


# 3. National Income

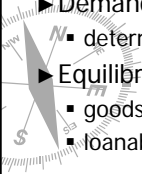
Cristina Echevarria



## Outline of model

A closed economy, market-clearing model

- ▶ Supply side
  - factor markets (supply, demand, price)
  - determination of output/income
- ▶ Demand side
  - determinants of C, I, and G
- ▶ Equilibrium
  - goods market
  - loanable funds market




## Production

**Production function:** how much can be produced given the amount of capital, labour and land available; and the state of technology


$$Y = F(K, L, N)$$

N assume constant:  $Y = F(K, L)$




## Assumptions

1. Technology is fixed.
2. The economy's supplies of capital and labor are fixed




## Determining GDP

Output is determined by the fixed factor supplies and the fixed state of technology:



## The distribution of national income

- ▶ determined by **factor prices**, the prices per unit firms pay for the factors of production
  - wage = price of **L**
  - **rental rate** = price of **K**



## Notation

<b><math>W</math></b>	= nominal wage
<b><math>R</math></b>	= nominal rental rate
<b><math>P</math></b>	= price of output
<b><math>W/P</math></b>	= real wage (measured in units of output)
<b><math>R/P</math></b>	= real rental rate



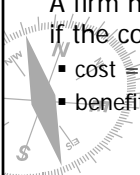
## How factor prices are determined

- ▶ Factor prices are determined by supply and demand in factor markets.
- ▶ Recall: Supply of each factor is fixed.
- ▶ What about demand?



## Demand for labor

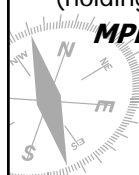
- ▶ Assume markets are competitive: each firm takes  **$W$** ,  **$R$** , and  **$P$**  as given.
- ▶ Basic idea:  
A firm hires each unit of labor if the cost does not exceed the benefit.
  - cost = real wage
  - benefit = marginal product of labor



## Marginal product of labor ( $MPL$ )

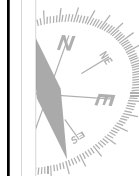
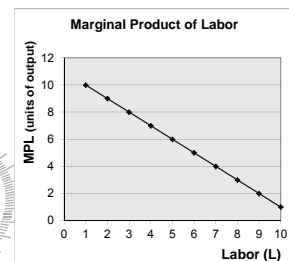
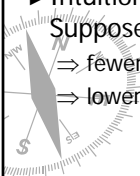
- ▶ definition:  
The extra output the firm can produce using an additional unit of labor (holding other inputs fixed):

