The Classical Model

Chapter 7

Lecture notes posted online

The Classical Model

- Model of output determination and economy-wide equilibrium
- Can be used to study economic growth and business cycles
- Considered a more complete description of the long-run than the short-run

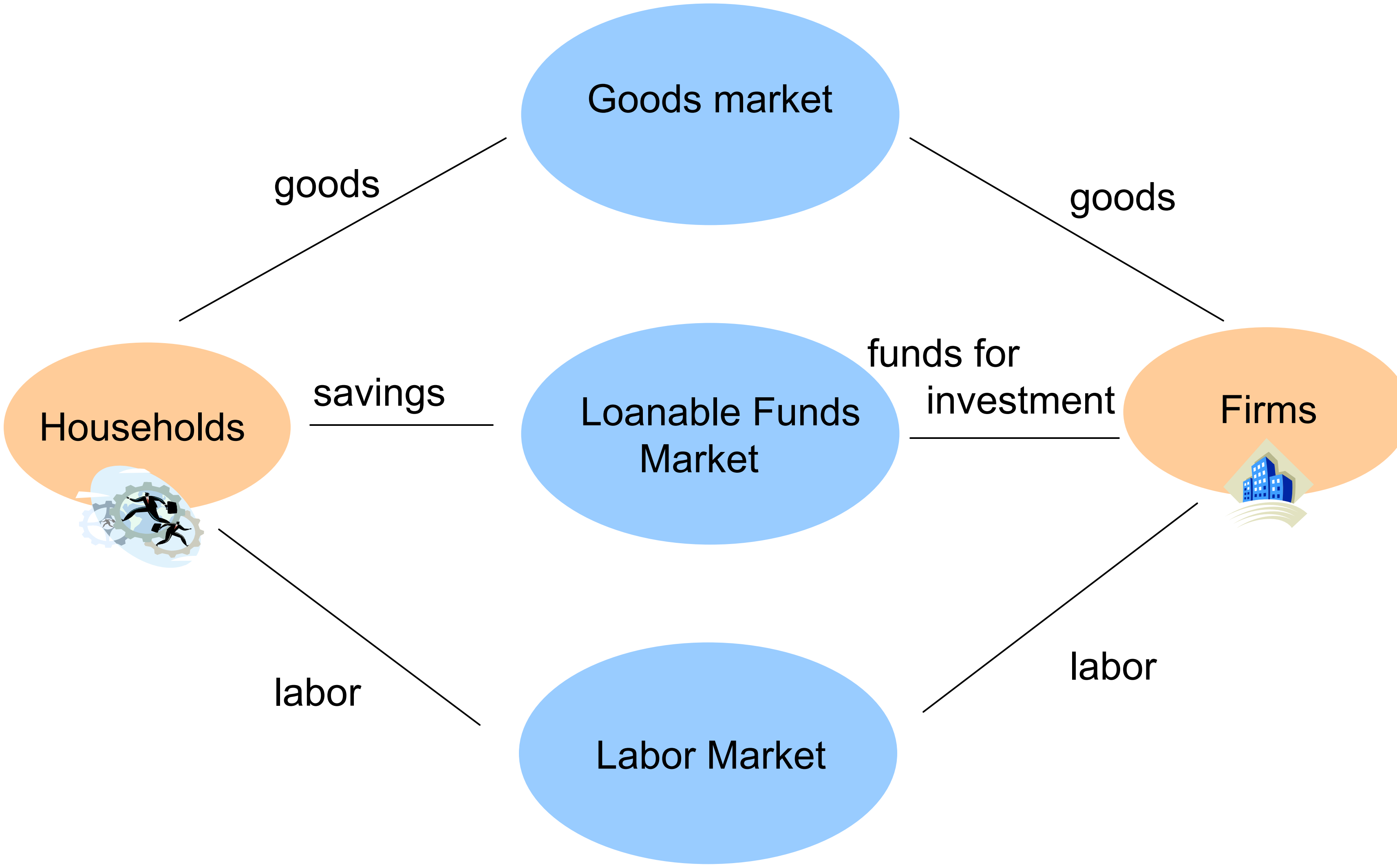
Key Building Blocks

- Closed economy (no exports and imports)
- Populated by two types of agents
  - Households
  - Firms
- (Later will also add government)

Key Building Blocks

- Agents interact in *three* markets
  - Goods Market (GM)
  - Loanable Funds Market (LFM)
  - Labor Market (LM)
- Markets are competitive
  - Like in Econ 101, demand and supply determine the equilibrium outcome

Agents and Markets in Classical Model



Markets

- Goods market is where firms sell their output to households (consumption goods) and other firms (investment goods)
- Loanable funds market is where household save funds for interest, and firms seek funds to finance investment projects
- Labor market is where households offer labor, and firms hire them to produce goods

Households

- Recipients of all factor payments by firms = income
- Make *two* important decisions:
  - Given income, decide how much to save S and consume C
  - Given time endowment, decide how much labor to supply to the market, and how much leisure to consume

