An Equilibrium Business-Cycle Model

Cyclical Behavior of Real GDP— Recessions and Booms

- Real GDP=

  trend real GDP + cyclical part of real GDP

- Cyclical part of real GDP=

  real GDP− trend real GDP

- **Cyclical part of real GDP** is
  - ✓Coming from the business cycle（经济周期）: short-term economic fluctuations.

Cyclical Behavior of Real GDP— Recessions and Booms

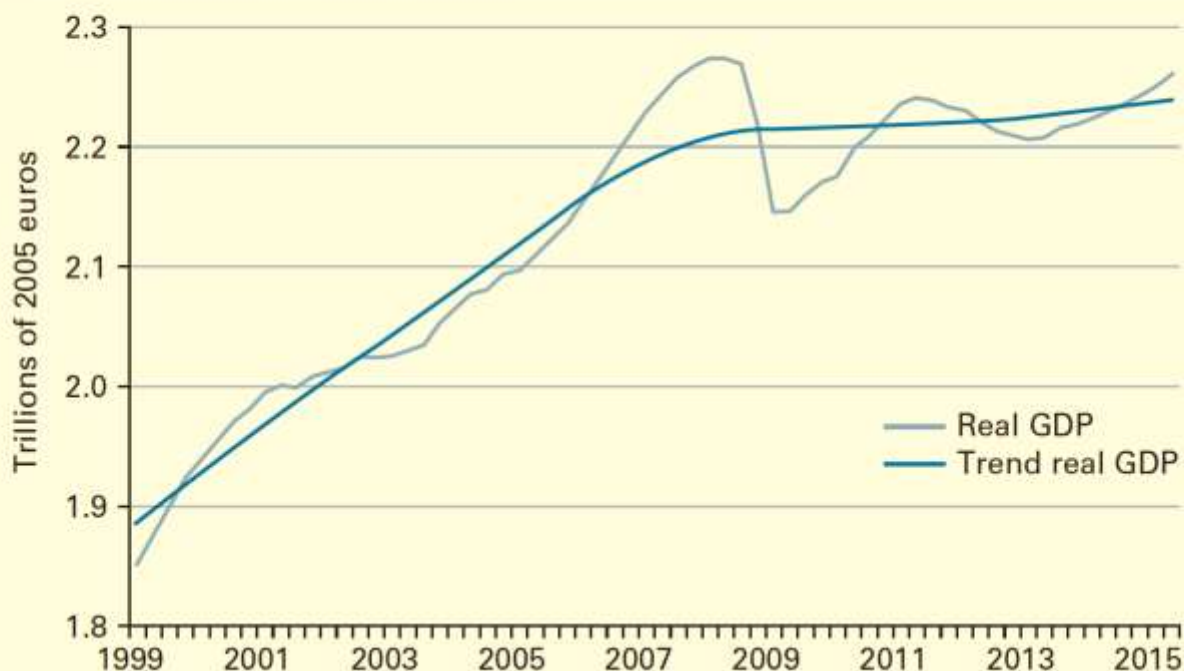**Figure 9.1** Eurozone real GDP, 1999–2015

The graph shows Eurozone real GDP from 1999.1 to 2015.2. The data are quarterly, seasonally adjusted, and measured in euros from the base year, 2005.

Cyclical Behavior of Real GDP—Recessions and Booms

**Figure 9.2** Calculating the trend of Eurozone real GDP, 1999–2015

The light blue curve shows Eurozone real GDP from Figure 9.1. The dark blue curve is a smooth trend drawn through the GDP data. We think of this trend curve as reflecting long-run economic growth.

