely unpredictable!

Testing the Theory:

- *Bob Hall (1978)*: stock prices weakly predict changes in consumption.
- *Campbell and Mankiw (1989)*: predictable changes in income are correlated with changes in consumption.
- *John Shea (1995)*: union workers increase consumption when their income rises, as previously agreed upon in contracts.
- *Johnson, Parker, and Souleles (2004)*: most people who received $300 tax rebates from 2001 tax cut spent all the money.
- *Hsieh (2003)*: Alaskans smooth large fluctuations in income from the Alaska permanent fund

What could make the theory fail?

- Non-rational behavior: agents live "hand-to-mouth" and spend all their income.
- Some agents don't have access to credit markets: hence their consumption equals their income.
- Liquidity constraints, i.e. limited borrowing.
- Shocks have to be sufficiently large to induce agents to "re-optimize"

2.3.1 Our Aggregate Consumption Function

The theory predicts that aggregate consumption C is given by:

$$C = \frac{1}{1+\beta}\left(Y_1 + \frac{Y_2}{1+r} + \frac{Y_3}{(1+r)^2} + \cdots\right)$$

Equivalently, consumption depends on permanent income and the interest rate:

$$C = C\left(\text{PermanentIncome}, r^-\right)$$

However, empirical evidence suggests that current income has a disproportionate effect on consumption. Therefore, a more general consumption function is:

$$C = C\left(Y - T, \text{PermanentIncome}, r^-\right)$$

Permanent income is the *expected* sum of current and future income. Consumer sentiment (CS) is used as a proxy:

$$C = C\left(Y - T, CS, r\right)$$

2.4 Endowment Economics

Consider an economy with different types of agents $A, B, C, \ldots$ with endowments $(y_1^A, y_2^A, \ldots), (y_1^B, y_2^B, \ldots)$. Total income each period is:

$$Y_i = N_A y_1^A + N_B y_1^B + \ldots$$

The goal is to solve for equilibrium consumption, saving allocations, and the equilibrium interest rate. How?

1. Solve for consumption and savings functions for each type of agent, conditional on income and interest rate.
2. Use a market-clearing condition to solve for the interest rate.
3. Given the equilibrium interest rate, solve for actual equilibrium consumption allocations.

Two equivalent market-clearing conditions:

- Goods Market Clearing Condition: $Y = C$
- Savings Market Clearing Condition: $S = 0$

Example.

For one type of agent with endowment (y_1, y_2) and $MU(c) = 1/c$
Part 1: Consumption and Saving Functions:

- Tangency condition: $c_2 = \beta(1+r)c_1$
- ITBC: $c_1 + \frac{c_2}{1+r} = y_1 + \frac{y_2}{1+r}$
- Consumption Function: $c_1 = \frac{1}{1+\beta}\left(y_1 + \frac{y_2}{1+r}\right)$
- Saving Function: $s_1 = y_1 - c_1 = \frac{\beta}{1+\beta}y_1 - \left(\frac{1}{1+\beta}\right)\frac{y_2}{1+r}$

Part 2: Market-Clearing Conditions:

- Goods Market: $Y = C \Rightarrow y_1 = c_1 \Rightarrow 1 + r = \frac{y_2}{\beta y_1}$
- Savings Market: $S = 0 \Rightarrow 1 + r = \frac{y_2}{\beta y_1}$

Part 3: Solve for Equilibrium Consumption/Saving Allocations: Given the equilibrium interest rate $1 + r = \frac{y_2}{\beta y_1}$:

$$c_1 = y_1, \quad s_1 = 0$$

2.5 Ricardian Equivalence

Introduce government spending G_1, G_2 and taxes T_1, T_2. The government's budget constraints are:

$$G_1 + S_1^G = T_1, \quad G_2 = T_2 + S_1^G(1+r)$$

The consumer's ITBC is:

$$c_1 + \frac{c_2}{1+r} = y_1 - T_1 + \frac{y_2 - T_2}{1+r}$$

The consumption function is independent of taxes and government borrowing. The market-clearing condition depends only on income, government spending, and consumption. Therefore, the equilibrium interest rate is also independent of taxes.

Ricardian Equivalence implies that the equilibrium consumption levels and real rate of return are independent of the choice of government financing.

Chapter 3

03 - Investment Theory

3.1 Investment Theory

3.1.1 What is Investment?

Definition 3.1.1: Investment

The purchase of physical durable items (capital) to be used in the process of production. Examples include factories, machinery, transportation equipment, electronics, and software.

3.1.2 Properties of Capital (K)

Definition 3.1.2: Capital

Capital is durable and subject to a rate of depreciation (δ). Structures have low depreciation (2-3% per year), machinery has higher depreciation (10-15% per year), and computers have very high depreciation (25% per year).

The stock of capital follows a law of motion:

$$K_t = (1 - \delta)K_{t-1} + I_{t-1}$$

3.1.3 Optimal Level of Capital for Firms

Firms decide whether to purchase an additional unit of capital based on the following:

Definition 3.1.3: User Cost of Capital

The equilibrium condition for optimal capital is given by:

$$MP_k = r + \delta$$

where MP_k is the marginal product of capital, r is the interest rate, and δ is the depreciation rate.

Example.

Example: Firm with production function $Y = K^{-1/3}L^{2/3}$ has a marginal product of capital:

$$MP_K = \frac{1}{3}K^{-2/3}L^{2/3}$$

The optimal level of capital is:

$$K^* = \frac{L}{[3(r+\delta)]^{3/2}}$$

and the optimal level of investment is:

$$I_t = K^* - (1-\delta)K_t$$

3.1.4 Investment Function

Definition 3.1.4: Investment Function

Current investment depends on the expectation of future profits ("animal spirits") and the current output. The investment function is given by:

$$I = I\left(SP, r, \overline{Y}\right)$$

where SP represents "animal spirits," r is the interest rate, and $\overline{Y}$ is the current output.

3.1.5 Borrowing Constraints for Firms

Firms may face borrowing constraints due to risks such as bankruptcy or gambling by owners. To mitigate these risks, banks require collateral, equity stakes, and regular financial reports. Firms that are borrowing-constrained must finance investment using internal funds (profits or cash flow).

Example.

Evidence for borrowing constraints: Firms' investment is strongly related to their cash flow.

3.1.6 Fixed Costs of Capital Adjustment

Definition 3.1.5: Fixed Costs of Capital Adjustment

In practice, installing new capital is disruptive, leading to a "band of inaction." Firms adjust capital only if the distance between current capital K and optimal capital K^* exceeds a certain threshold.

Example.

Numeric Example: If K is within the band of inaction, firms do not adjust capital. This leads to periods of inaction followed by sudden adjustments when the threshold is crossed.

3.1.7 Time-Varying Price of Capital

Definition 3.1.6: Time-Varying Price of Capital

When the price of capital varies over time, the equilibrium condition for purchasing capital becomes:

$$P_t = \left(\frac{1}{1+r}\right)[MP_{K,t+1} + (1-\delta)P_{t+1}]$$

The price of capital is forward-looking and depends on future marginal products and prices.

Example.

Jorgenson's User Cost of Capital: The user cost of capital is given by:

$$MP_k = r + \delta - \Delta P_K$$

where ΔP_K is the change in the price of capital.