Firms

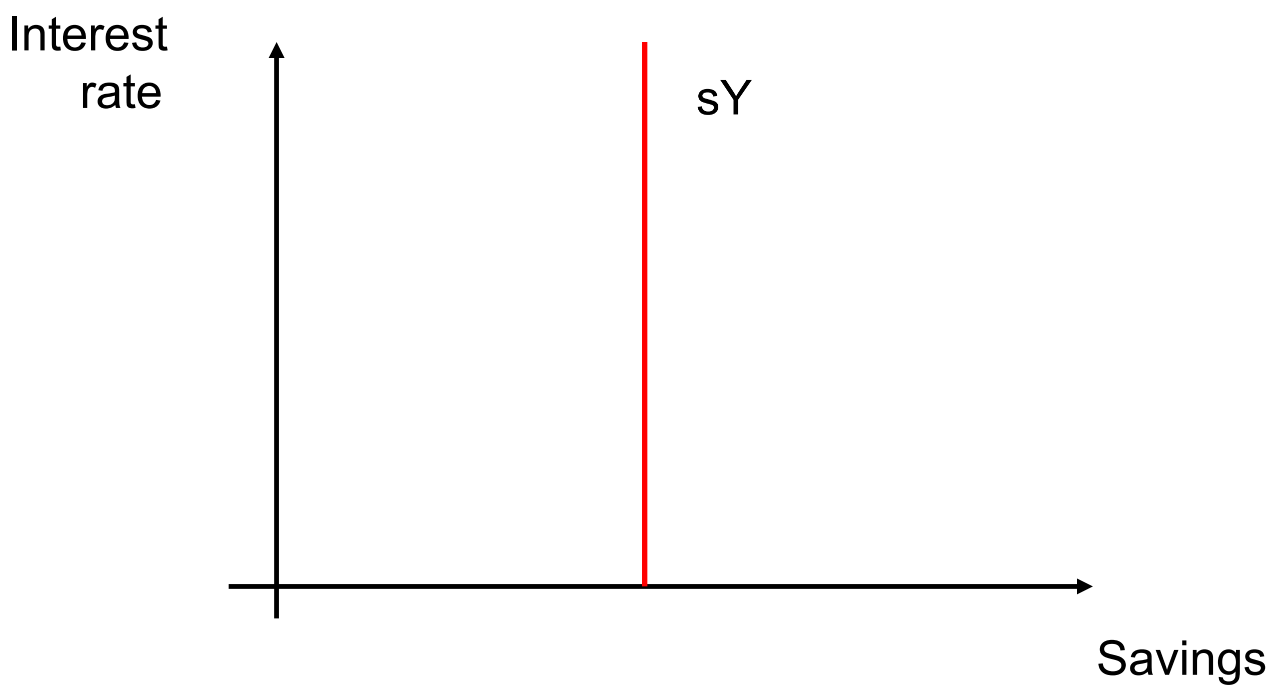
- Produce output using capital (machines) and labor (people)
- Make two important decisions:
  - How much labor to employ
  - How much to invest in new machines, that will result in more capital in the future

Savings/Consumption Decision of HH

- Will assume households decide to save a constant fraction of their income: $S=sY$
  - Implies consumption is also a constant fraction of income: $C=Y-S=(1-s)Y$
  - Example: $s=1/3$, if income is 150, $S=50$, consumption is $C=Y-S=(1-1/3)150=100$

Implied Supply of Savings

- Supply of savings by households as function of interest rate (return on savings)

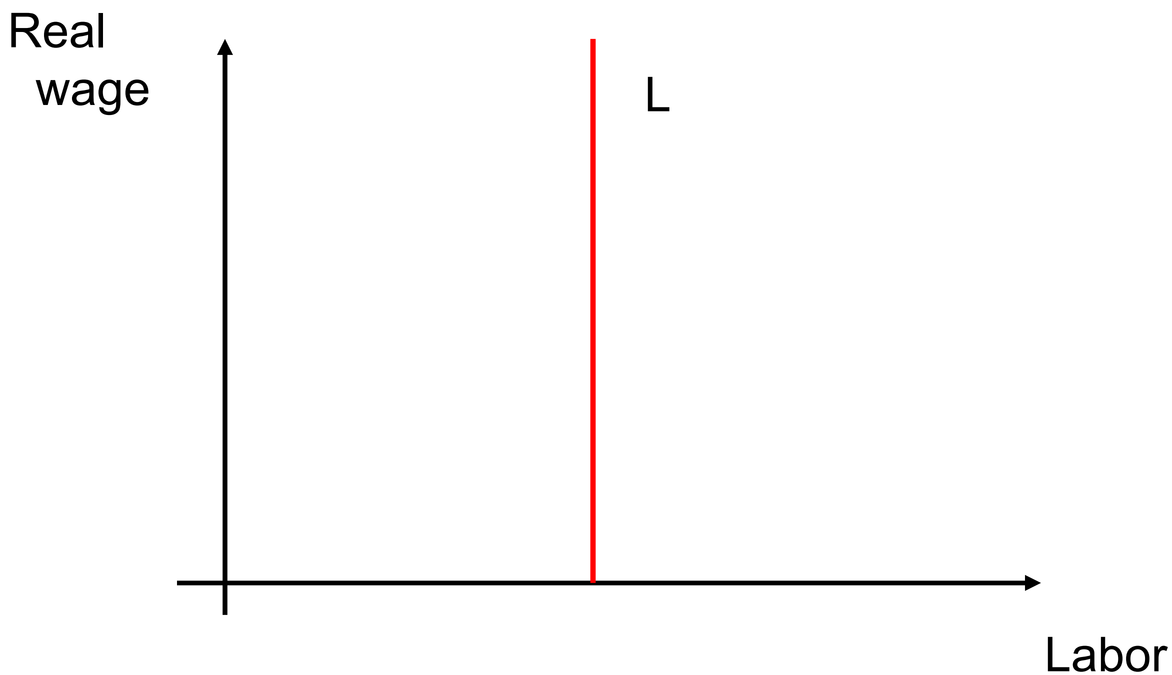


Labor/Leisure Choice of HH

- Assume households supply 1 unit of labor each, and so supply of labor simply equals population size = L

Supply of Labor

- Supply of labor by households as a function of real wage (real compensation of labor)