Cyclical Behavior of Real GDP— Recessions and Booms

Figure 9.3 Cyclical part of Eurozone real GDP, 1999–2015

The graph plots the difference between real GDP (the light blue curve in Figure 9.2) and its trend (the dark blue curve in Figure 9.2). The resulting series – the cyclical part of real GDP – shows the deviations of real GDP from its trend. This cyclical part is measured in a proportionate sense; for example, 0.02 means that real GDP is 2% above trend, and –0.02 means that real GDP is 2% below trend.
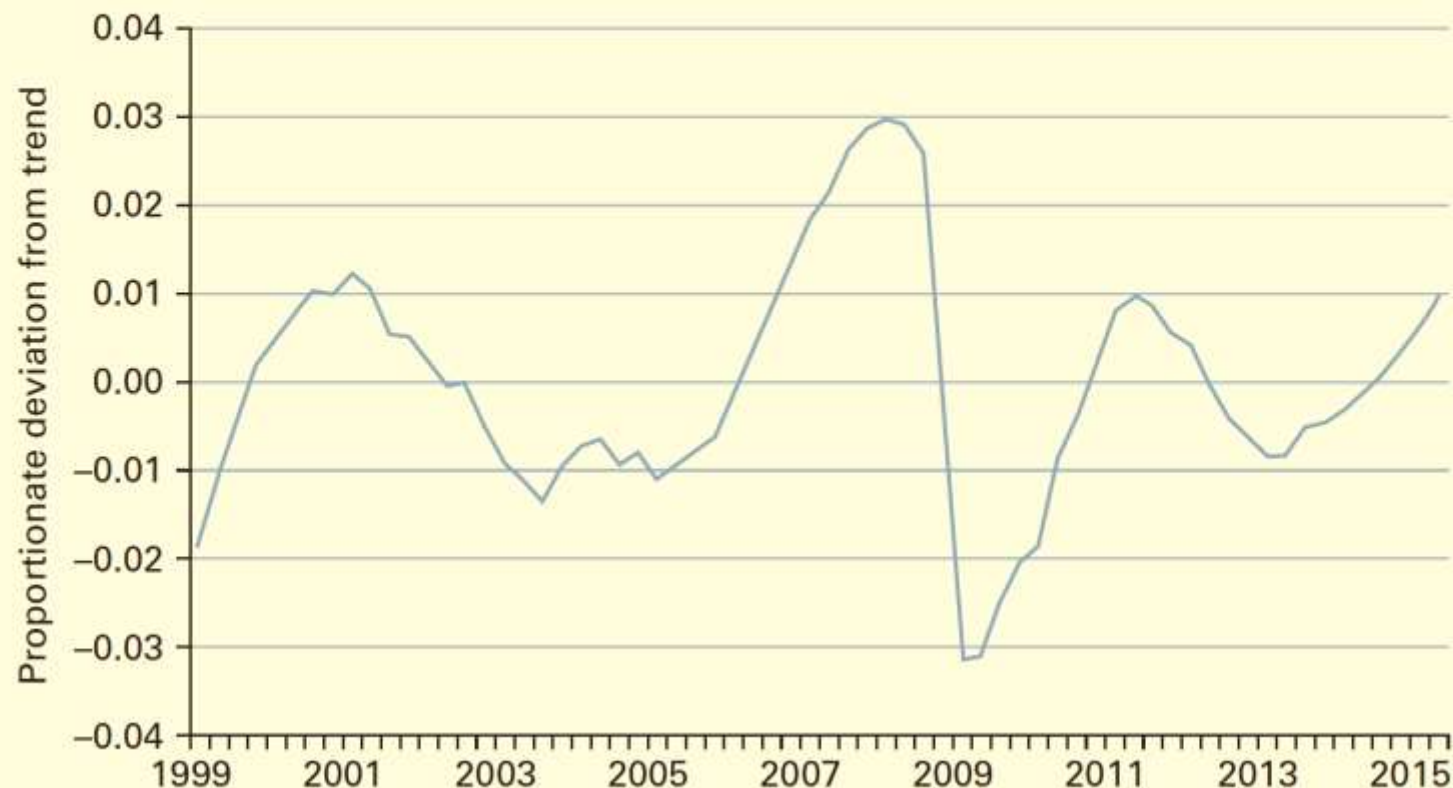
An Equilibrium Business-Cycle Model

- **Equilibrium business-cycle model**
  - Uses equilibrium conditions to determine how the real shocks affect real GDP, Y, and other macroeconomic variables, such as consumption, C, investment, I, the quantity of labor input, L, and more.
    - 2004 Nobel Laureates
    - 加利福尼亚大学圣巴巴拉校区的基德兰德教授(Finn kydland)和亚利桑那州立大学、联邦储备银行明尼阿波利斯分行的普雷斯科特(Edward Prescott), 以表彰他们对动态宏观经济学的贡献。

An Equilibrium Business-Cycle Model

- **Equilibrium business-cycle model**
    - 他们是新古典宏观经济学实际经济周期学派的代表人物，提出<u>实际经济周期模型</u>。
    - Real shock: 实际冲击，即生产率或者工人工作意愿的冲击。
    - 实际经济周期模型（real business cycle model）假设所有的工资和价格都是完全灵活的，实际冲击导致潜在产出或长期总供给的波动，在工资和价格完全灵活的情况下，短期总供给和长期总供给曲线相同，因此在关于实际经济周期的总供给和总需求分析中，只有一条长期总供给曲线LRAS。

An Equilibrium Business-Cycle Model

- Conceptual Issues

  - Assuming that these fluctuations reflect real shocks to the economy.

    - E.g. change in level of technology : $Y = A \cdot F(K, L)$
    - An increase in A（生产率的提高）means that the economy is more productive.
    - A decrease in A means that the economy is less productive.