3.1.8 Anticipation Effects

Firms can accelerate or delay investment based on future expectations. For example, anticipation of an investment tax credit (ITC) in the future can reduce current investment.

Example.

Example: The Bush administration's accelerated bonus depreciation in 2001 exacerbated the recession by reducing current investment.

3.1.9 Stock Prices

Definition 3.1.7: Stock Prices

The price of a stock p_t is determined by the present discounted value of future dividends:

$$p_t = \left(\frac{1}{1+r}\right) \sum_{j=0}^{\infty} \frac{D^e_{t+1+j}}{(1+r)^j}$$

This is known as the "fundamental" stock price.

Example.

> Random Walk Hypothesis: At high frequencies (e.g., daily), stock prices should follow a random walk, meaning that expected changes in stock prices are approximately zero:
>
> $$E[p_{t+1} - p_t] \approx 0$$

3.1.10 Performance of Actively Managed Funds

Most actively managed funds cannot outperform stock indices, consistent with the random walk hypothesis.

Example.

> Example: Over a 10-year period, most US large-cap equity funds underperformed the S&P 500 index.

Chapter 4

04 - IS-LM Model of Aggregate Demand

4.1 Loanable Funds Market

- This is the market for Savings & Investment.
- Saving is the supply in loanable funds market.
- Investment is the demand for loanable funds market.

Sources of Saving in the Economy include:

- Private Saving: $S_p = Y - T - C$
- Public Saving: $S_g = T - G$
- Total Saving: $S = S_p + S_g = Y - C - G$

4.1.1 Supply of Saving

- Total saving in the economy $S = Y - C - G$
- Recall our aggregate consumption function:

$$C = C(Y - T, CS, r)$$

- So, aggregate savings is

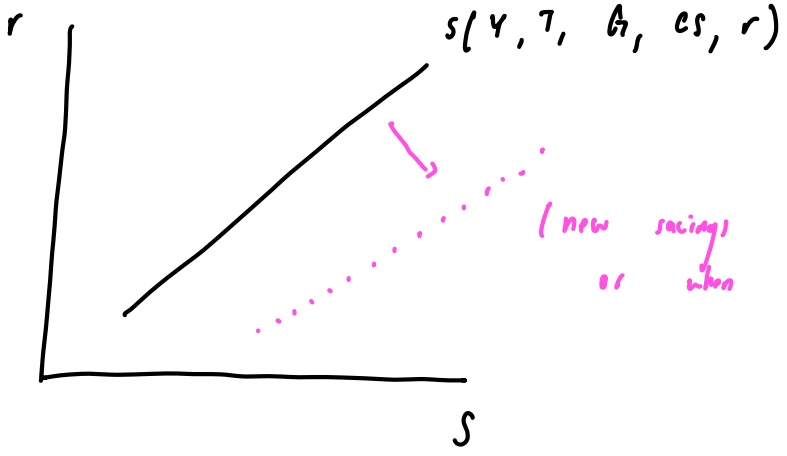
$$S = Y - C(Y - T, CS, r) - G$$

or in functional form

$$S = S(Y(+), T(+), G(-), CS(-), r(+))$$

Supply of Saving

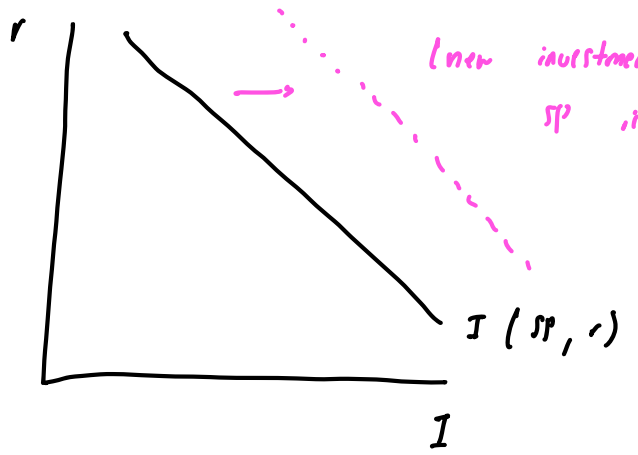
$$S = S(\overset{+}{Y}, \overset{+}{T}, \overset{-}{G_T}, \overset{-}{CS}, \overset{+}{r})$$



(new savings curve when Y or T rise, or when G_T or CS fall)

Demand in Saving : Investment

- Recall our investment function : $I = I(\overset{+}{SP}, \overset{-}{r})$



(new investment demand when SP rises)

Equilibrium in the Savings Market

Recall the National Income Accounting Identity :

$$Y = C + I + G_T + NX$$

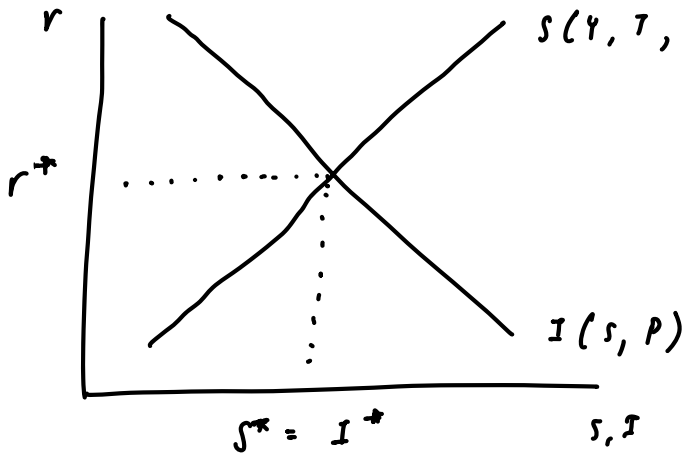
$$Y - C - G_T = I + NX$$

$$S = I + NX$$

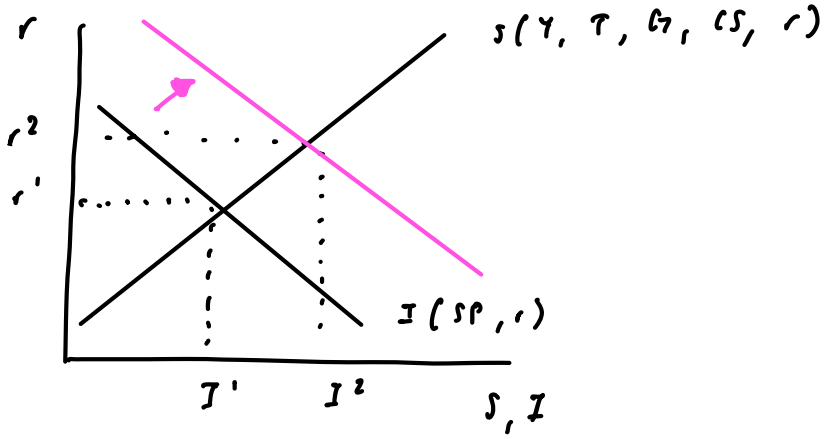
Remember that $S = Y - C - G_T$

Focusing on a closed economy, where $NX = 0$, we have $\boxed{S = I}$

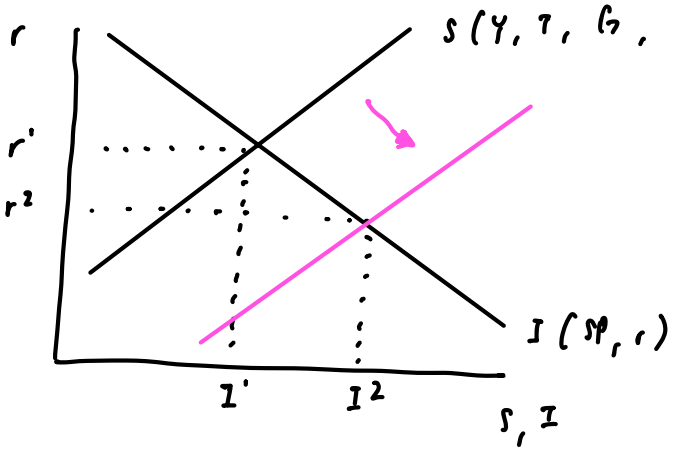
An equilibrium in a savings market is an interest rate that ensures $S = I$, conditional on Y, T, G_T, CS, and SP.



