ECONOMIC GROWTH

- Understand what causes differences in income over time and across countries
- Sources of economy’s output: factors of production (K, L) and production technology
  → differences in income must come from differences in K, L, and technology
- The Solow-Swan model shows how saving, population growth, and technological progress affect the level of an economy’s output and its growth over time

1. THE ACCUMULATION OF CAPITAL

- How the supply and demand for goods and services determine the accumulation of capital

   (1) The Supply of Goods and the Production Function

- Aggregate production function: \( Y=F(K,L) \)
  1) Constant Returns to Scale
     → allow us to analyze all quantities relative to the size of the labor force
     → \( y=f(k) \)
       where \( y= Y/L \): output per worker
       \( k= K/L \): capital per worker
       \( f(k)=F(K/L, I) \): capital per worker
  2) Positive Marginal Product
     → \( MPK=f(k+I) - f(k) > 0 \)
3) Diminishing Marginal Product

when k is low $\rightarrow$ the average worker has only a little capital to work with, so an extra unit of capital is very useful and produces a lot of additional output

when k is high $\rightarrow$ the average worker has a lot of capital to work with, so an extra unit of capital increases production only slightly

(2) The Demand for Goods and the Consumption Function

- Demand (No gov’t, closed economy): $y = c + i$
- Consumption per person: $c = (1-s)y$, $s = \text{saving rate}$

$\Rightarrow i = sy = sf(k)$  [figure 7-2, p.184]

- $s$ is also the fraction of output devoted to investment
- Allocation of output between consumption and saving is determined by saving rate $s$

(3) Growth in the Capital Stock and the Steady State

- Capital stock is a key determinant of the economy’s output
- Change in capital stock $\Rightarrow$ economic growth
  1) Investment: expenditure on new plant and equipment
  2) Depreciation: wearing out of old capital

$\Rightarrow \Delta k = i - \delta k = sf(k) - \delta k$

- Steady-state level of capital ($k^*$):  [figure 7-4, p.186]

$\Rightarrow \Delta k = 0 \text{ at } k^*$
→ “Long-run equilibrium of the economy”

- Stability of a steady-state $k^*$
  Investment $> \text{depreciation} \rightarrow k \uparrow$
  Investment $< \text{depreciation} \rightarrow k \downarrow$

  Once the capital stock reaches the steady state, investment equals depreciation, and there is no pressure for the capital stock to change

- A numerical example
  \[ Y = K^{1/2}L^{1/2}, \ s = 0.3, \ \delta = 0.1 \rightarrow k^* = ? \]

(4) How Saving Affects Growth

- Different saving rates $\rightarrow$ international differences in output?
- An increase in saving rate
  $s \uparrow \rightarrow \text{Investment} > \text{depreciation} \rightarrow k \uparrow$ until the economy reaches the new steady-state $k^*$
- Saving rate is a key determinant of the steady-state capital stock
  $\rightarrow$ If $s$ is high (low), the economy will have a large (small) capital stock and a high (low) level of output
- Persistent gov’t budget deficits reduce national saving and crowd out investment $\rightarrow$ lower capital stock $\rightarrow$ lower national income
- Problem: “temporary” effect on growth rate
  $\rightarrow$ high rate $s$ of saving lead to high growth temporarily, but the economy eventually approaches a steady state in which capital and output are constant
  $\rightarrow$ **CANNOT** explain sustained economic growth
2. The Golden Rule Level of Capital

- Is higher saving always good?
- Optimal amount of capital accumulation from the standpoint of economic well-being

(1) Comparing Steady State

- Assume that a benevolent policy maker can set the economy’s saving rate at any level, thus steady-state \( k^* \)
- Choose \( k^* \) with the highest level of consumption → “Golden Rule Level of Capital” (\( k^* \))
- Since \( c = y - i \), steady-state consumption is
  \[
  c^* = f(k^*) - \delta k^*
  \]
- An increase in \( k^* \) has two opposing effects
  - More output
  - Replacement of capital that is wearing out
- If \( k < k^g \), \( k \uparrow \) will raise output more than depreciation, so that consumption rise → the production function is steeper than the \( \delta k^* \) line
- Therefore, at the Golden Rule level of capital, the production function and the \( \delta k^* \) line have the same slope, and consumption is at its greatest level → \( MPK = \delta \)
- A numerical example
  \[
  Y = K^{1/2}L^{1/2}, \quad \delta = 0.1 \rightarrow s = ? \text{ for } k^g
  \]