An Equilibrium Business-Cycle Model

- The Model
  - $Y = A \cdot F(K, L)$
    - ✓ the capital stock, K, as fixed in the short run,
    - ✓ the labor input, L, is fixed as well.
    - ✓ Changes in Y will reflect only changes in A.
    - ✓ When A rises, Y rises,
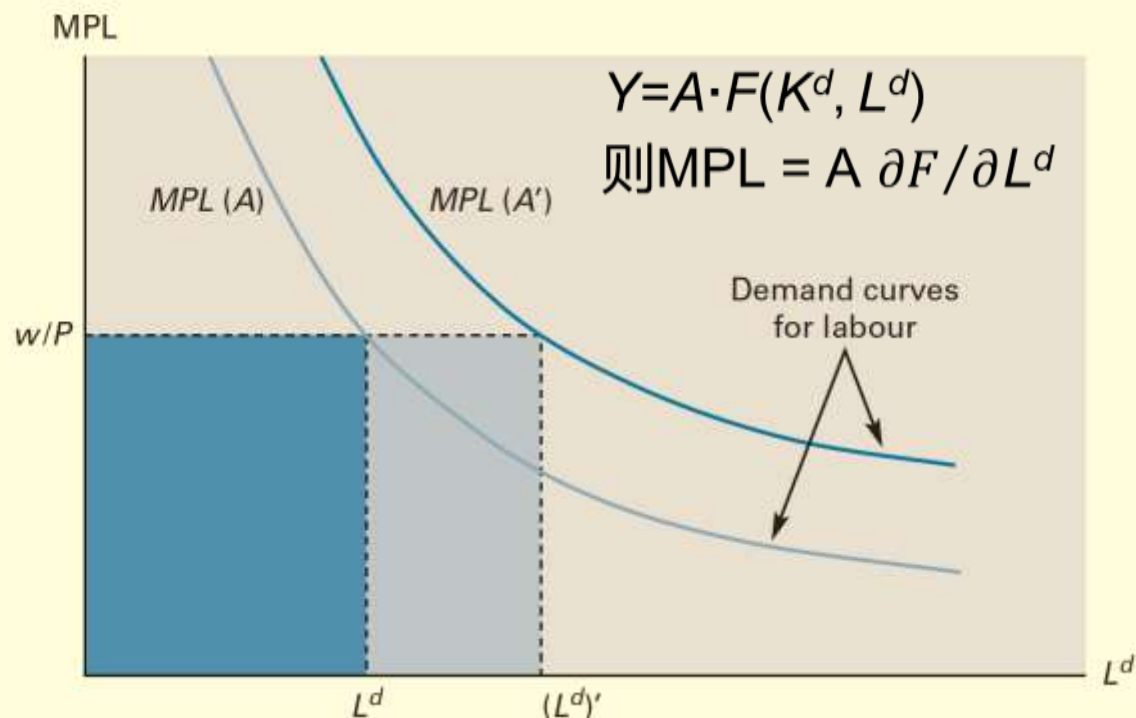   - ✓ When A falls, Y falls.

An Equilibrium Business-Cycle Model

- ## The Model

  - ## The marginal product of labor and the real wage rate

    - ✓ An increase in the technology level, *A*, raises the marginal product of labor, MPL, for given inputs of capital, *K*, and labor, *L*.

An Equilibrium Business-Cycle Model

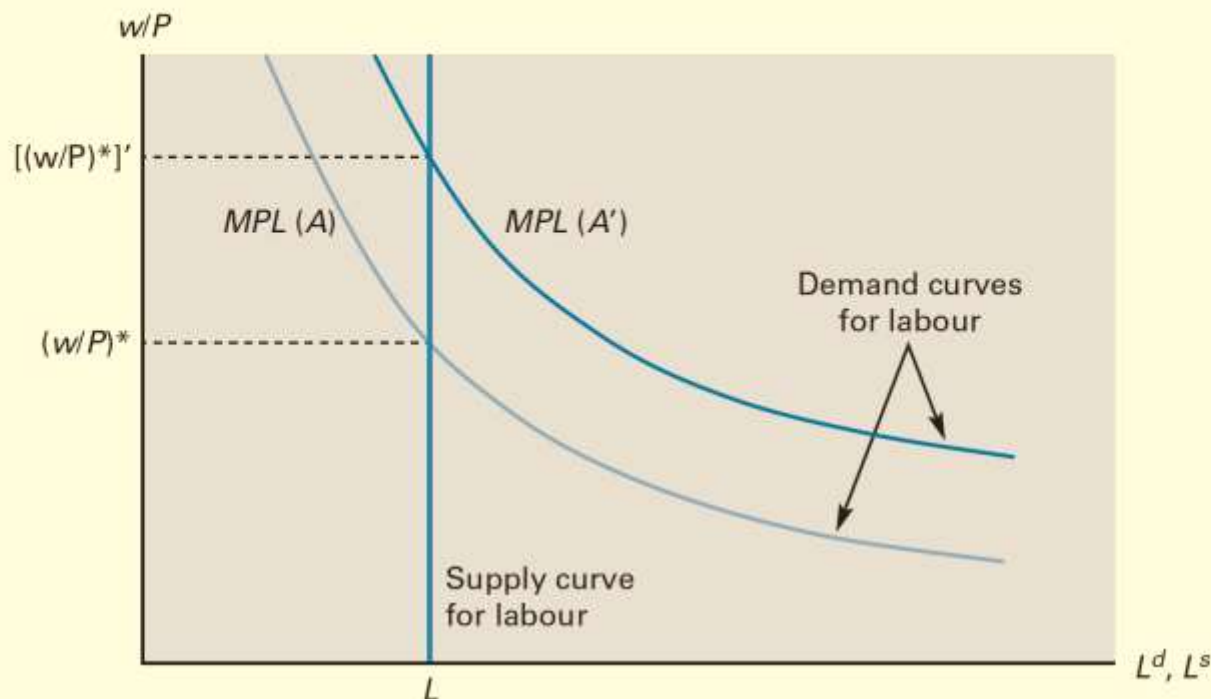**Figure 9.4** Effect of an increase in the technology level on the demand for labour

When the technology level is A, the MPL is given by the light blue curve, labelled MPL (A). At the real wage rate w/P, shown on the vertical axis, the quantity of labour demanded is L on the horizontal axis. The technology level A' is greater than A. Therefore, the MPL, given by the dark blue curve labelled MPL (A'), is higher at any labour input than the value along the light blue curve. When the technology level is A' and the real wage rate is w/P, the quantity of labour demanded is (L^d)', which is greater than L.