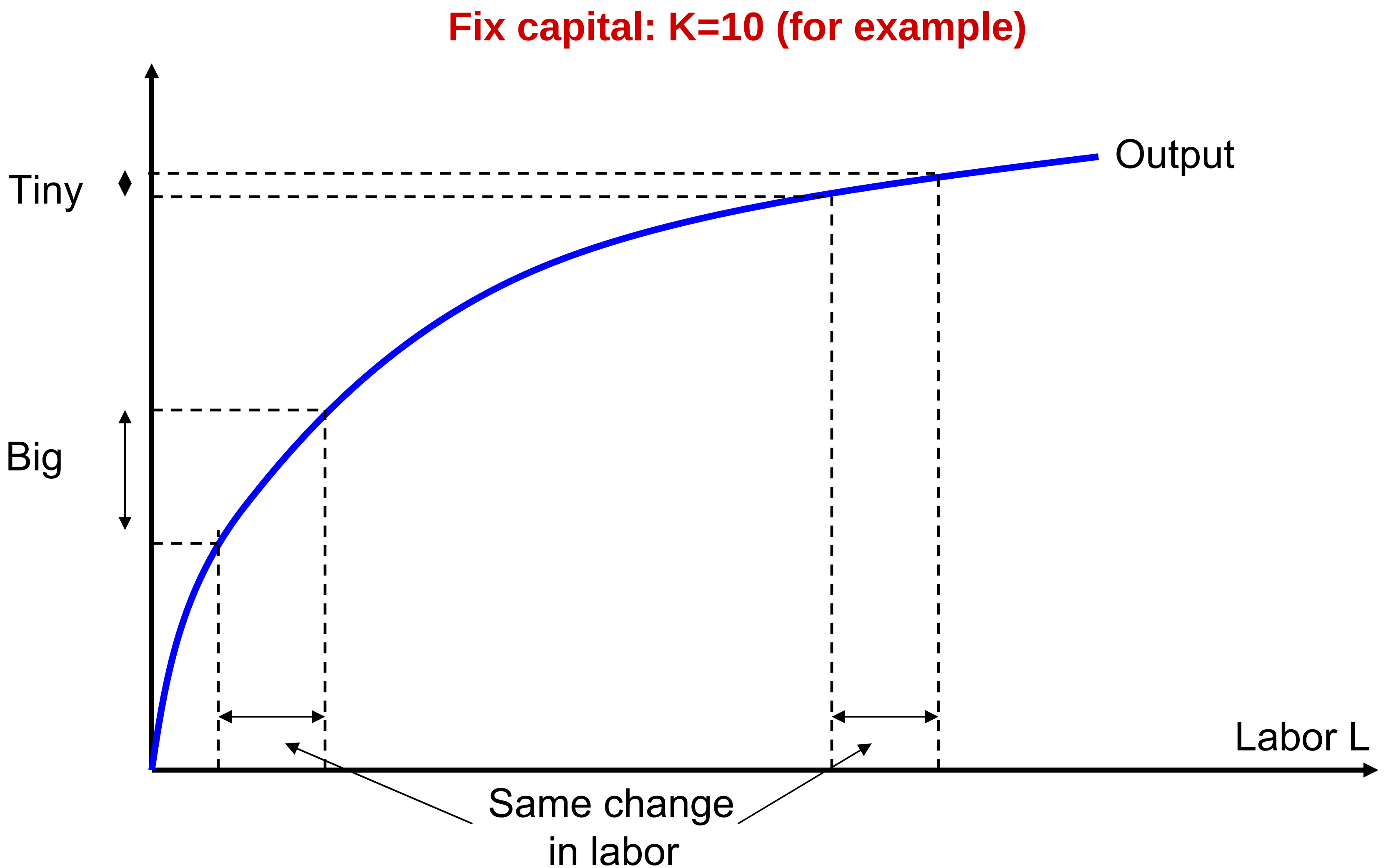
Production in Firms

- Produce output using capital (machines) K and labor (people) L
  - Production summarized is by a production function
  - Example: $Y = \sqrt{KL}$
- Assumed properties of the production function:
  - Output increasing in labor and capital
  - Diminishing returns from labor and capital
  - Returns to scale are constant