(2) Transition to the Golden Rule Steady State

- Starting with too much capital
- Starting with too little capital
3. Population Growth

- Another possibility of the sustained growth?
- The rate of population growth = n (US: 1%)

(1) The Steady State with Population Growth

- The growth in the number of workers causes capital per worker to fall
  \[ \Delta k = i - (\delta + n)k = sf(k) - (\delta + n)k \]
- \((\delta + n)k\) = break-even investment: the amount of investment necessary to keep the capital stock per worker constant
  Note that \(nk\) is the amount of investment necessary to provide new workers with capital
- Steady-state level of capital \((k^*)\): [figure 7-11, p.201]
  \[ \Delta k = 0 \text{ at } k^* \]
- Stability of a steady-state \(k^*\)
  Investment > break-even investment \(\Rightarrow k \uparrow\)
  Investment < break-even investment \(\Rightarrow k \downarrow\)

(2) The Effect of Population Growth

- In the steady state, \(k\) and \(y\) are constant
  \(\Rightarrow\) **CANNOT** explain sustained economic growth
- However, \(K\) and \(Y\) must also growing at rate \(n\)
  \(\Rightarrow\) **CAN** explain sustained growth in total output
- An increase in population growth [figure 7-12, p.202]
  \(\Rightarrow\) Countries with higher population growth will have lower levels of GDP per person
- Golden Rule (consumption-maximizing) level of capital
  \(\Rightarrow MPK - \delta = n\)
4. Technological Progress in the Solow-Swan Model

- Introduce exogenous technological progress, which over time expands society’s ability to produce

(1) The Efficiency of Labor

- Labor-augmenting aggregate production function:
  \[ Y = F(K, E* L) \]
- \( E \) is the efficiency of labor or a society’s knowledge about production method and grows at some constant rate \( g \)
- \( E* L \) is the number of effective workers and grows at rate \( n + g \)

(2) The Steady State with Technological Progress

- Let \( k = K/(E* L) \) be capital per effective worker and
  \( y = f(k) = Y/(E* L) \) be output per effective worker
- The evolution of \( k \) over time
  \[ \Delta k = i - (\delta + n + g)k = sf(k) - (\delta + n + g)k \]
- Break-even investment
  1) \( \delta k \) : replace depreciating capital
  2) \( nk \) : provide capital for new workers
  3) \( gk \) : provide capital for new effective workers created by technological progress
- Steady-state level of capital \( (k^*) \): [figure 8-1, p.209]
  \[ \Delta k = 0 \text{ at } k^* \]
(3) The Effect of Technological Progress

- In the steady state, \( K/(EL) \) and \( Y/(EL) \) are constant
- However, \( Y/L \) grows at rate \( g \) and \( Y \) grows at rate \( g+n \)
  \( \Rightarrow CAN \) explain sustained growth in total output!
- Golden Rule (consumption-maximizing) level of capital
  \( \Rightarrow MPK - \delta = n + g \)

5. Policies to Promote Growth

(1) Evaluating the Rate of Saving

- Is US economy at, above, or below the Golden rule steady state?
- Facts
  Rate of real GDP growth=3% \((n+g)\)
  Capital stock=2.5*GDP
  Depreciation =10% of GDP
  Capital income =30% of GDP
  \( \Rightarrow MPK - \delta = 8\% > n + g = 3\% \)
- Capital stock in the US economy is well below the Golden rule level
- Changing the rate of saving

(2) Allocating the Economy’s Investment

- Physical capital or Human capital?
- Human capital: the knowledge and skills that workers acquire through education
- Technological externality (knowledge spillover) \( \Rightarrow \) the social returns to capital exceed the private returns, and the benefits of increased capital accumulation to society are greater than the Solow model suggests
(3) **Encouraging Technological Progress**
- The Solow model takes technological progress as exogenous
  → Determinants of technological progress?