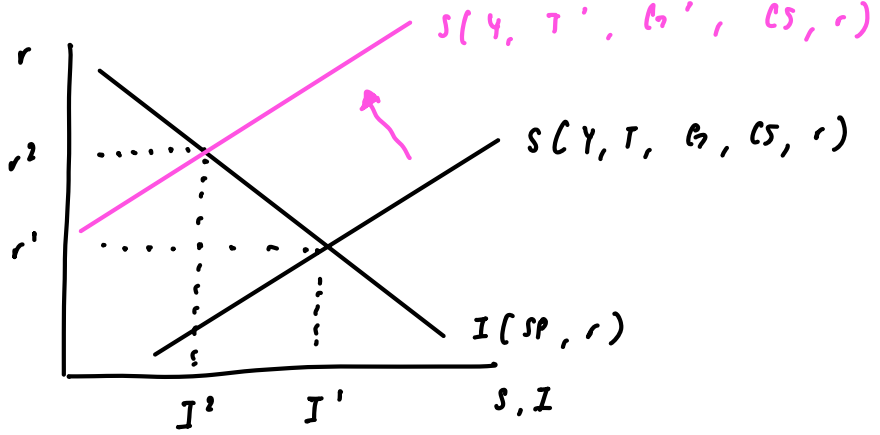
An increase in "animal spirits" increases savings, investment, and the interest rate. Graphically,



A decrease in consumer sentiment raises savings, investment, but lowers interest rate. Graphically,



An equal increase in taxes and government spending decreases saving and investment, but raises the interest rate.



The Dual Role of r

r adjusts to equilibriate the goods market and the loanable funds market simultaneously.

How? ⇒ If loanable funds market is in equilibrium, then

$$Y - C - G = I \quad \text{(saving = investment)}$$

If the goods market is in equilibrium, then

$$Y = C + I + G \quad \text{(goods supply = demand)}$$

Thus, these two are the same rules of the same coin.

4.2 The Classical Model

It shouldn't be surprising that these markets are linked:

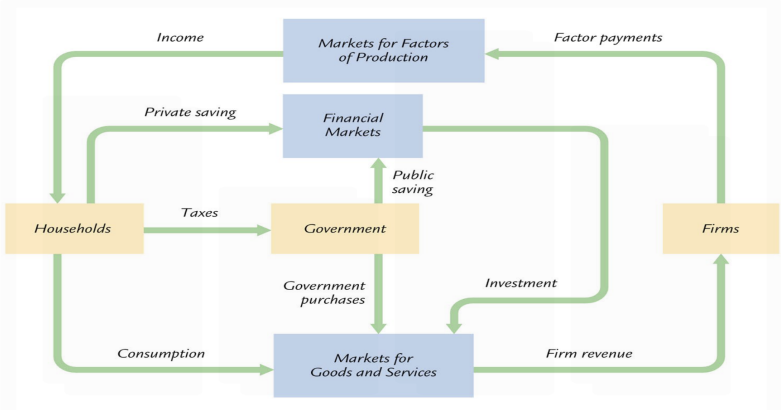


Figure 4.1: In equilibrium, total infows = total outflows for every box.

4.3 The Money Market

Definition 4.3.1: Money

Money is the stock of cash and checkable deposits.

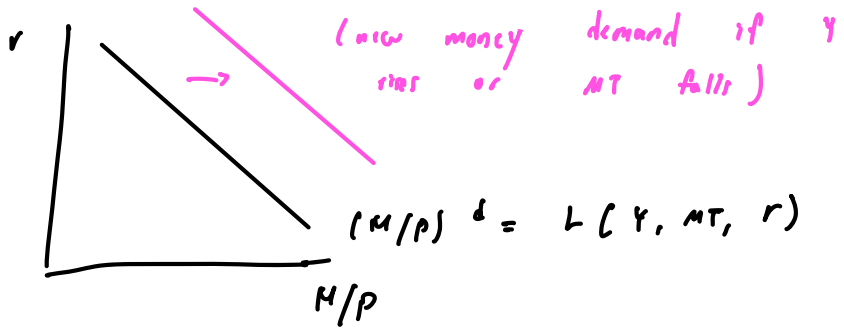
4.3.1 Demand for Real Money Balances

- Demand for real money balances is the amount of wealth that agents want to hold in cash or checking accounts.
- Key factors that affect money demand:
  1. Income: more income, more consumption, hence more cash
  2. Interest rate: opportunity cost to holding money
  3. Technology: some technologies change people's need to hold cash

$$(\frac{M}{P})^d = L(Y, MT, r)$$

Demand for Real Money Balances

$$\left(\frac{M}{P}\right)^d = L(\overset{+}{Y}, \overset{-}{MT}, \overset{-}{r})$$



Supply of Real Money Balances

- The central bank is the agency that controls money supply.
- Money supply is typically adjusted via OPEN-MARKET OPERATIONS: the purchase/sale of bonds in bond markets.
- Bond is a financial instrument that guarantees a certain monetary value in the future.

Suppose the central bank buys a $100 bond in the market.

Money supply goes ↑.

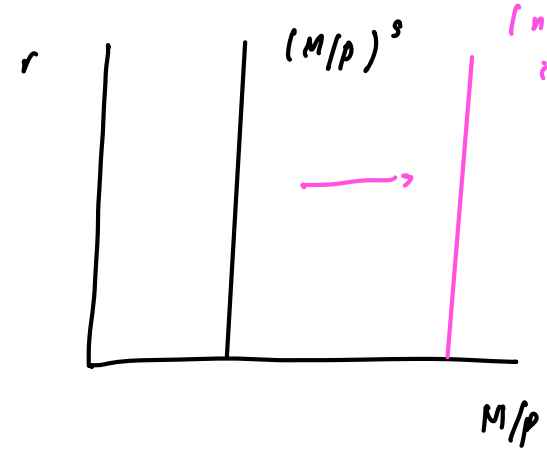
Suppose the central bank sells a $100 bond in the market.

Money supply goes ↓.

The Central Bank's Tools

- There are three standard methods of affecting money supply:
  1) Open-market operations: buy/sell bonds
  2) Reserve Ratio: fraction of liabilities banks hold as reserves
  3) Discount Rate: Interest rates charged by central bank to banks for overnight loans.