MPL

$$Y=A \cdot F(K^d, L^d)$$
$$则 MPL = A \, \partial F / \partial L^d$$

MPL (A)   MPL (A')

Demand curves for labour

w/P

L^d $(L^d)'$ L^d

An Equilibrium Business-Cycle Model

Figure 9.5 Effect of an increase in the technology level on the real wage rate

Labour supply is the given value L, shown on the horizontal axis. If the technology level is A, the schedule for the MPL determines the light blue labour-demand curve, labelled MPL (A). Therefore, the market-clearing real wage rate is $(w/P)^*$, shown on the vertical axis. The technology level A' is greater than A, as in Figure 9.4. Therefore, the schedule for the MPL is given by the dark blue labour-demand curve, labelled MPL (A'). In this case, the market-clearing real wage rate is $[(w/P)^*]'$, which is greater than $(w/P)^*$.
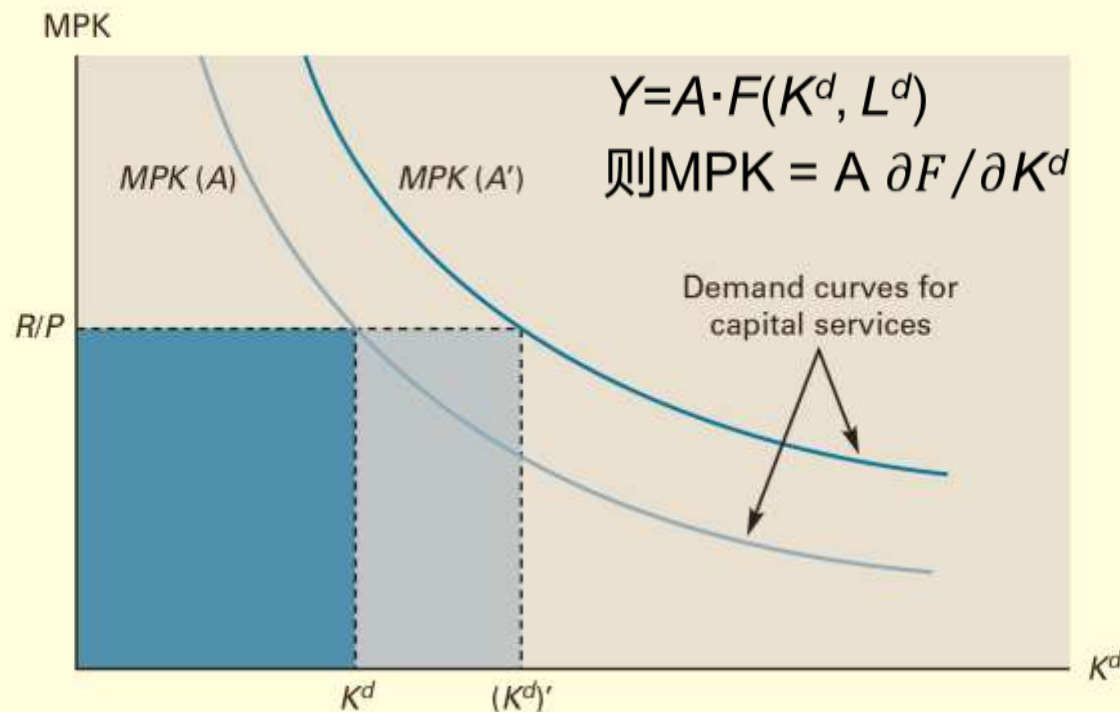
An Equilibrium Business-Cycle Model

- ## The Model

  - ### Marginal product of capital, real rental price, and the interest rate

    - ✓ An increase in the technology level, A, raises the marginal product of capital, MPK, for given inputs of capital, K, and labor, L

An Equilibrium Business-Cycle Model

**Figure 9.6** Effect of an increase in the technology level on the demand for capital services

When the technology level is A, the MPK is given by the light blue curve, labelled MPK (A). At the real rental price R/P, shown on the vertical axis, the quantity of capital demanded is K on the horizontal axis. The technology level A' is greater than A. Therefore, the MPK, given by the dark blue curve labelled MPK (A'), is higher at any capital input than the value along the light blue curve. When the technology level is A' and the real rental price is R/P, the quantity of capital demanded is $(K^d)'$, which is greater than K^d.

MPK

$MPK (A)$ $MPK (A')$

$Y = A \cdot F(K^d, L^d)$

则$MPK = A \, \partial F / \partial K^d$

Demand curves for capital services

R/P

K^d $(K^d)'$ K^d

An Equilibrium Business-Cycle Model

Figure 9.7 Effect of an increase in the technology level on the real rental price of capital