6. **FROM GROWTH THEORY TO GROWTH EMPIRICS**

(1) **Balanced Growth**
- Technological progress causes the values of many variables to rise together in the steady state
- The Solow model’s prediction is consistent with LR data for the US economy
  → $Y/L$ and $K/L$ grow at the rate of technological progress

(2) **Convergence (Catch-up)**
- Economies converge over time?
- Little evidence of (absolute) convergence: countries that start off poor do not grow faster on average than countries that start off rich
- The economies of the world appear to be converging to their own steady states, which in turn are determined by saving, population growth, and education
  → Conditional convergence

(3) **Factor Accumulation Versus Production Efficiency**
- International differences in income per person can be attributed to
  1) Differences in the factors of production
  2) Differences in the efficiency
→ 1) and 2) are positively correlated: countries with high levels of physical and human capital also tend to use those factors efficiently

7. **Beyond the Solow Model: Endogenous Growth Theory**

*Where does technological progress come from?*

(1) **Basic Model (the AK model)**
- Aggregate production function: \( Y = A \times K \),
  Where \( A \) is a constant measuring the amount of output produced for each unit of capital
- No diminishing marginal products
- Since \( \Delta K = sY - \delta K \), \( \Delta Y / Y = \Delta K / K = sA - \delta \)
  \( \rightarrow \) As long as \( sA > \delta \), income grows forever, even without exogenous tech. Progress
  \( \rightarrow \) Saving and investment can lead to persistent growth
- Interpret \( K \) more broadly

(2) **The Microeconomics of Research and Development**
- Try to explain the decisions that determine the creation of knowledge through R&D
  - Profit motive
  - Temporary monopoly
  - Creative destruction
MONEY AND INFLATION

1. What is Money?

- Definition: the stock of assets that can be readily used to make transaction

- The functions of money
  • Store of value: a way to transfer purchasing power from the present to the future
  • Unit of account: the terms in which prices are quoted and debts are recorded
  • Medium of exchange: what we use to buy goods and services (liquidity)

- The types of money
  • Fiat money: money that has no intrinsic value e.g., dollar bills
  • Commodity money: money that has intrinsic value e.g., gold
    \[ \Rightarrow \] Using raw gold as money is costly

- How the quantity of money (Money Supply) is controlled \[ \Rightarrow \] monetary policy
  • Delegated to a partially independent institution
  • US: Federal Reserve (Fed), Federal Open Market Committee
- Open market operation: the purchase and sale of government bonds
e.g., buy bonds from the public $\Rightarrow M^S \uparrow$

- How the quantity of money is measured (table 4-1, p.81)

2. The Quantity Theory of Money

$\Rightarrow$ How the quantity of money affects the economy

- Transactions and the quantity equation

  • Quantity equation: the link b/t transactions and money

  $\Rightarrow M \times V = P \times T$

  1) $M$: the quantity of money

  2) $V$: the transaction velocity of money
     (measures the rate at which money circulates in the economy)

  3) $P$: the price of a typical transaction
     (the number of dollars exchanged)

  4) $T$: total number of transactions during some period of time $\Rightarrow$ difficult to measure

  $\Rightarrow M \times V = P \times Y,$
\( Y \) : Total output of the economy (real GDP)

\( P \) : GDP deflator

\( V \) : Income velocity of money

- Money demand function

  ➔ What determines the quantity of real money balance (\( M / P \)) people wish to hold

  ➔ \( M / P = kY \)

  ➔ \( M (1/k) = PY \)

  ➔ If \( V = 1/k \), \( M \times V = P \times Y \)

- The link b/t the demand for money and the velocity

  e.g., If People want to hold a lot of money for each dollar of money, money changes hands infrequently

- The quantity theory of Money

  Assuming constant velocity, \( M \times V = P \times Y \).