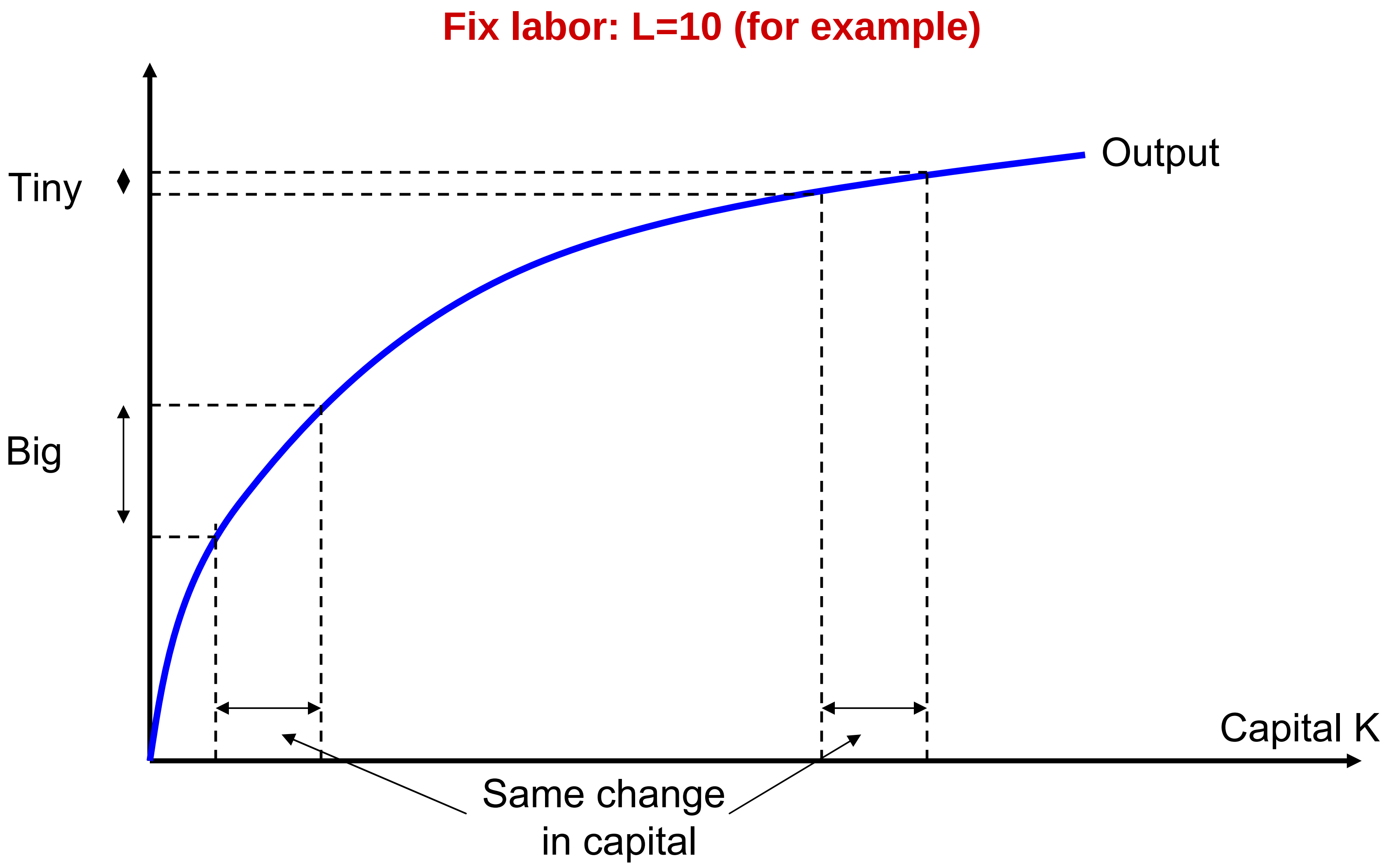
Properties of Production Function

- Increasing in labor and capital
  - Add labor or capital → output will increase
- Diminishing returns from labor and capital
  - Add labor while keeping capital fixed → output increases, but increments smaller and smaller as you keep adding more and more labor
- Returns to scale are constant → production process is replicable – double labor and capital, and output will *exactly* double

Diminishing Returns From Labor



Diminishing Returns From Capital

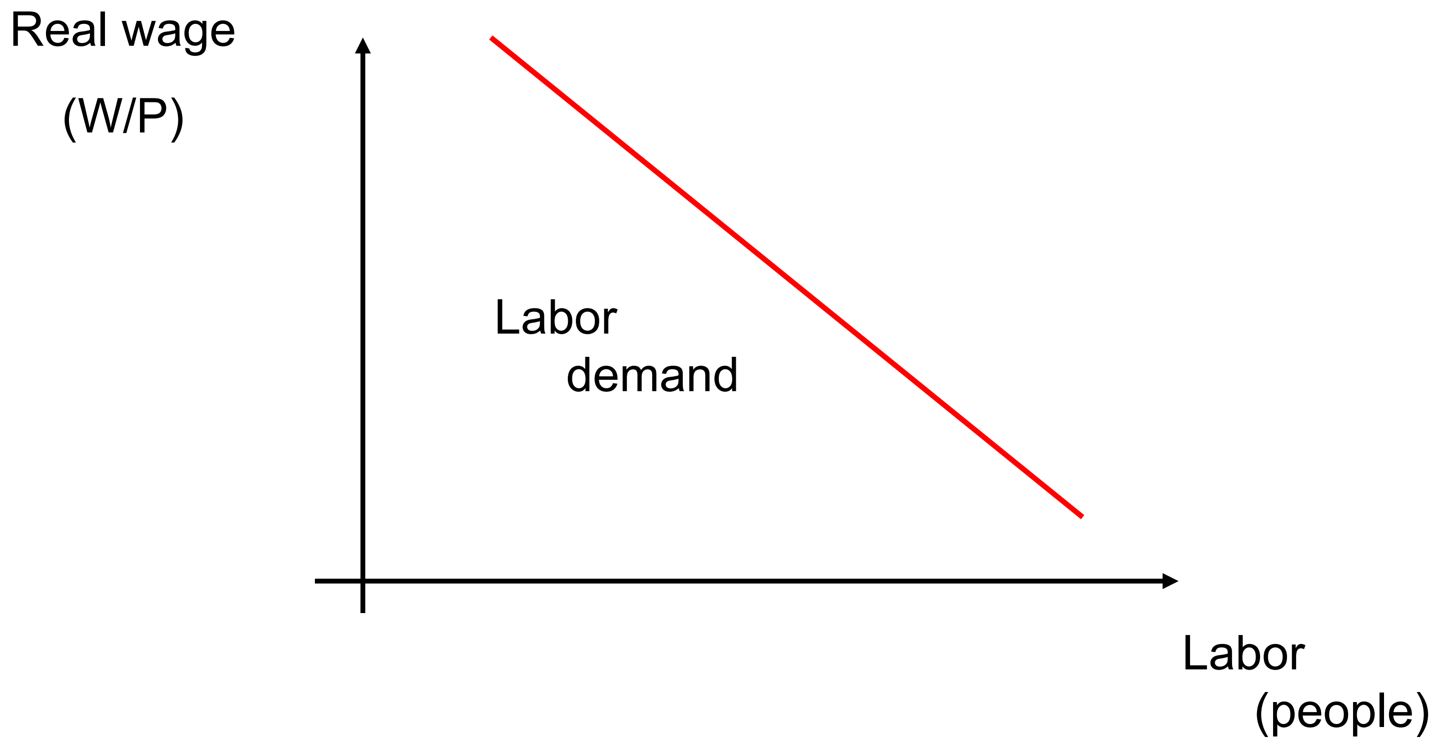


Demand for Labor

- Diminishing returns from labor → demand for labor decreasing function of real wage
  - Given a fixed level of capital K, each incremental worker adds *less and less* to production
    - Cost of hiring a worker increases → firms are willing to hire *fewer* workers