The supply of capital services is the given value K, shown on the horizontal axis. If the technology level is A, the schedule for the MPK is given by the light blue curve, labelled MPK (A). This curve gives the demand for capital services when the technology level is A. The market-clearing real rental price is (R/P)*, shown on the vertical axis. The technology level A' is greater than A, as in Figure 9.6. Therefore, the schedule for the MPK is given by the dark blue curve, labelled MPK (A'). This curve gives the demand for capital services when the technology level is A'. In this case, the market-clearing real rental price is [(R/P)*]', which is greater than (R/P)*.
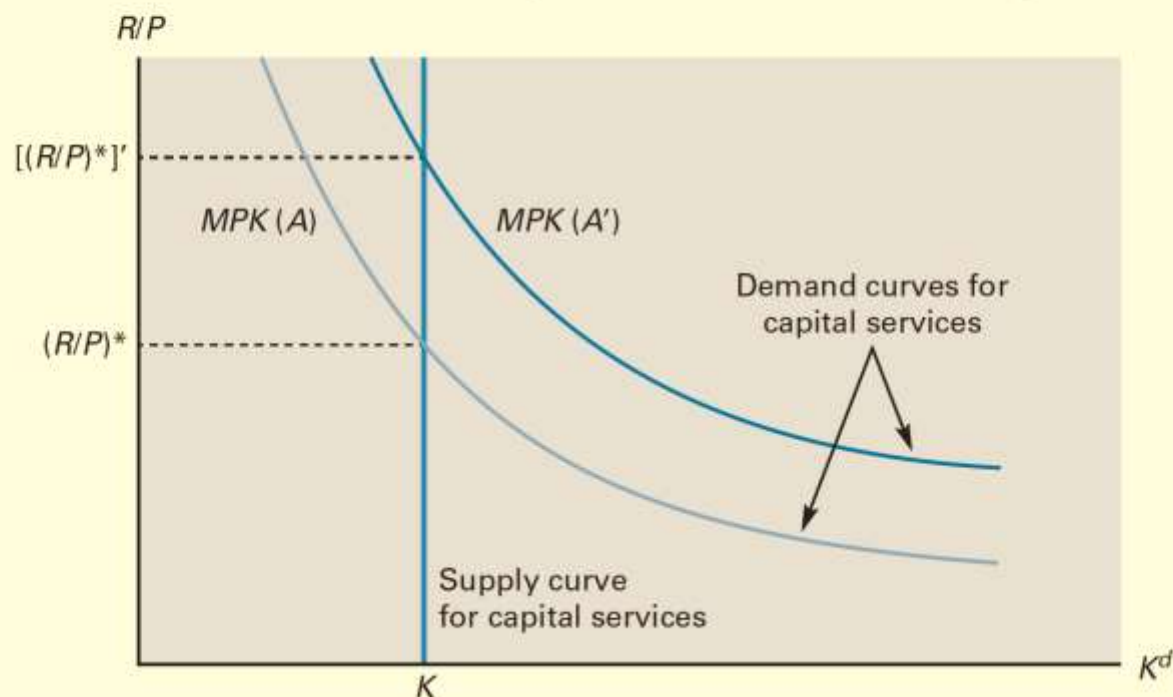
An Equilibrium Business-Cycle Model

- The Model

  - Marginal product of capital, real rental price, and the interest rate

    - ✓ $i = R/P - \delta$

    - ✓ $i = MPK(\text{ evaluated at given } K \text{ and } L) - \delta$

    - ✓ An increase in the technology level, A, raises the marginal product of capital, *MPK*, at given inputs of capital, *K*, and labor, *L*, as well as the real rental rate, *R/P.*

    - ✓ The model also predicts that an economic boom（solo determined by A）will have a relatively high interest rate, *i,* whereas a recession will have a relatively low interest rate.

An Equilibrium Business-Cycle Model

- ## The Model

  - ### Consumption, saving and investment

    - ✓ Given the markets for bonds, labor, and capital services clear (or in equilibrium):

    $$C + \Delta K = Y - \delta K$$

    - ✓ Consumption + net investment

      = *real GDP − depreciation*

      = *real net domestic product*

An Equilibrium Business-Cycle Model

- The Model
  - Consumption, saving and investment
    - ✓ $C + \Delta K = A \cdot F(K, L) - \delta K$

      depreciation, δK, is fixed in the short run
    - ✓ An increase in A raises real GDP for given K and L, that is, rise in A raises overall real income.

An Equilibrium Business-Cycle Model

- The Model

  - Consumption, saving and investment

    - ✓ The increase in real income motivates households to raise current consumption and future consumption —— "income effect".

    - ✓ The increase in the interest rate (A lifts i as well) has intertemporal-substitution effect, which tends to reduce current consumption.

    - ✓ The net change depends on whether the income effect is stronger or weaker than the intertemporal-substitution effect.

An Equilibrium Business-Cycle Model

- The Model
  - Consumption, saving, and investment
    - ✓ Assume that the change in *A* is permanent. (Thus, the increases in real income tend also to be permanent).
    - ✓ The propensity to consume out of higher income would be close to one.
    - ✓ Current consumption will rise.
    - ✓ However, as long as the intertemporal-substitution operates at all, the increase in current consumption will be less than the increase in real GDP.

An Equilibrium Business-Cycle Model

- ## The Model

  - ### Consumption, saving and investment

    - ✓ Since current consumption, *C*, rises, but by less than the increase in real GDP, *Y*. net investment, ΔK, must increase.

    - ✓ Increase in real GDP shows up partly as more *C* and partly as more *K*.

    - ✓ Since net investment, ΔK, equals real saving (assume bonds market clears), this result is consistent with our finding that real saving increased.