  ➔ A change in the quantity of money must cause a proportionate change in nominal GDP

  ➔ i.e., If velocity is fixed, the quantity of money determines the dollar value of the economy’s output
Money, Price, and Inflation (fig. 4-1 – 4-2)

1) The factor of production & the production function
   \[ Y \]

2) Money supply \( \rightarrow \) the (nominal) value of output \( (PY) \)

3) \( P \) is determined
   \[ \rightarrow \text{The price level is proportional to the money supply} \]

   \[
   \% \text{ change in } M + \% \text{ change in } V = \% \text{ change in } P + \% \text{ change in } Y
   \]

   \( cf) \) “Inflation is always and everywhere a monetary phenomenon” (Milton Friedman)

3. Inflation and Interest Rates

- Nominal interest rate vs. Real interest rate

  • Nominal interest rate \( (i) \): the rate of interest that investors pay to borrow money

  • Real interest rate \( (r) \): the nominal interest rate corrected for the effects of inflation

   \[ \rightarrow r = i - \pi \]
- The Fisher Effect

  • Fisher equation: \( i = r + \pi \)

  \( \Rightarrow \) Nominal interest rate can change b/c

  1) real interest rate changes
  2) inflation rate changes

  • The Fisher effect: one-for-one relationship b/t the inflation rate and nominal interest rate
    (fig. 4-3 & 4-4, pp. 90-91)

    i.e., an increase in the rate of money growth of 1%
    \( \Rightarrow \) 1% increase in the rate of inflation
    \( \Rightarrow \) 1% increase in the nominal interest rate

4. Nominal Interest Rate and the Demand for Money

- The nominal interest rate is the opportunity cost of holding money

- The quantity of money demanded depends both on the level of income and on the nominal interest rate.

  \( \Rightarrow \) \( (M / P)^D = L(i, Y) = L(r + \pi, Y) \)

- The linkage among money, price, and interest rates (fig. 4-5, p.94)
5. The Social Costs of Inflation

(1) The costs of “expected” inflation

- The distortion of the inflation tax on the amount of money people hold

- Menu costs: firms change their posted price very often

- Variability in relative prices → microeconomic inefficiency

- The distortion of individuals’ tax liability

- Inconvenience of living in a world with a changing price level

(2) The costs of “unexpected” inflation

- Arbitrarily redistributes wealth among individuals

- Hurt individuals on fixed pensions

- Uncertainty
6. Hyperinflation

- Inflation that exceeds 50 percent per month.
  → more than 100-fold increase in price level over a year
- The costs of hyperinflation
- The causes of hyperinflation
  • Excessive growth in the supply of money
- Hyperinflation in interwar Germany (fig.4-6, p.106)
1. Some Facts about Economic Fluctuation

- Significant short-run variations in aggregate output and employment
  - No simple regular or cyclical pattern: output changes very considerably in size and spacing
    → The economy is perturbed by disturbances of various types and sizes at more or less random interval
  - Fluctuations are distributed very unevenly over the components of output
    → Investment is the most volatile component
    → consumption, government purchases, and net exports are relatively stable
  - The behavior of some important macroeconomic variables during recession
    → procyclical? or countercyclical?

2. The Classical Dichotomy

- Nominal variables vs. Real variables
  - Nominal variables: variables expressed in terms of money
  - Real variables: variables measured in physical units, such as quantities and relative prices
- Classical dichotomy: theoretical separation of real and nominal variables

  • Monetary neutrality: changes in the money supply do not influence real variables \((Y)\).

### 3. Time Horizons in Macroeconomics

- Short Run (SR) vs. Long Run (LR)

  • LR: prices are flexible and can respond to changes in supply or demand

  • SR: many prices are “sticky” at some predetermined level

  \(\Rightarrow\) Economic policies have different effects over different time horizon.

- The Model of Aggregate Supply (AS) and Aggregate Demand (AD)

  • Flexible prices are a crucial assumption of classical macroeconomic theory

  \(\Rightarrow\) supplies of capital and labor + available technology

  \(\Rightarrow\) the economy’s ability to supply goods and services

  \(\downarrow\) flexible price

  \(\Rightarrow\) the amount of output = total demand

• Sticky prices
→ Output also depends on the demand for goods and services

→ Demand is influenced by monetary policy and fiscal policy, …..