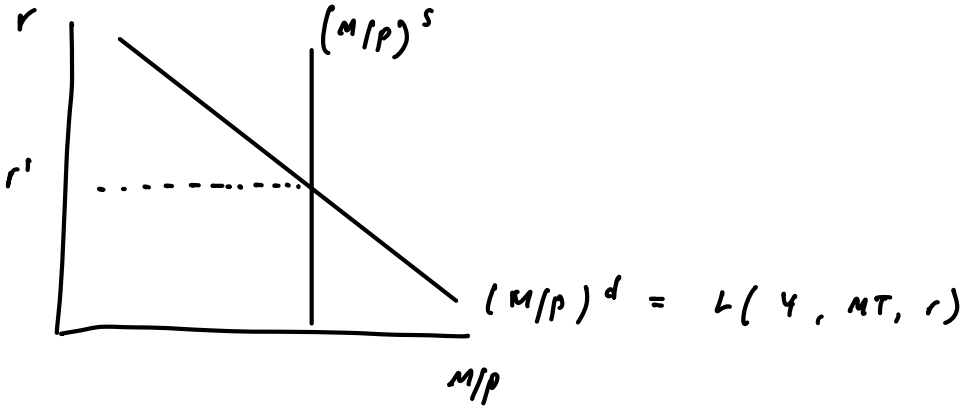
Real Money Supply



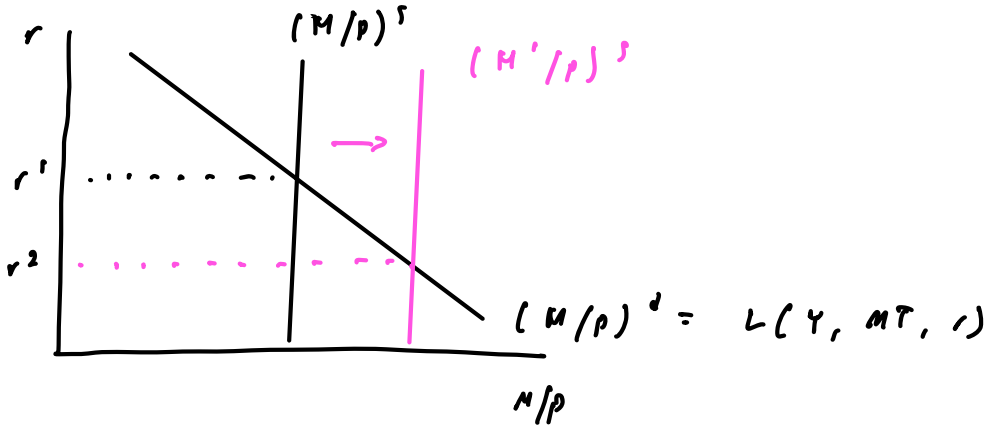
[new real money supply if M rises or P falls]

Equilibrium in Money Market

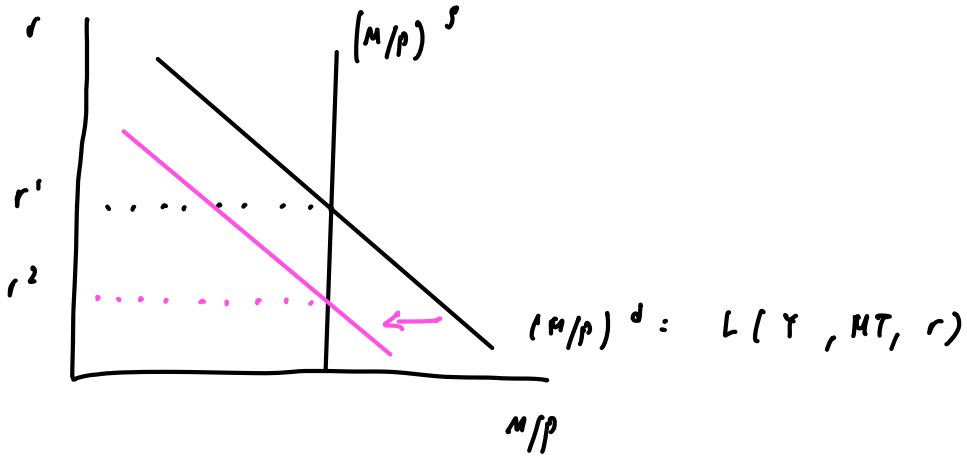
An equilibrium in the money market is an interest rate that ensures $(M/P)^S = (M/P)^d$, on conditions Y, M, MT, and P.



An increase in the money supply pushes the interest rate down:



An increase in the money technology (MT) pushes the interest rate down.


r
(M/P)^s
r'
r^2
(M/P)^d : L(Y, HT, r)
M/P

4.3.2 Summary

We have two markets:

1. *Loanable funds market*: equilibrium interest rate such that $S = I$ given $Y, CS, T, G,$ and SP.
2. *Money market*: equilibrium interest rate such that real money supply is equal to real money demand given $Y, P, M,$ and MT.

Each market yields equilibrium interest rate *conditional* on Y. But output is an *endogenous variable*. ***Both the interest rate and output will adjust to ensure equilibrium in both markets***.

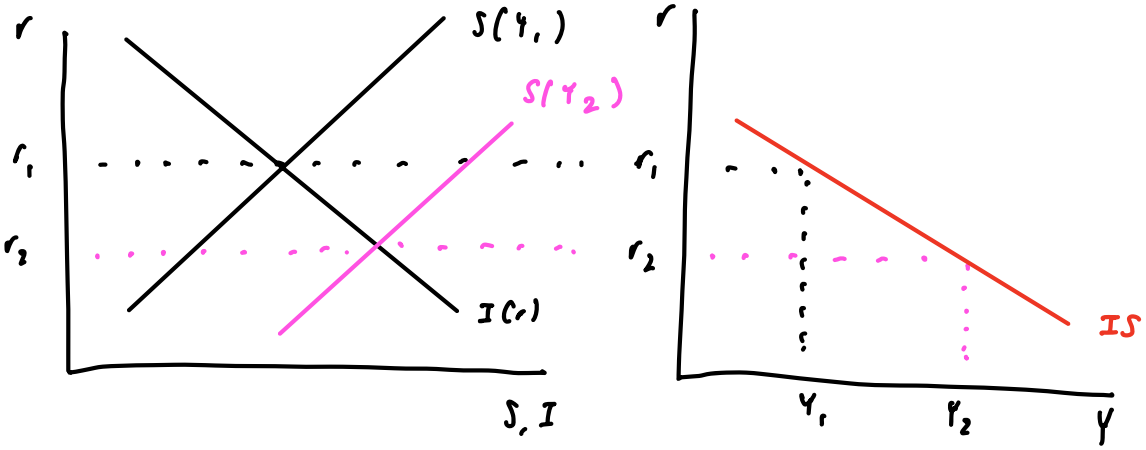
4.4 Graphs & Aggregate Supply & Aggregate Demand

Remark.