Matching the Theory with the Facts

- Consumption and Investment
  - When a variable fluctuates in the same direction as real GDP that variable is <mark>procyclical</mark>.
    - A procyclical variable moves in the same direction as the business cycle—it tends to be high relative to its trend in a boom and low relative to its trend in a recession.

Matching the Theory with the Facts

- Consumption and Investment
  - A variable that fluctuates in the opposite direction from real GDP is <mark>countercyclical</mark>.
  - A variable that has little tendency to move in a particular direction during a business cycle is <mark>acyclical</mark>.

Matching the Theory with the Facts

Figure 9.8 Cyclical behaviour of Eurozone real GDP and consumer expenditure

The dark blue curve is the deviation of real GDP from its trend. The light blue curve is the deviation of real consumer expenditure from its trend. These deviations are measured in a proportionate sense. The data on GDP and consumer expenditure are quarterly and seasonally adjusted. Real consumer expenditure is procyclical – it fluctuates closely with real GDP but is less variable than real GDP.

[5]From 1999.1 to 2015.2, the correlation of the cyclical part of real consumer expenditure with the cyclical part of real GDP in the Eurozone was 0.94.

Matching the Theory with the Facts

Figure 9.9 Cyclical behaviour of Eurozone real GDP and investment

The dark blue curve is the deviation of real GDP from its trend. The light blue curve is the deviation of real gross private domestic investment from its trend. These deviations are measured in a proportionate sense. The data on GDP and investment are quarterly and seasonally adjusted. Real gross investment is procyclical – it fluctuates closely with real GDP but is far more variable than real GDP.

Matching the Theory with the Facts

- Consumption and Investment
  - Permanent shifts in the technology level, *A*, match up with some of the empirical patterns
    - ✓ Increases in *A* generate economic booms, where real GDP increases, consumption and investment increases.
    - ✓ Decreases in *A* create recessions, where real GDP, consumption and investment all decline.
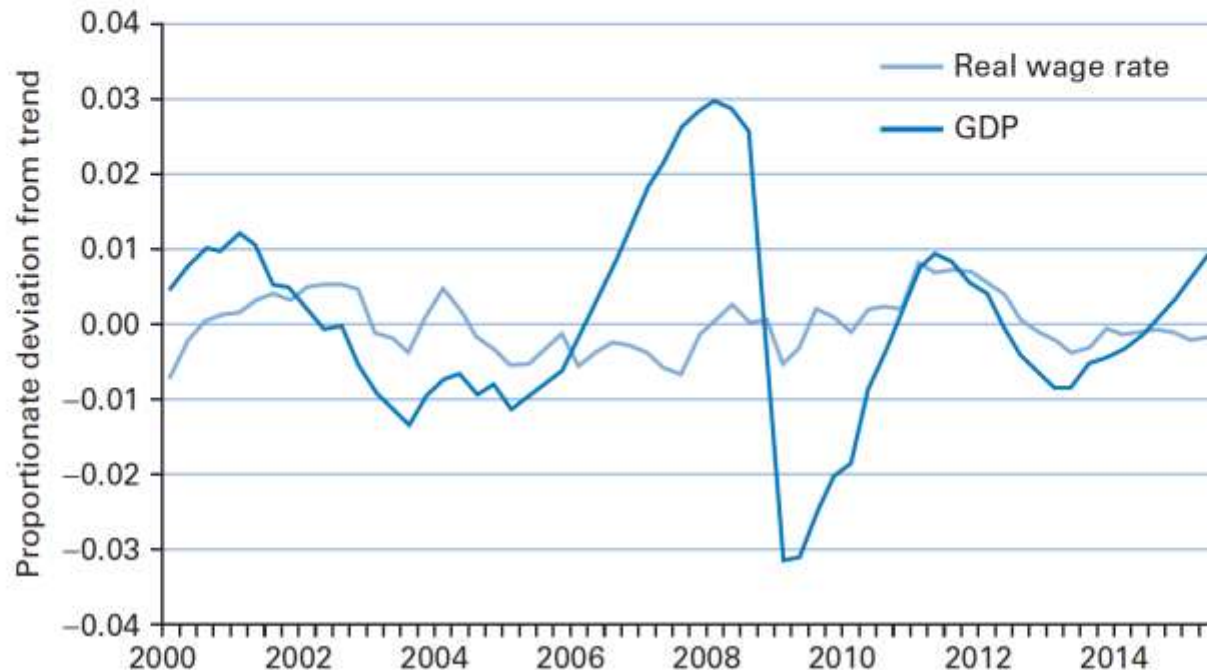
Matching the Theory with the Facts

- The Real Wage Rate
  - The model predicts that the real wage rate, w/P, will be relatively high in booms and relatively low in recessions.