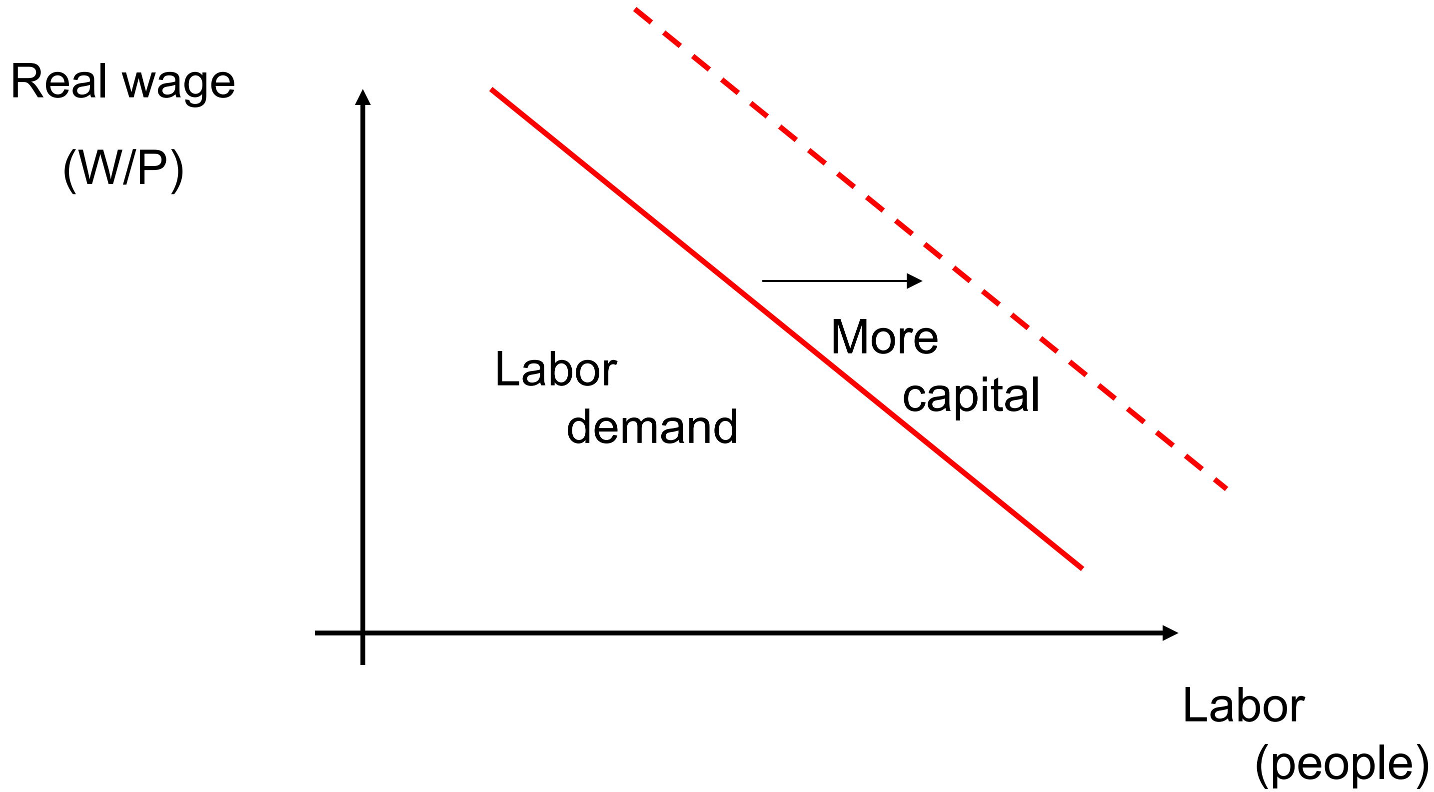
Demand for Labor

- Demand for labor (for a fixed level of capital K)