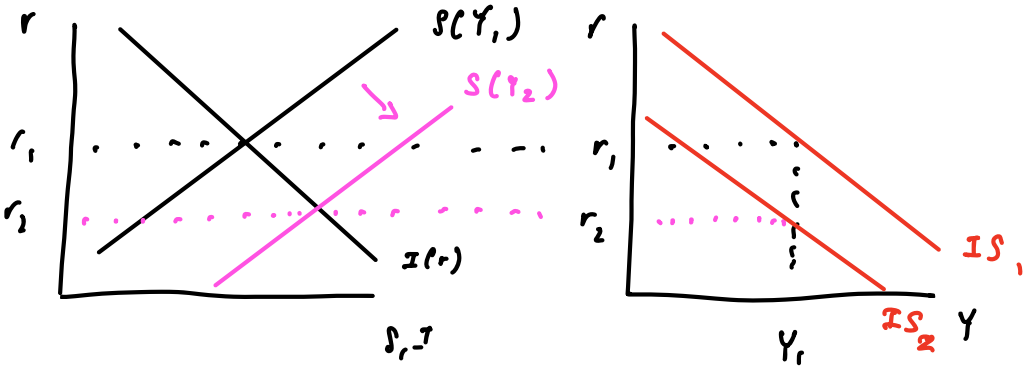
Continued on next page.

IS Curve

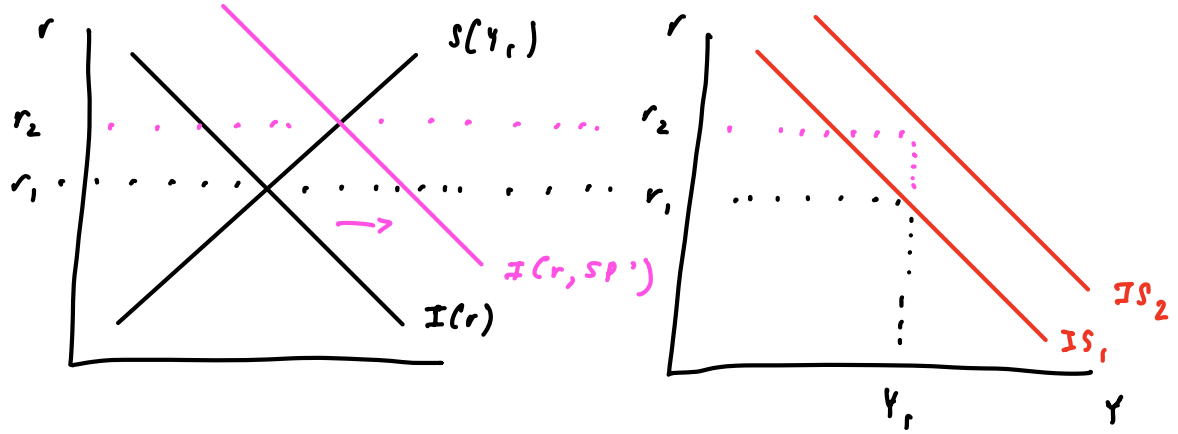
The IS curve summarizes the equilibrium interest rate that clears the savings market for different levels of output.



If T goes up, or if PT or PS goes down, the savings curve shifts right, causing the IS curve to shift down (left).

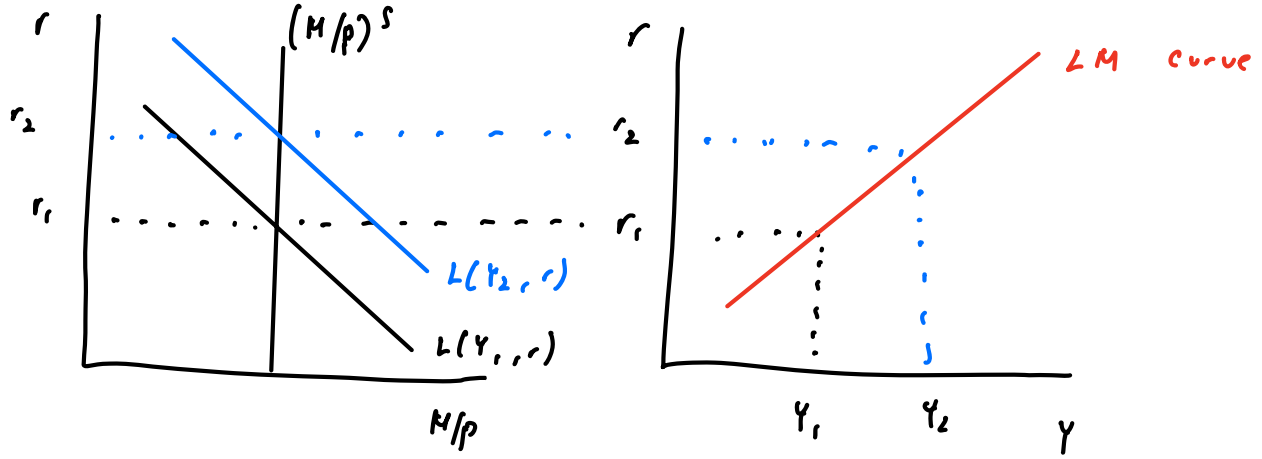


If "Animal Spirits" (SP) goes up, the investment curve shifts right, causing the IS curve to shift up (right).