Matching the Theory with the Facts

Figure 9.10 Cyclical behaviour of Eurozone real GDP and the real wage rate

The dark blue graph is the deviation of real GDP from its trend. The light blue graph is the deviation of the real wage rate from its trend. These deviations are measured in a proportionate sense. The real wage rate is calculated by dividing wages and salaries, for which data are available from 2000.1, by the number of employed workers and then adjusted by the price deflator for the GDP. The data on GDP and wage rates are quarterly and seasonally adjusted. The real wage rate is procyclical – it fluctuates with real GDP but is not as variable as real GDP.
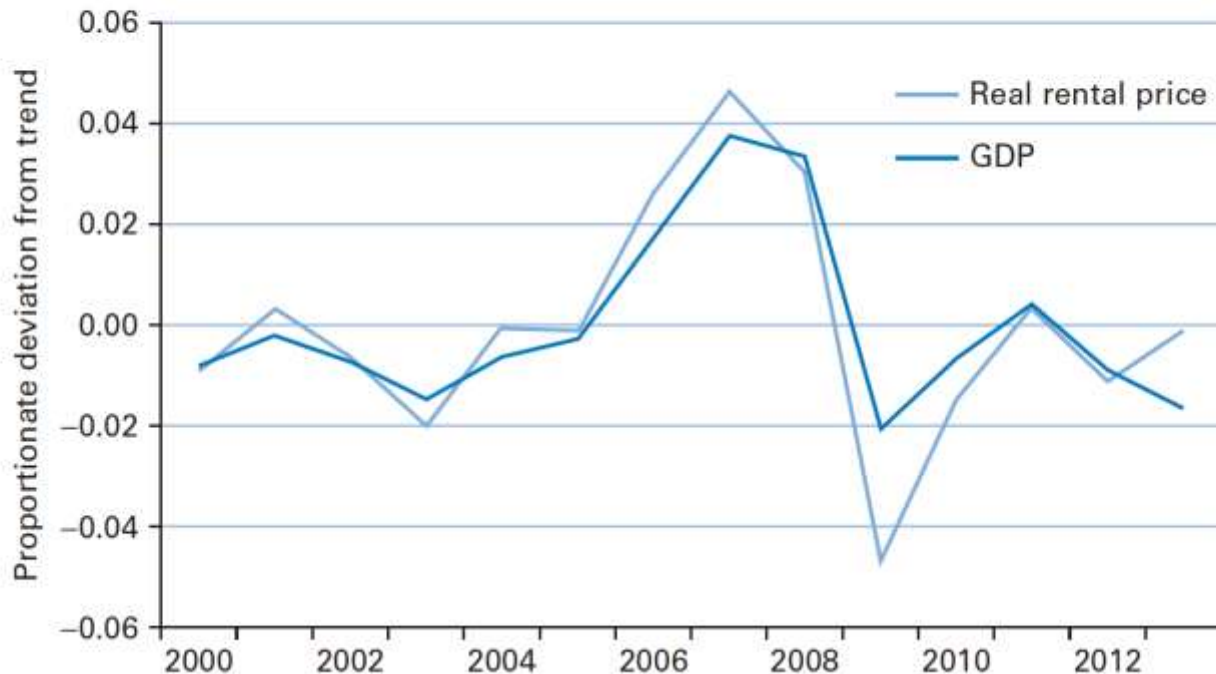
Matching the Theory with the Facts

- The Real Rental Price
  - The model predicts that the real rental price of capital, R/P, will be relatively high in booms and relatively low in recessions.

Matching the Theory with the Facts

Figure 9.11 Cyclical behaviour of Eurozone real GDP and the real rental price of capital

The dark blue curve is the deviation of real GDP from its trend (in a proportionate sense). The light blue curve is the deviation of the real capital rental price from its trend. The real rental price of capital is procyclical – it fluctuates with real GDP.

Matching the Theory with the Facts

- The Interest Rate
  - The model predicts that booms will have a high interest rate, i, whereas recessions will have a low interest rate.
  - *Can you find facts ?(using China's data)*

Temporary Changes in the Technology Level

- A decrease in *A* due to a harvest failure or a general strike would be temporary.

- To allow for these cases, we now assume that the change in *A* is temporary.

Temporary Changes in the Technology Level

- If A increases temporarily, real GDP ($Y=A \cdot F$ (K, L)), still rises for fixed values of K and L.

- The marginal product of capital, MPK, and the interest rate, i, also rise as before.

- The intertemporal-substitution effect from the higher i still motivates households to reduce current consumption, C, and raise current real saving.

Temporary Changes in the Technology Level

- The model therefore predicts that economic boom would feature high real GDP and high investment.

  - ✓ Since income effect would increase current consumption by a small amount.

- A recession would have low real GDP and low investment,

  - ✓ Income effect would lower current consumption by a small amount.

Variations in Labor Input

- Labor Supply
  - More labor supplied means less leisure time for the family.
  - Assume that households also like more leisure time.(两种消费品：闲暇和普通商品，都是正常品，收入增加，两种都增加)
  - As with consumption and saving, the choice of L^s involves substitution effect and income effect.

Variations in labor Input

- The <u>substitution</u> effect for leisure and consumption

  - ✓ If the household chooses to work one more hour（and thereby have one less hour of leisure）, the extra *w/P* of real wage income pays for *w/P* more units of consumption.

  - ✓ Therefore, the household can substitute one less hour of leisure for *w/P* more units of consumption.

Variations in Labor Input

✓ If real wage rate, *w/P*, rises, the household gets a better deal by working more because it gets more consumption for each extra hour worked.

✓ Since the deal is better, the household responds to a higher *w/P* by working more.

✓ A higher real wage rate, *w/P*, raises the quantity of labor supplied, L^s.

Variations in labor Input

- <u>Income</u> effects on labor supply

  - ✓ A higher w/P means higher real wage income, $(w/P) \cdot L^s$

  - ✓ Household spends the extra income on both consumption and leisure time.