Demand for Labor

- Increase in capital K shifts labor demand

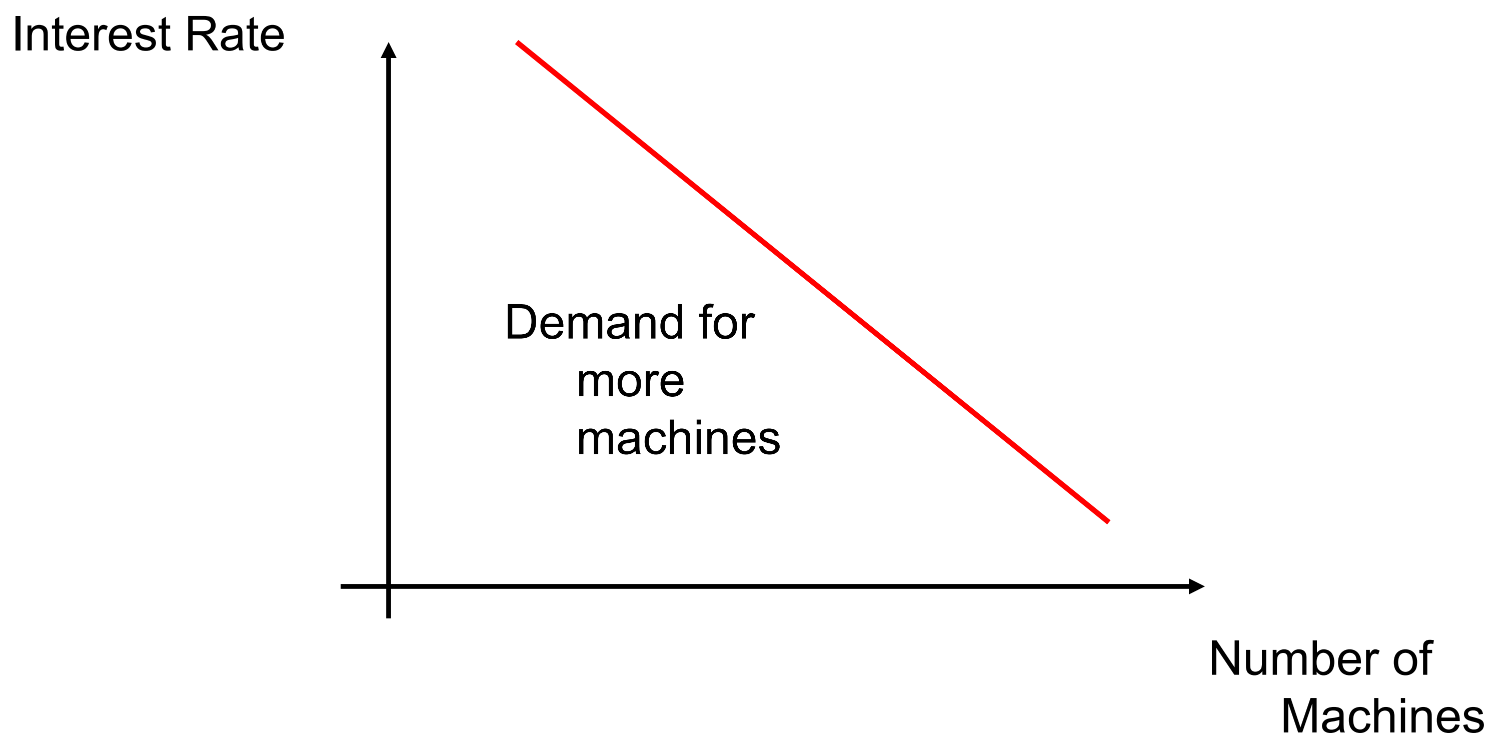


Demand for Investment (Funds)

- Diminishing returns from capital → demand for investment decreasing function of interest rate
  - Given a fixed level of labor L, each incremental unit of capital adds less and less to production
    - Cost of funds increases → firms want to invest less

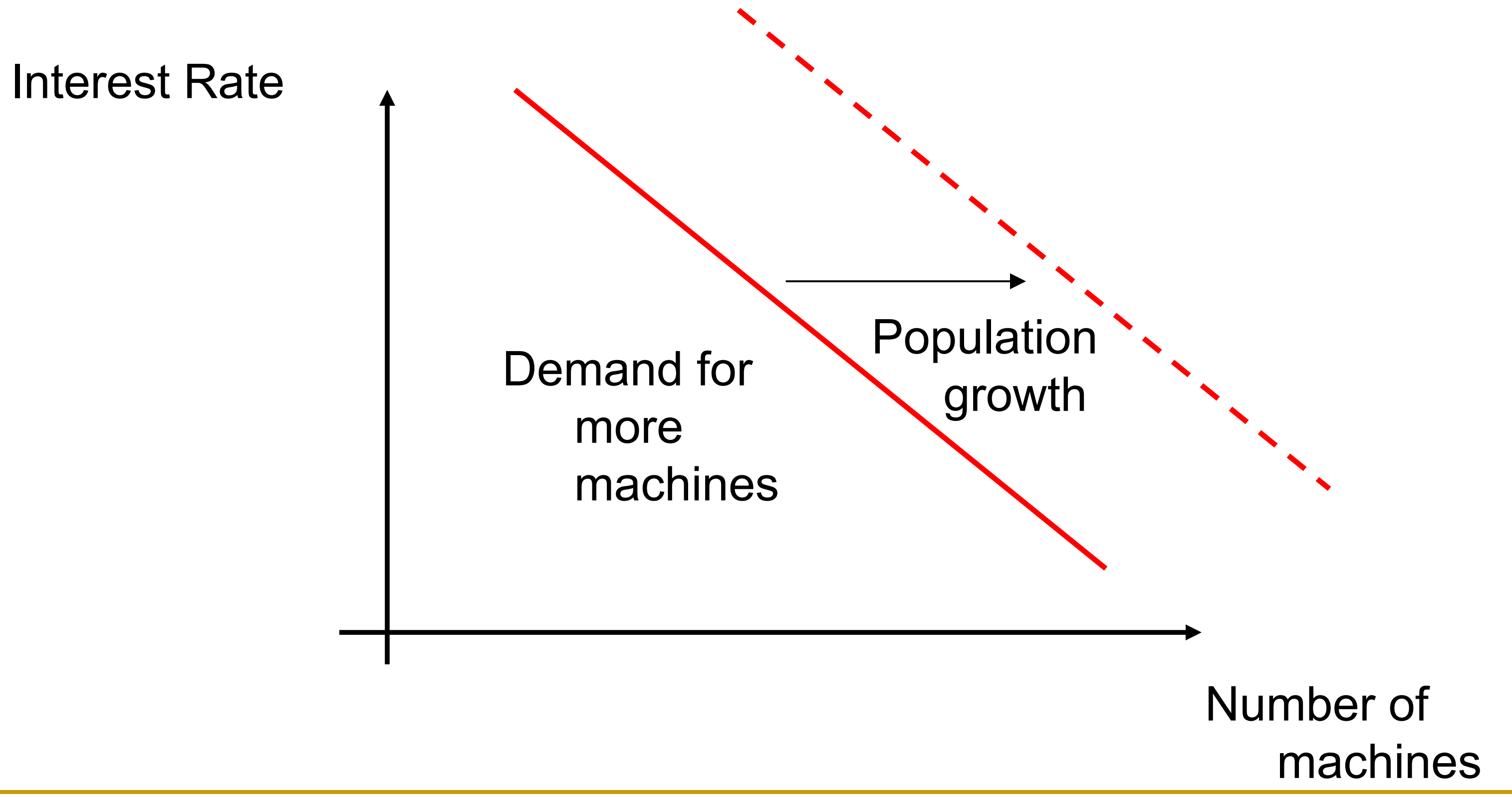
Demand for Investment (Funds)

- Demand for funds (for a fixed level of labor)



Demand for Investment (Funds)

- Increase in labor force (here=population) shifts demand for investment



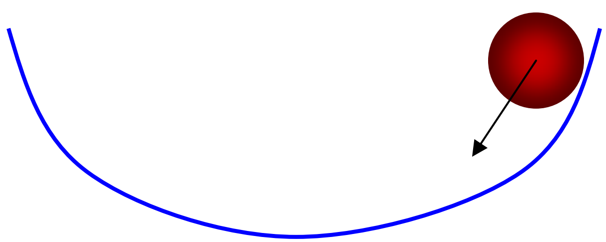
Recap

- So far, determined demand and supply in
  - Labor market
  - Loanable funds market
- Now, need to answer what will be the outcome in the entire economy

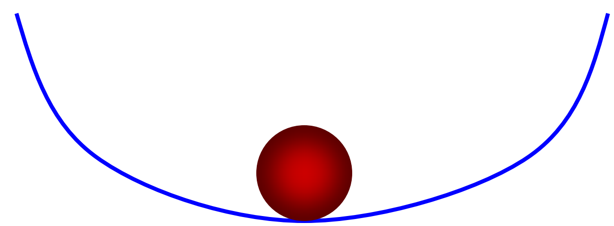
What is Going to Happen?