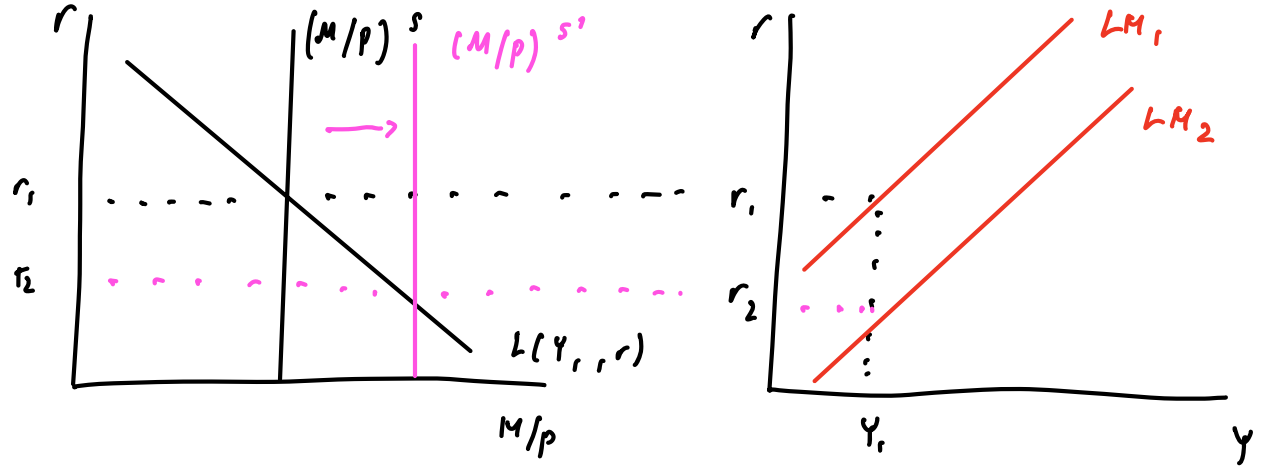


LM Curve

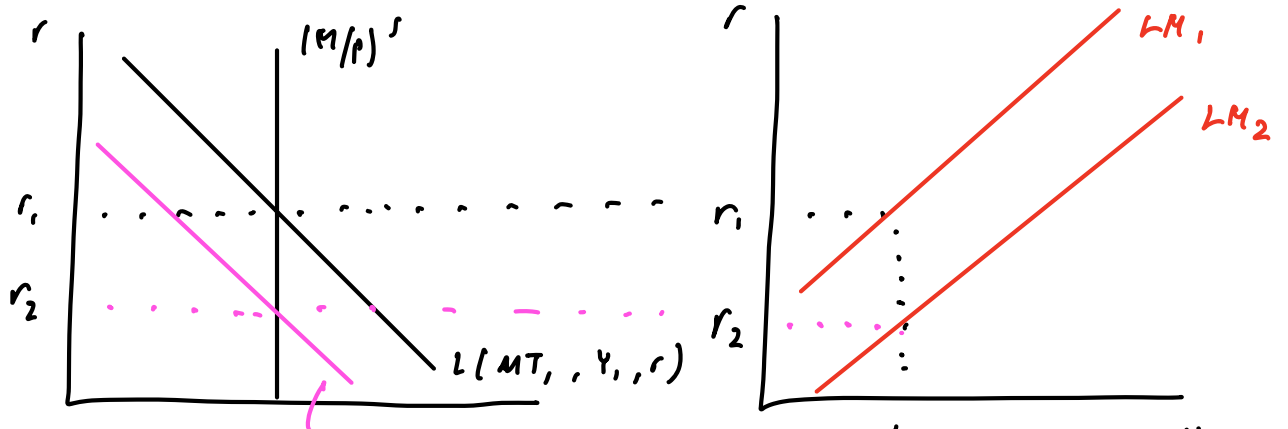
The LM curve summarizes the equilibrium interest rate that clears the money market for different levels of output.



If nominal money supply (M) rises or if prices (P) fall, real money supply expands, pushing interest rates and the LM curve down.



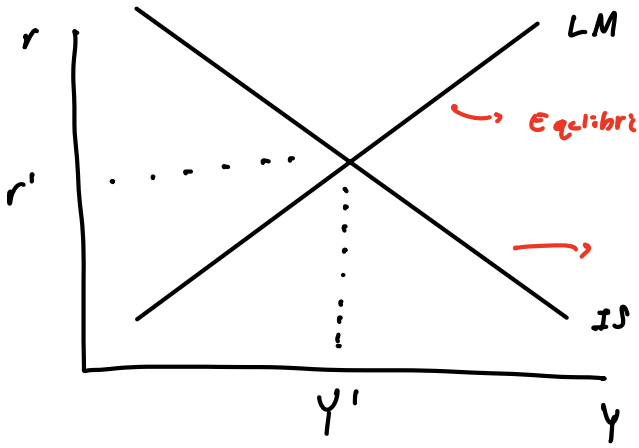
If money technology (MT) rises, then money demand falls, pushing the interest rate down and shifting the LM curve down.



$L(MT_2, Y_1, r)$ M/P Y_1 Y

Equilibrium of the IS-LM Model

An IS-LM equilibrium is a (r^*, Y^*) such that both loanable funds market and the money market clear, given SP, CS_r, T, G, M, P, and MT.



→ Equilibrium in Financial Markets

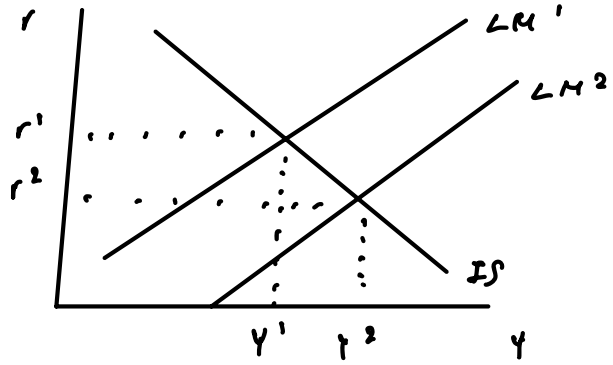
→ Equilibrium in Goods Market

Comparative Statics in the IS-LM Model

Suppose the money supply (M) rises: Expansionary

Note that r goes down and Y goes up.

What about C and I?



1) Investment (I)

$I = I(\overset{+}{SP}, \overset{-}{r})$

If r goes down and SP is unchanged, investment must rise.

2) Consumption (C)

$C = C(\overset{+}{Y - T}, \overset{+}{CS}, \overset{-}{r})$

If Y goes up and r goes down, the change in consumption must be positive.

M going up pushes interest rates down, which increases investment and consumption, thereby raising output.

Chapter 5

05 - Aggregate Supply

5.1 Labor Market Equilibrium and Aggregate Supply

5.1.1 Introduction to Aggregate Supply

Definition 5.1.1: Aggregate Supply

The relationship between the price level and the quantity of output supplied in the economy. It is derived from the labor market equilibrium, where labor demand (based on firm profit maximization) and labor supply (based on reservation wages) interact.

Long-Run vs. Short-Run Aggregate Supply

Definition 5.1.2: Long-Run Aggregate Supply (Neoclassical)

In the long run, output is independent of prices. The long-run aggregate supply curve is vertical.

Definition 5.1.3: Short-Run Aggregate Supply (Keynesian)

In the short run, higher prices require higher output to clear the labor market. The short-run aggregate supply curve is upward-sloping.

5.1.2 US Labor Market Stylized Facts

Example.

Average Monthly Flows

The flows of workers in and out of employment, unemployment, and non-participation are large. The average duration of unemployment is about 3 months.

Example.

Unemployment Rate and Job Finding

When unemployment is high, the proportion of unemployed finding jobs is low.

Example.

Unemployment Rate and Job Separation

When unemployment is high, a higher proportion of workers lose their jobs.

5.2 Labor Demand

5.2.1 Production Function

Definition 5.2.1: Production Function

The relationship between inputs (capital and labor) and output. For a firm, the production function is given by:

$$Y = AK^{\alpha}N^{1-\alpha}$$

where Y is output, A is total factor productivity, K is capital, N is labor, and α is the output elasticity of capital.

Marginal Product of Labor

Definition 5.2.2: Marginal Product of Labor (MP_N)

The additional output produced by one more unit of labor:

$$MP_N = (1-\alpha)AK^{\alpha}N^{-\alpha}$$

5.2.2 Demand Curve

Definition 5.2.3: Demand Curve

The relationship between the price level and the quantity of output demanded. For a firm, the demand curve is given by:

$$P = Y^{-\mu/(1+\mu)}$$

where μ is the degree of competitiveness ($\mu = 0$ for perfect competition).

Marginal Revenue

Definition 5.2.4: Marginal Revenue (MR)

The additional revenue from selling one more unit of output:

$$MR = \left(\frac{1}{1+\mu}\right) P$$

5.2.3 Marginal Cost of Production

Definition 5.2.5: Marginal Cost (MC)

The cost of producing one more unit of output:

$$MC = \frac{W}{MP_N} = \frac{W}{(1-\alpha)AK^{\alpha}N^{-\alpha}}$$

5.2.4 Profit-Maximizing Condition

Definition 5.2.6: Profit-Maximizing Condition

Firms maximize profit by setting marginal revenue equal to marginal cost:

$$MR = MC \iff P = (1+\mu)MC$$

5.2.5 Labor Demand Curve

Definition 5.2.7: Labor Demand Curve

The relationship between the real wage and the quantity of labor demanded:

$$\frac{W}{P} = \frac{1}{1+\mu} MP_N$$

The labor demand curve shifts out if A or K increases, or if μ decreases.