→ Monetary policy and fiscal policy may be useful in stabilizing the economy in the short run

4. Aggregate Demand (AD)

→ The relationship b/t the quantity of output demanded and the aggregate price level

- The quantity equation as AD

  • Quantity equation: \( M \times V = P \times Y \)

  \[ m \times v = k \times y \text{, where } k = 1/V \]

  • For any fixed \( k \) (or \( V \)), the quantity equation yields a negative relationship b/t the price level and output (fig. 9-2, p.243)

- Why the AD curve slopes downward

  • Since the velocity of money is fixed, the money supply determines the dollar value of all transactions in the economy

  1) If the price level rises, so that each transaction
requires more dollars, the number of transactions and thus quantity of goods and services purchased must fall

2) If output is higher, people engage in more transactions and need higher real balances.

⇒ For a given money supply, higher real balances imply a lower price level

- Shift in the AD curve (fig. 9-3, p.244)
  • AD curve is drawn for a fixed value of the money supply
  ⇒ the possible combinations of $P$ and $Y$, given $M$
  • If $M$ changes, the possible combinations of $P$ and $Y$ change ⇒ shifts in AD curve

5. Aggregate Supply (AS)

⇒ The relationship b/t the quantity of output supplied and the aggregate price level

- The firms that supply goods and services have flexible prices in the LR but sticky prices in the SR
  ⇒ AS depends on the time horizon
(1) **The Long Run: The vertical AS curve (LRAS)**

- The amount of output produced in the LR depends on the fixed amounts of capital and labor and on the available technology

  \[ Y = \bar{Y} = F(\bar{K}, \bar{L}) \]

- Output does not depend on the price level (fig. 9-4)

- Change in AD \(\rightarrow\) classical dichotomy (fig. 9-5)

(2) **The Short Run: The horizontal AS curve (SRAS)**

- Sticky price \(\rightarrow\) a horizontal AS curve (fig. 9-6)

- Change in AD \(\rightarrow\) changes in real variables (fig. 9-7)

(3) **Transition from the Short Run to the Long Run**

Ex) Fed reduces the money supply (fig. 9-9)

6. **Stabilization Policy**

- Fluctuations in the economy come from changes in AS and/or AD

  \(\rightarrow\) demand shock & supply shock

  \(\rightarrow\) disrupt economic well-being by pushing output and employment away from their natural values

- Stabilization policy: the policy actions aimed to reducing the severity of SR economic fluctuations
(1) **Shocks to AD**

Ex) the introduction and expanded available credit cards

→ reduce the quantity of money people choose to hold

→ $k$ falls ($V$ rises) → AD shifts outward

- SR and LR effects (fig. 9-10)
- The Fed can reduce $M^S$ to offset the increase in $V$

(2) **Shocks to AS**

Ex) changes in the cost of producing goods and services

• The organization of an international oil cartel
  → SRAS shifts upward (fig. 9-11)

- The Fed can increase $M^S$ to accommodate the supply shock (fig. 9-12)
7. Real Business Cycle (RBC) Theory

- Short-run economic fluctuations should be explained while maintaining the assumptions of classical model

- RBC assumes that prices are fully flexible, even in the short run, and macroeconomic analysis should be based on this assumption
  \(\rightarrow\) consistent with classical dichotomy
  \(\rightarrow\) nominal variable, such as the money supply and the price level, do not influence real variable, such as output and employment

- In order to explain fluctuations in real variables, RBC emphasizes real changes in the economy, such as changes in production technologies

- “Real” \(\rightarrow\) Exclusion of nominal variables in explaining short-run economic fluctuation

THE ECONOMICS OF ROBINSON CRUSOE

- Technological progress and economic growth may occur unevenly

- There might be shocks to the economy that induce SR fluctuations in the natural rates of output and employment

- Crusoe’s decisions
  - Leisure: swimming
  - Work: fish (consumption), nets (investment)
  \(\rightarrow\) GDP = the number of fish caught + the number of net made
• Allocate time among swimming, fishing, and making nets based on preferences and the opportunities

- Crusoe’s decisions change as shocks impinge on his life
  • a big school of fish
    → productivity and employment rise
    → GDP rises (boom)
  • a storm
    → productivity and employment fall
    → GDP falls (recession)

- Fluctuations in output, employment, consumption, investment, and productivity are all the natural and desirable response of an individual to the inevitable changes in his environment
  → Fluctuations have nothing to do with monetary policy, sticky prices, or any type of market failure