- Equilibrium of a system is a state of the system in which there are no internal forces in the system to produce a change

This is *not* an equilibrium



This is an equilibrium

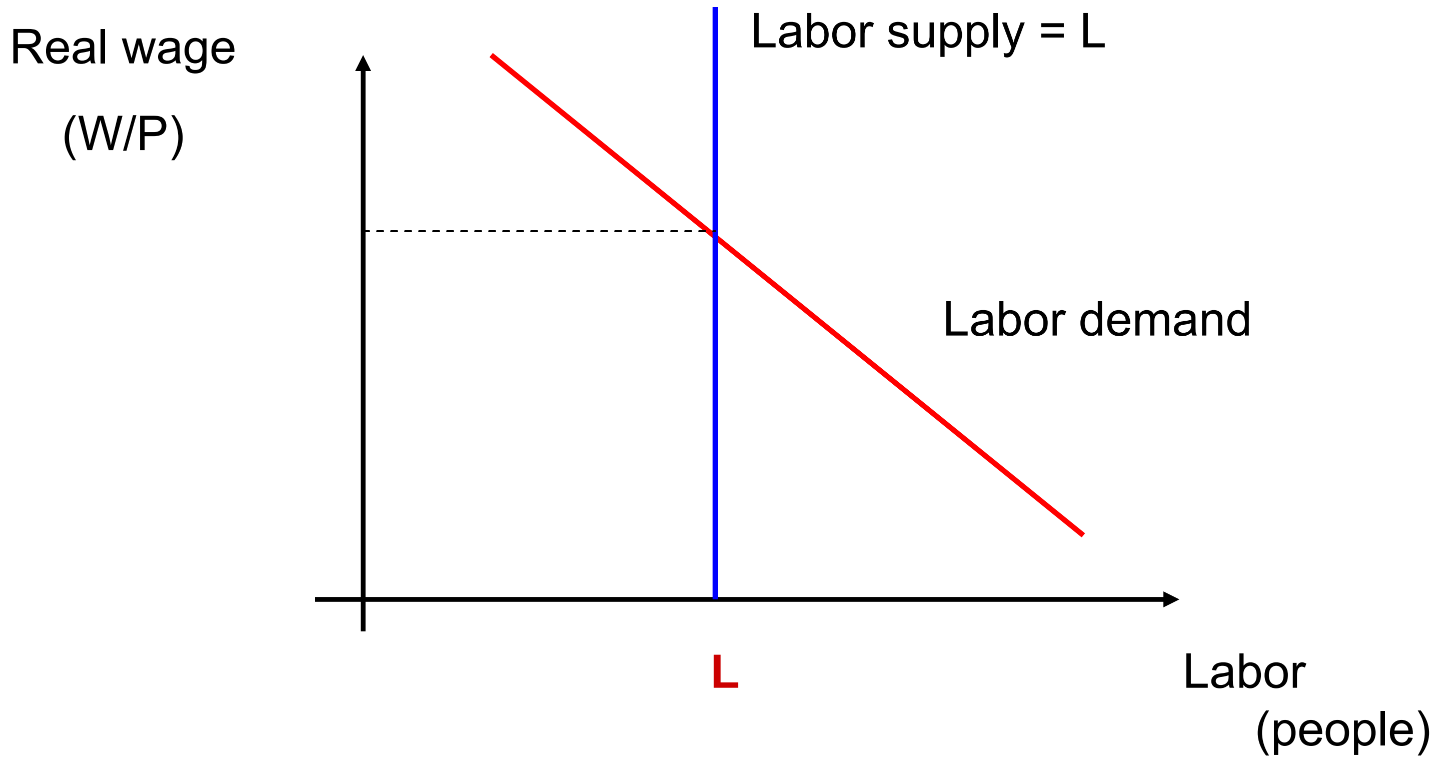


What is Going to Happen?

- Equilibrium in this model is when all markets clear
  - Demand for labor = supply of labor
  - Demand for investment = supply of funds
  - All output gets sold, i.e. planned consumption and planned investment equals output (C+I=Y)