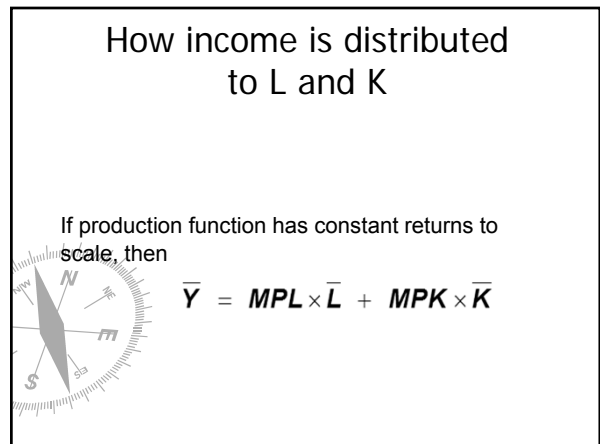
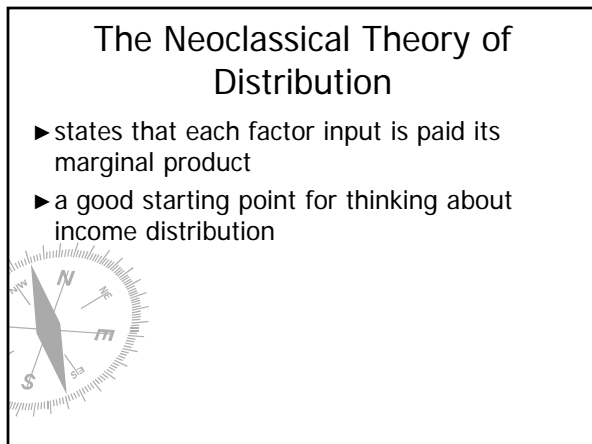
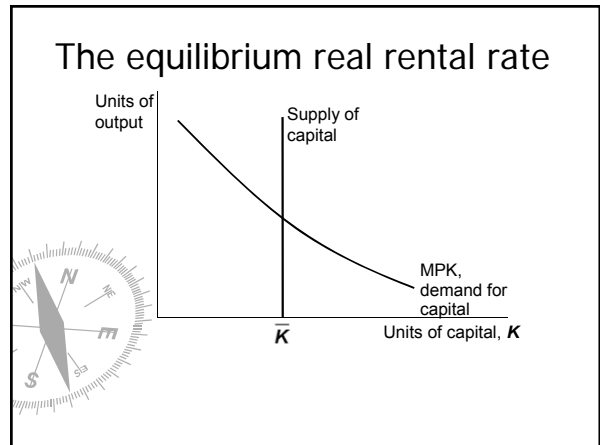
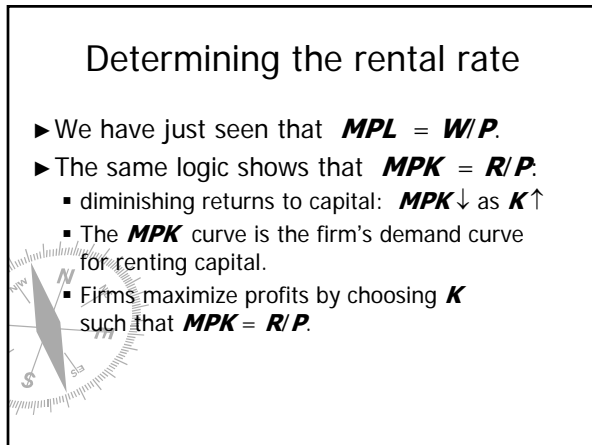
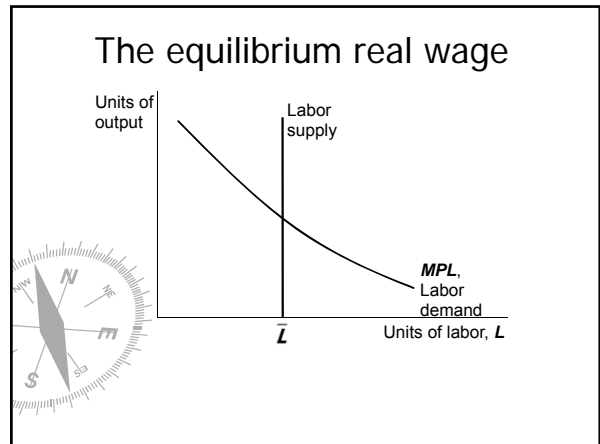
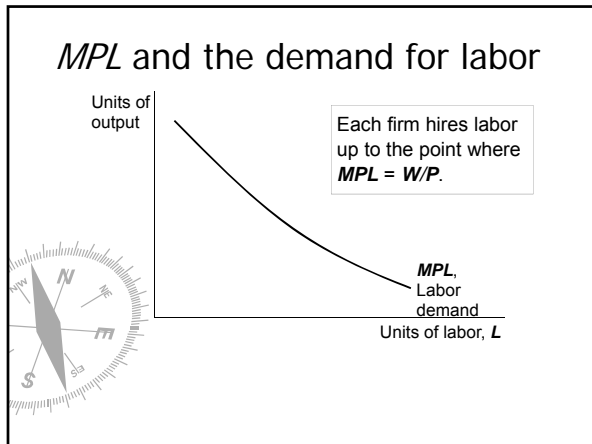
$$MPL = F(K, L+1) - F(K, L)$$