5.3 Labor Supply

5.3.1 Individual Labor Supply

Definition 5.3.1: Labor Supply

The relationship between wages and the quantity of labor supplied by individuals. It is influenced by the income effect (higher wages may lead to less work) and the substitution effect (higher wages may lead to more work).

Backward-Bending Labor Supply Curve

Definition 5.3.2: Backward-Bending Labor Supply Curve

At low wages, the substitution effect dominates, and labor supply increases with wages. At high wages, the income effect dominates, and labor supply decreases with wages.

5.3.2 US Labor Market Trends

Example.

Real Compensation and Hours

In the long run, the income effect slightly dominates, leading to a slight decrease in average weekly hours worked as real compensation increases.

5.3.3 Intensive vs. Extensive Margin

Definition 5.3.3: Intensive Margin

Changes in total hours worked due to changes in hours worked by employed individuals.

Definition 5.3.4: Extensive Margin

Changes in total hours worked due to changes in the number of people entering or leaving the labor force.

5.3.4 Infinite Elasticity of Labor Supply

Definition 5.3.5: Infinite Elasticity of Labor Supply

An assumption that labor supply is perfectly elastic, meaning that workers are willing to supply any amount of labor at a given wage. This can be justified by wage contracts or high elasticity along the extensive margin.

5.3.5 Shifts in Labor Supply

Definition 5.3.6: Labor Supply Shifts

The labor supply curve shifts due to changes in expected prices (P^e/P) or reservation wages (z):

$$\frac{W}{P} = z\frac{P^e}{P}$$

5.4 Labor Market Equilibrium

5.4.1 Equilibrium in the Labor Market

Definition 5.4.1: Labor Market Equilibrium

The real wage $(W/P)^*$ and employment level N^* where labor supply equals labor demand.

5.4.2 Comparative Statics

Example.

Increase in Marginal Product of Labor

An increase in A or K, or a decrease in μ, shifts the labor demand curve out, increasing employment.

Example.

Increase in Expected Prices or Reservation Wages

An increase in P^e/P or z shifts the labor supply curve up, decreasing employment.

5.5 Aggregate Supply Curve

5.5.1 Short-Run Aggregate Supply (SRAS)

Definition 5.5.1: Short-Run Aggregate Supply (SRAS)

In the short run, higher prices lead to higher output as firms increase production to meet demand. The SRAS curve is upward-sloping.

5.5.2 Long-Run Aggregate Supply (LRAS)

Definition 5.5.2: Long-Run Aggregate Supply (LRAS)

In the long run, output is determined by factors such as technology, capital, and labor supply, and is independent of prices. The LRAS curve is vertical.

Natural Level of Output

Definition 5.5.3: Natural Level of Output

The level of output consistent with long-run equilibrium in the labor market:

$$Y_n = A^{1/\alpha} K \left[\frac{1-\alpha}{z(1+\mu)} \right]^{(1-\alpha)/\alpha}$$

5.5.3 Shifts in Aggregate Supply

What happens if z increases?

Example.

> An increase in z shifts both the SRAS and LRAS curves left, reducing output, and increasing the natural rate of unemployment.

5.6 Natural Rate of Unemployment

5.6.1 Definition

Definition 5.6.1: Natural Rate of Unemployment

The unemployment rate consistent with long-run equilibrium in the labor market:

$$U^n = 1 - \left[\frac{(1-\alpha)}{z(1+\mu)}\right]^{1/\alpha} A^{1/\alpha}\left(\frac{K}{L}\right)$$

5.6.2 Factors Affecting the Natural Rate

Example.

> High z

High reservation wages (z) are associated with a high natural rate of unemployment.

Example.

> High Regulation

High regulation (high μ) is correlated with a high natural rate of unemployment.

Example.

> High Real Interest Rates

High real interest rates, which reduce the capital-labor ratio (K/L), are associated with a high natural rate of unemployment.

5.7 Phillips Curve

5.7.1 Short-Run Phillips Curve

Definition 5.7.1: Short-Run Phillips Curve

The negative relationship between inflation and unemployment in the short run:

$$\pi = \pi^e - \alpha(u - u^n)$$

where π is inflation, π^e is expected inflation, u is the unemployment rate, and u^n is the natural rate of unemployment.

5.7.2 Long-Run Phillips Curve

Definition 5.7.2: Long-Run Phillips Curve

In the long run, inflation equals expected inflation, and the unemployment rate equals the natural rate. The long-run Phillips curve is vertical:

$$u = u^n$$

5.7.3 Empirical Evidence

Example.

US Phillips Curve

The US Phillips Curve shows a negative relationship between inflation and unemployment, especially when controlling for expected inflation and the natural rate of unemployment.

5.8 Extension to Raw Materials

5.8.1 Production Function with Raw Materials

Definition 5.8.1: Production Function with Raw Materials

A generalized production function that includes raw materials (O):

$$Y = AK^{\alpha}N^{\beta}O^{1-\alpha-\beta}$$

where $0 < \alpha, \beta < 1$.

5.8.2 Profit-Maximizing Condition

Definition 5.8.2: Profit-Maximizing Condition with Raw Materials

Firms optimize by setting the marginal cost of using raw materials equal to the marginal cost of using labor:

$$\frac{MC_O}{MP_O} = \frac{MC_N}{MP_N}$$

5.8.3 Effect of Raw Material Prices

Example.

- Increase in Raw Material Prices

An increase in the price of raw materials (P_O) leads to a decrease in both labor demand and output, shifting the SRAS and LRAS curves left and increasing the natural rate of unemployment.

5.8.4 Empirical Evidence

Example.

- Oil Prices and Unemployment

There is a positive correlation between real oil prices and the moving average of unemployment rates in the US from 1948 to 2007.

Chapter 6

06 - Evaluating Business Models

6.1 Evaluating the Model

This document provides an overview of how economists evaluate macroeconomic models, particularly focusing on comparing model predictions to real-world data in response to various shocks. We also discuss different identified shocks, such as *monetary policy shocks* and *government spending shocks*, and examine how well the models align with observed economic outcomes. Finally, we explore possible sources of recessions and review Lucas's calculation of the costs of business cycles.

6.1.1 Business Cycle Analysis

Business cycle analysis involves:

- Assessing the validity of a macroeconomic model by comparing the model's predictions to observed data after a specified shock.
- Applying the model to understand which shocks drive real-world business cycle fluctuations.
- Using the model to predict how policymakers can or should respond to business cycle fluctuations.

Definition 6.1.1: Business Cycle

A pattern of economic expansions and recessions. In the modern view, actual output fluctuates around its *natural level*, and these deviations are what we refer to as business cycles.

6.2 Assessing the Validity of the Model

One common approach to evaluating a macroeconomic model is based on the **Robert Lucas criterion**:

1. Identify a shock in the real world and measure how the economy responds to that shock.
2. Apply the same shock to the model and see what response the model predicts.
3. Compare the model's predicted response with the actual response. If they match closely, we gain confidence in the model's usefulness.

Limitations of this approach:

- It is typically very hard to identify shocks in the real world precisely.
- Matching the model's response to one particular shock does not guarantee that it will match responses to other, potentially more important, shocks.

6.3 Identified Shocks: Monetary Policy

6.3.1 Monetary Policy Shocks

Definition 6.3.1: Monetary Policy Shock

An unexpected change in the stance of monetary policy that is not anticipated by economic agents, often measured by changes in interest rates or the money supply that deviate from what markets had forecast.