  - ✓ A higher w/P leads to more leisure time as well, that is, a smaller quantity of labor supplied, L^s.

Variations in labor Input

✓Resolve the ambiguity by considering whether the income effect is strong or weak.

✓A <u>permanent</u> increase in real wage rates results in a stronger income effect on labor input, thus more leisure is choosen.

✓If the change in year$_1$'s real wage rate, $(w/P)_1$, is <u>temporary</u>, the income effect on labor input is small. In this case, the substitution effect on leisure time is stronger.

Variations in labor Input

- <u>Intertemporal-substitution</u> effects on labor supply

$$C_1 + C_2/(1+i_1) + C_3/[(1+i_1) \cdot (1+i_2)] + \cdots$$

$$= (1 + i_0) \cdot (B_0/P + K_0) +$$

$$(w/P)_1 \cdot L^s_1 + (w/P)_2 \cdot L^s_2/(1+i_1) +$$

$$(w/P)_3 \cdot L^s_3 /[(1+i1) \cdot (1+i_2)] + \cdots$$

Variations in labor Input

✓If A rises, leading the interest rate, i_1, to rise, a unit of year$_2$'s real wage income, $(w/P)_2 \cdot L^s_2$, becomes less valuable as a present value compared to a unit of year$_1$'s real wage income, $(w/P)_1 \cdot L^s_1$.

✓The household would thus increase L^s_1 and decrease L^s_2 as the interest rate, i_1, increases.

Variations in labor Input

Figure 9.12 Cyclical behaviour of Eurozone real GDP and employment

The dark blue curve is the deviation of real GDP from its trend. The light blue curve is the deviation of employment from its trend. These deviations are measured in a proportionate sense. The data on real GDP and employment are quarterly and seasonally adjusted. Employment is procyclical – it fluctuates closely with real GDP but it is not as variable as real GDP.
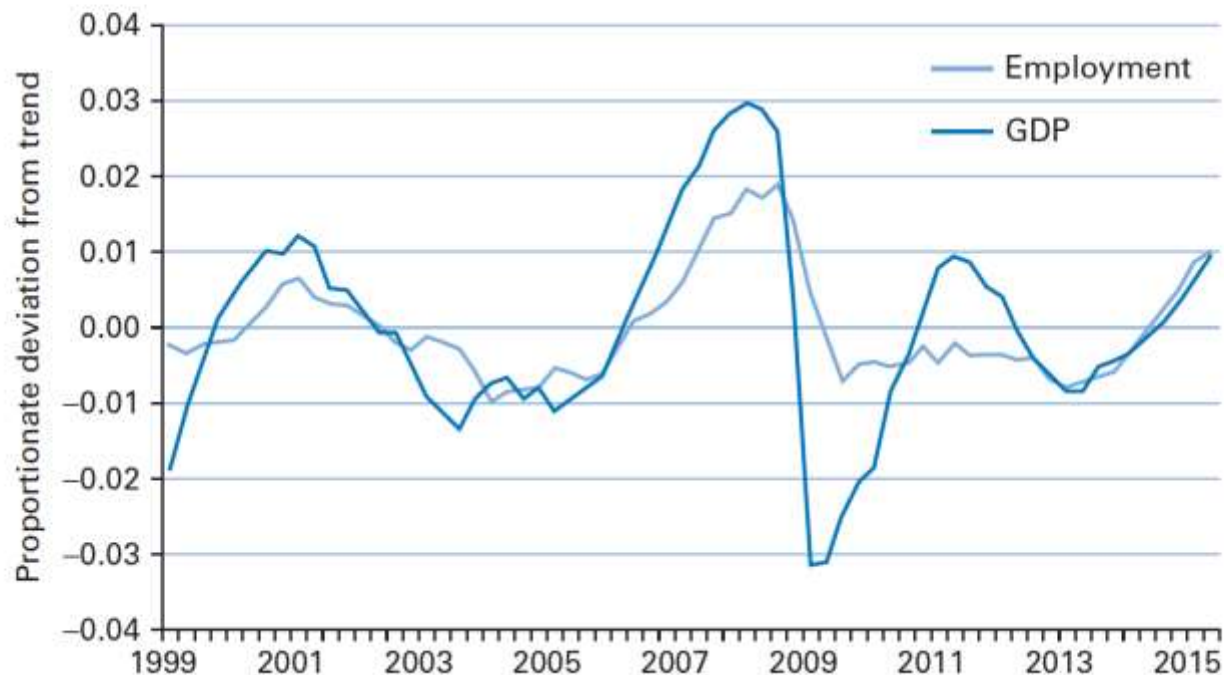
Variations in labor Input

- The cyclical behavior of labor input: theory
  - ✓Increase in A will lead to:
    - ❑The real wage rate increases
    - ❑labor inputs increase
- Fluctuations in labor Input: facts
  - ✓Measures of labor input are pro-cyclical: they move in the same direction as real GDP during booms and recessions.
    - ❑Employment rate
    - ❑Total hours worked per worker

Variations in labor Input

- The cyclical behavior of labor productivity
  - ✓Measures of labor productivity,
    - ☐ *Y/L*, is real GDP per worker, or
    - ☐Real GDP per worker-hour
    - ☐labor productivity turns out to be procyclical in both measures.
    - ☐*Can you find out data to support this?*