## Diminishing marginal returns

- ▶ As a factor input is increased, its marginal product falls (other things equal).
- ▶ Intuition:  
Suppose  $\uparrow L$  while holding  $K$  fixed
  - $\Rightarrow$  fewer machines per worker
  - $\Rightarrow$  lower worker productivity





### Distributing national income to the factors of production

#### Division of national income

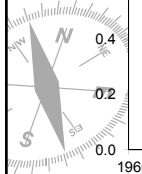
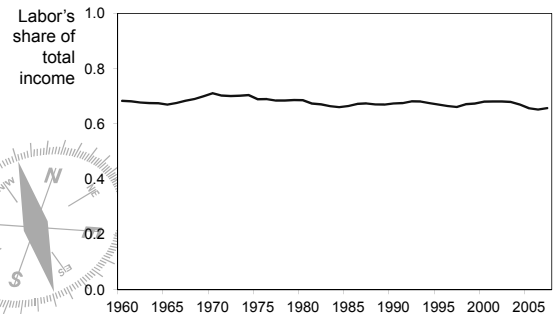
1927: Douglas (economist) asked Cobb (mathematician) to come up with a prod. func. such that

$$rK = MPK K = 0.3 Y = \alpha Y \quad (1)$$

$$wL = MPL L = 0.7 Y = (1-\alpha) Y \quad (2)$$



### The ratio of labor income to total income in the U.S., 1960-2007



### The Cobb-Douglas Production Function

- ▶ The Cobb-Douglas production function has constant factor shares:

$\alpha$  = capital's share of total income:

$$\text{capital income} = MPK \times K = \alpha Y$$

$$\text{labor income} = MPL \times L = (1 - \alpha) Y$$

- ▶ The Cobb-Douglas production function is:

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

where  $A$  represents the level of technology.

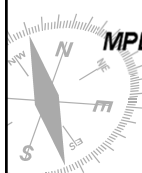


### The Cobb-Douglas Production Function

- ▶ Each factor's marginal product is proportional to its average product:

$$MPK = \alpha AK^{\alpha-1} L^{1-\alpha} = \frac{\alpha Y}{K}$$

$$MPL = (1-\alpha)AK^\alpha L^{-\alpha} = \frac{(1-\alpha)Y}{L}$$



### Distributing national income to the factors of production

This function is a CRS (constant returns to scale) prod. func.

Exhibits constant returns to scale



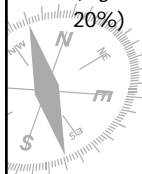
### Returns to scale: A review

Initially  $Y_1 = F(K_1, L_1)$

Scale all inputs by the same factor  $z$ :

$$K_2 = zK_1 \text{ and } L_2 = zL_1$$

(e.g., if  $z = 1.2$ , then all inputs are increased by 20%)



## Returns to scale: A review

What happens to output,  $Y_2 = F(K_2, L_2)$ ?

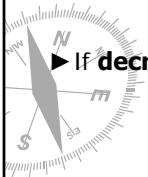
► If **constant returns to scale**,  $Y_2 = zY_1$

► If **increasing returns to scale**,

$$Y_2 > zY_1$$

► If **decreasing returns to scale**,

$$Y_2 < zY_1$$



## Demand for goods & services

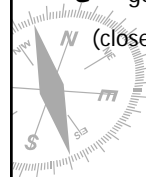
Components of aggregate demand:

$C$  = consumer demand for g & s

$I$  = demand for investment goods

$G$  = government demand for g & s

(closed economy: no  $NX$ )



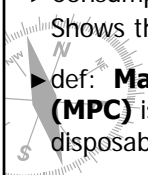
## Consumption, $C$

► def: **Disposable income** is total income minus total taxes:  $Y - T$ .