Macroeconomists have devoted substantial effort to studying monetary policy shocks to test the principle of **monetary neutrality**. Several methods exist for identifying such shocks:

1. **Narrative approach** (Romer and Romer, 1989).
2. **Statistical methods** (Christiano et al., 1999).
3. **Natural experiments** (Friedman and Schwartz, 1963).
4. **Financial markets** (using federal funds futures to extract unanticipated components of policy announcements).

Example.

> **Example of high-frequency identification:** By examining changes in federal funds futures prices immediately following Federal Open Market Committee (FOMC) press releases (within minutes or hours), we can isolate unforecastable policy shocks.

6.3.2 Short-Run and Long-Run Responses to a Monetary Policy Shock

Empirical studies typically show the following qualitative responses after a contractionary monetary policy shock (i.e., an increase in interest rates or reduction in the money supply):

- **Money Supply (M2):** Decreases in the short run, tending to stabilize to zero effect in the long run.
- **Interest Rate (Fed Funds Rate):** Increases in the short run, often returns to neutral (no effect) in the longer run.
- **Production (Industrial Production):** Decreases in the short run, returns to its original trend in the long run (zero net effect).
- **Prices (e.g., PPI):** Often little immediate response (in the data), but eventually a decline in the long run.
- **Employment:** Decreases in the short run, returns to trend in the long run.
- **Unemployment:** Increases in the short run, returns to trend in the long run.
- **Consumption:** Decreases in the short run, returns to trend in the long run.
- **Investment:** Decreases in the short run, returns to trend in the long run. Housing (residential investment) often accounts for a large share of this decline.
- **Real Wages:** Tends to decrease in the short run, with little net effect in the long run.

6.3.3 Model Versus Data: Key Observations

Comparisons of a standard Aggregate Supply–Aggregate Demand (AS–AD) model to observed data reveal:

1. The empirical price level often does not respond immediately to monetary policy shocks (sticky prices), whereas a simple AS–AD model predicts an immediate price movement.
2. The data suggest that **housing investment** is strongly affected, whereas the simplest version of the model might treat **firm investment** as the main driver.
3. In the real world, real wages tend to go down after a contractionary shock, whereas some simple models predict they go up.

6.3.4 Sticky Prices and Model Refinements

How macroeconomists respond: If the data show that prices do not instantly adjust, we alter the model to incorporate *sticky prices*. In the short run, the price level does not immediately move; thus firms may produce just enough to meet demand at the existing price. When a monetary contraction reduces aggregate demand, output and employment fall, while the nominal price may remain temporarily fixed.

Definition 6.3.2: Sticky Prices

A situation in which prices do not adjust instantly to changes in economic conditions, often due to menu costs, contractual agreements, or other frictions.

6.4 Identified Shocks: Government Spending

6.4.1 Government Spending Shock

Historically, one of the largest identifiable government spending shocks was **World War II**. During WWII, government spending (G) rose substantially over a relatively short period, providing a "natural experiment" for analyzing fiscal policy.

Example.

> **Example (WWII data):**
>
> - **Government Spending (G):** Rose dramatically.
> - **Output (GDP):** Increased significantly.
> - **Prices:** Rose.
> - **Investment:** Decreased sharply (crowded out by war spending).
> - **Consumption:** Fell somewhat.
> - **Real Interest Rates:** Stayed elevated for a sustained period from 1942–1946.

6.4.2 Short-Run Model Predictions for a Government Spending Shock

- **Prices:** Should rise.
- **Output:** Should rise.
- **Consumption:** Could rise or fall, depending on the specific model. Historically, consumption dropped only a little during WWII.
- **Investment:** Falls because of **crowding out** (higher government spending raises interest rates, which makes private investment more expensive).
- **Interest Rate:** Tends to rise because of increased demand for funds.

Definition 6.4.1: Crowding Out

A phenomenon where increased government spending (financed by borrowing) leads to higher interest rates, thereby reducing private investment.

Because WWII spending was ultimately temporary, many longer-run implications cannot be directly compared with standard steady-state model predictions.

6.5 Possible Sources of Recessions

6.5.1 Overview

Economists often debate what triggers recessions. Two main possibilities discussed in these slides are:

1. Diminished expectations (shifts in consumer sentiment and *animal spirits*).
2. Contractionary monetary policy induced by the central bank.

6.5.2 Possibility 1: Diminished Expectations

- Both consumer sentiment (affecting consumption) and **animal spirits** (affecting investment) may decline together.
- Consumption of durables and residential investment often fall even before a recession officially starts.
- This can explain simultaneous declines in consumption, investment, and interest rates under a **demand-side** interpretation.
- The drawback is explaining why consumer sentiment and animal spirits fall in the first place.

Definition 6.5.1: Animal Spirits

A term coined by John Maynard Keynes referring to the emotional and psychological drivers of consumer or investor decisions—essentially, waves of optimism or pessimism.

6.5.3 Possibility 2: The Fed Did It

Many economists argue that **Federal Reserve policy** aiming to control inflation can induce downturns:

- Historically, recessions in the United States often follow substantial interest rate hikes.
- Monetary policy changes have delayed effects, which could explain why a rate hike now leads to lower output in subsequent quarters.
- Empirically, a typical **monetary policy shock** in the short run involves:
  - Higher interest rates.
  - Lower output.
  - Lower employment.
  - Little immediate effect on the price level, but eventually lower prices.

6.6 What Is a Business Cycle?

In a modern view, total output (Y) fluctuates around its **natural level** over time. Short-term shocks may push actual output above or below this natural level, creating *booms* or *recessions*. The **cost** of business cycles, in this framework, is the loss in welfare (or utility) when output dips below what would have been produced in the absence of these shocks.

6.7 Lucas's Calculation of the Costs of Business Cycles

Definition 6.7.1: Lucas's Approach

A method devised by Robert Lucas to estimate how much society would be willing to pay (in terms of forgone consumption) to eliminate the fluctuations caused by the business cycle.

- Lucas used a **second-order Taylor expansion** of utility around its mean to estimate the welfare cost.
- With plausible parameter values, Lucas found that the welfare cost of eliminating business cycles may be quite small—on the order of a fraction of one percent of average consumption.

Example.

> **Interpretation:** Even though recessions are painful, when spread over a long time horizon, the cost of consumption volatility might be modest compared to the cost of sustained reductions in the average growth rate.

6.8 Conclusion

Evaluating macroeconomic models requires comparing their predictions with real-world data for specific, identifiable shocks. Empirical findings show that monetary and fiscal shocks can significantly affect output, employment, and prices in the short run. Nevertheless, the **long-run** effects often revert to zero changes in levels of output, employment, and real wages, suggesting that much of the debate centers on short-run dynamics and the *frictions* (such as sticky prices) that slow adjustment.

Furthermore, identifying the causes of recessions remains a core challenge in macroeconomics. While diminished expectations and policy-induced contractions are two popular explanations, it is often the interplay of multiple shocks—demand-side, supply-side, or policy-related—that drive business cycles.

Overall, these insights shape how policymakers decide to respond to or preempt fluctuations, and they inform the ongoing refinement of theoretical frameworks that aim to capture the true complexities of the economy.