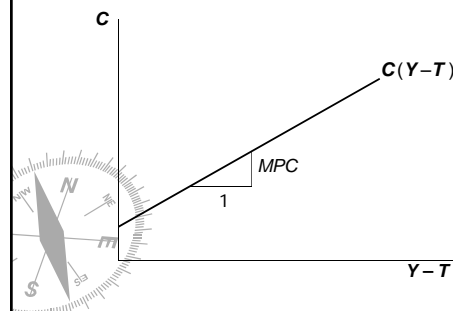
► Consumption function:  $C = C(Y - T)$

Shows that  $\uparrow(Y - T) \Rightarrow \uparrow C$

► def: **Marginal propensity to consume (MPC)** is the change in  $C$  when disposable income increases by one dollar.



## The consumption function

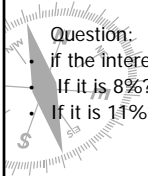


## Demand for goods and services

- Investment
- Two projects:
  - you think project will yield a return of 100,000 per year or 10%;
  - project will yield a return or 50000 per year or 5%;

Question:

- if the interest rate is 3% which project will you invest in?
- If it is 8%?
- If it is 11%?



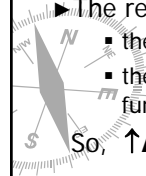
## Investment, $I$

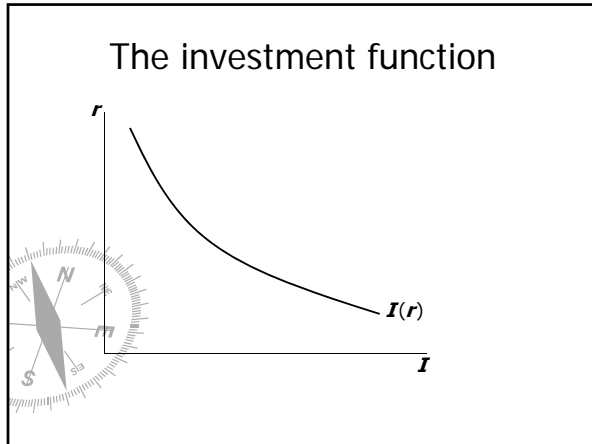
► The investment function is  $I = I(r)$ , where  $r$  denotes the **real interest rate**, the nominal interest rate corrected for inflation.

► The real interest rate is

- the cost of borrowing
- the opportunity cost of using one's own funds to finance investment spending

So,  $\uparrow r \Rightarrow \downarrow I$





### Demand for goods and services

Basic interest rate: short-term and risk-free.

### Demand for goods and services

- Government consumption  
G and T exogenous.  
G=T balanced public budget  
If  $G > T$ , public deficit  
 $G < T$ , public surplus.

### The market for goods & services

- ▶ Aggregate demand:  $C(\bar{Y} - \bar{T}) + I(r) + \bar{G}$
- ▶ Aggregate supply:  $\bar{Y} = F(\bar{K}, \bar{L})$
- ▶ Equilibrium:  $\bar{Y} = C(\bar{Y} - \bar{T}) + I(r) + \bar{G}$

The real interest rate adjusts to equate demand with supply.

### The loanable funds market

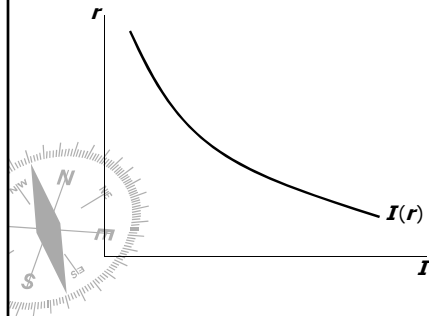
- demand for funds: investment
- supply of funds: saving
- "price" of funds: real interest rate

### Demand for funds: Investment

The demand for loanable funds...

- comes from investment:
- depends negatively on  $r$ , the "price" of loanable funds (cost of borrowing).

### Loanable funds demand curve



### Supply of funds: Saving

- ▶ The supply of loanable funds comes from (national) saving:
  - Private (households') saving
  - Public (government's) saving



### Types of saving

**private saving** =  $(Y - T) - C$

**public saving** =  $T - G$

**national saving,  $S$**

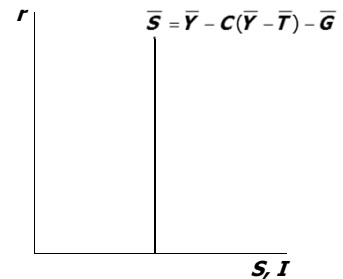
= private saving + public saving

$$= (Y - T) - C + T - G$$

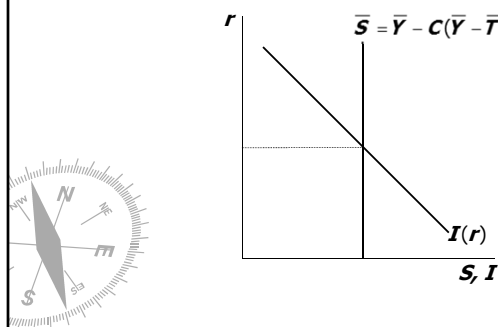
$$= Y - C - G$$



### Loanable funds supply curve



### Loanable funds market equilibrium



### The special role of $r$

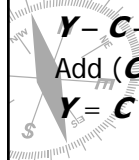
$r$  adjusts to equilibrate the goods market and the loanable funds market simultaneously:

If L.F. market in equilibrium, then

$$Y - C - G = I$$

Add  $(C + G)$  to both sides to get

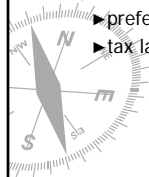
$$Y = C + I + G \text{ (goods market equil.)}$$



## Mastering the loanable funds model

Things that shift the saving curve

- public saving
  - ▶ fiscal policy: changes in  $G$  or  $T$
- private saving
  - ▶ preferences
  - ▶ tax laws that affect saving

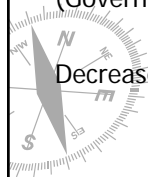


## Equilibrium

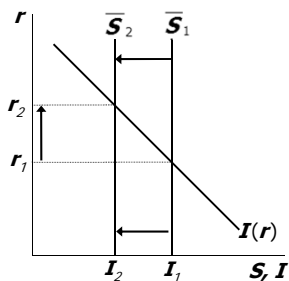
Effects of fiscal policy

Increase in  $G$  = less  $S$  = excess demand  $\rightarrow$   
 $r$  rises  $\rightarrow$   $I$  decreases (crowding out)  
 (Government borrows)

Decrease in taxes similar effects



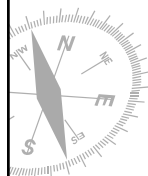
Increase in  $G$  or decrease in  $T$



## Mastering the loanable funds model, *continued*

Things that shift the investment curve:

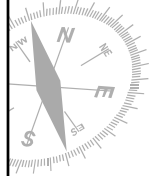
- some technological innovations,
- tax laws that affect investment, ...



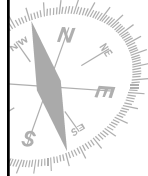
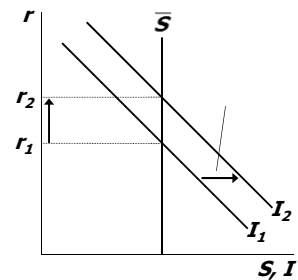
## Equilibrium

Changes in investment demand

at the same  $r$ , larger quantity demanded =  
 excess demand  $\rightarrow$   $r$  increases but quantity  
 traded equals  $S$



An increase in investment demand



## Summary

- ▶ Total output is determined by:
  - the economy's quantities of capital and labor
  - the level of technology
- ▶ Competitive firms hire each factor until its marginal product equals its price.
- ▶ If the production function has constant returns to scale, then labor income plus capital income equals total income (output).

## Summary

- ▶ A closed economy's output is used for:
  - consumption
  - investment
  - government spending
- ▶ The real interest rate adjusts to equate the quantity demanded and supplied of:
  - goods and services
  - loanable funds

## Summary

- ▶ A decrease in national saving causes the interest rate to rise and investment to fall.
- ▶ An increase in investment demand causes the interest rate to rise, but does not affect the equilibrium level of investment if the supply of loanable funds is fixed.