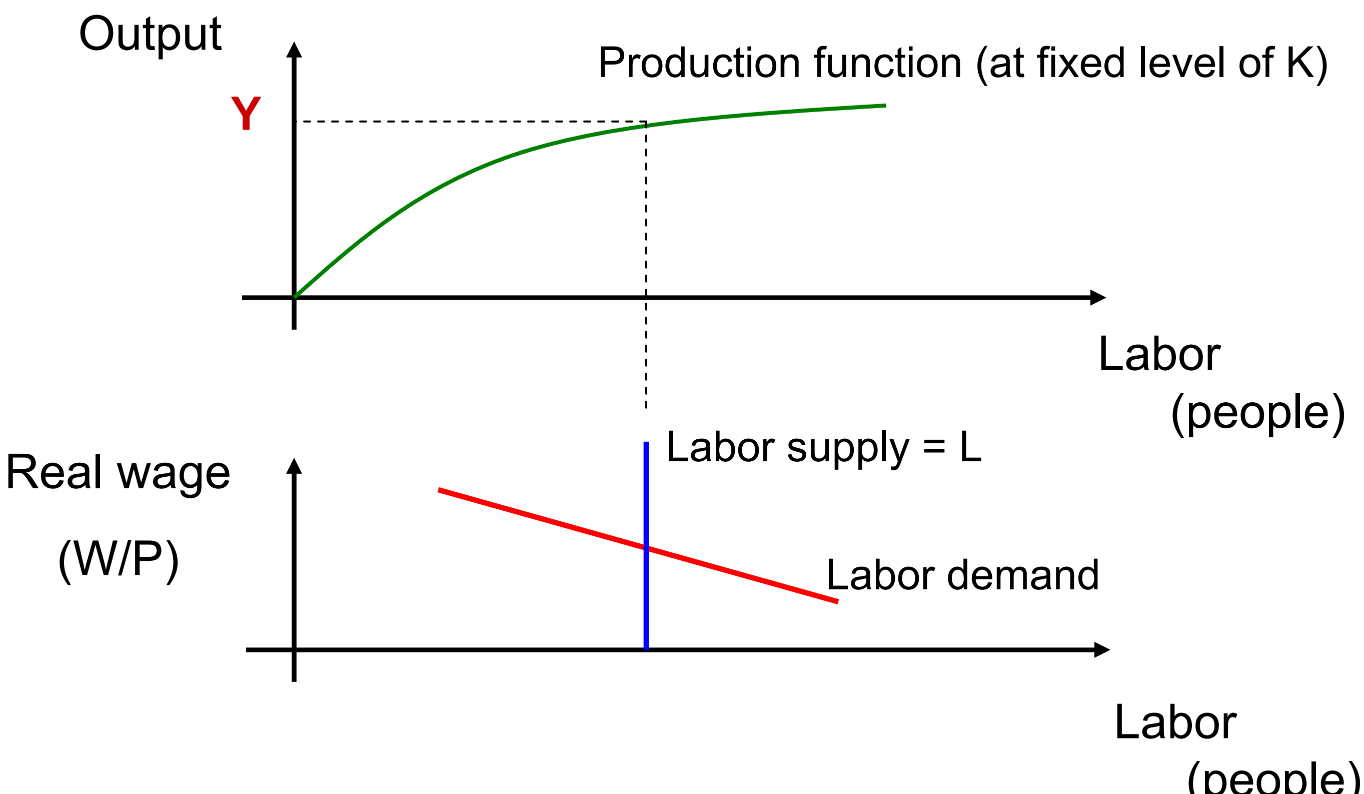
Equilibrium Employment *L*

- Labor market equilibrium determines L



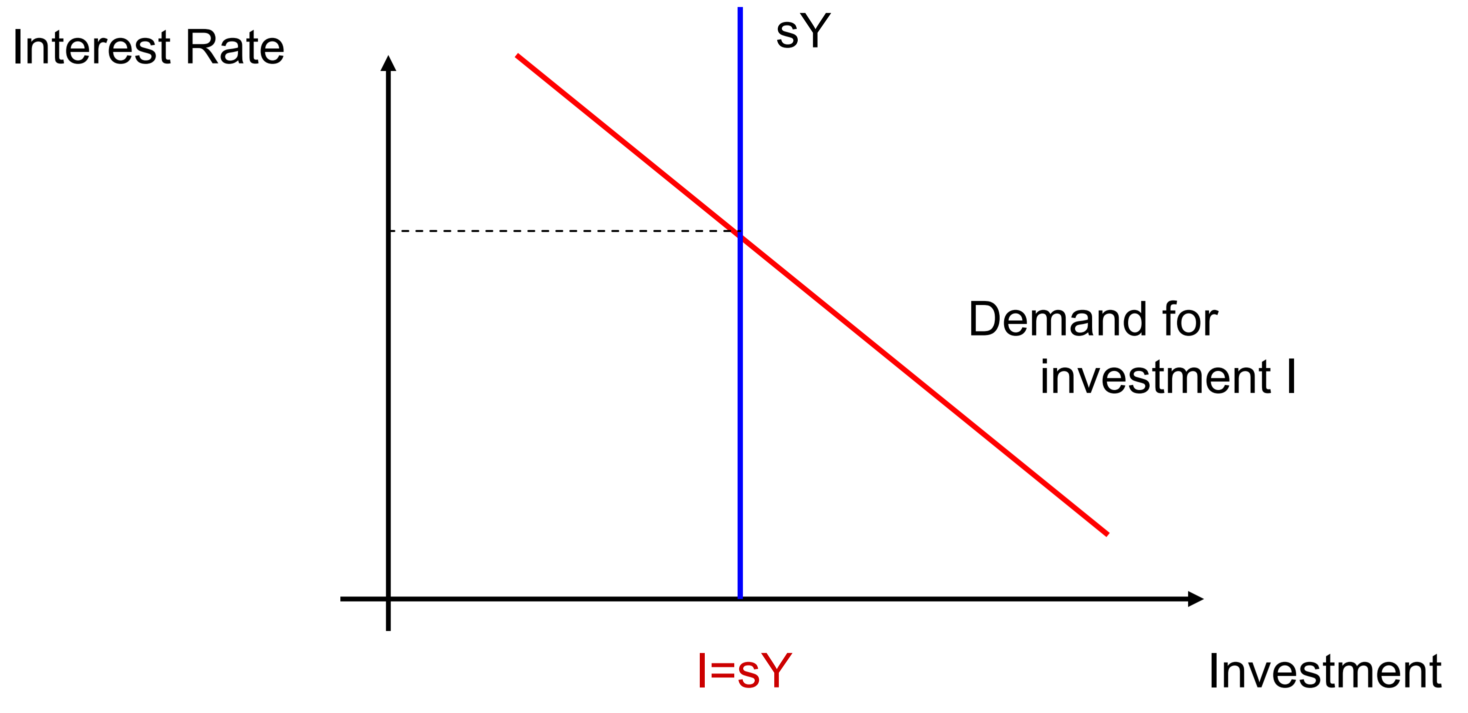
Equilibrium Output *Y*

- Y determined by L (capital K predetermined)



Equilibrium (Planned) Investment *I*

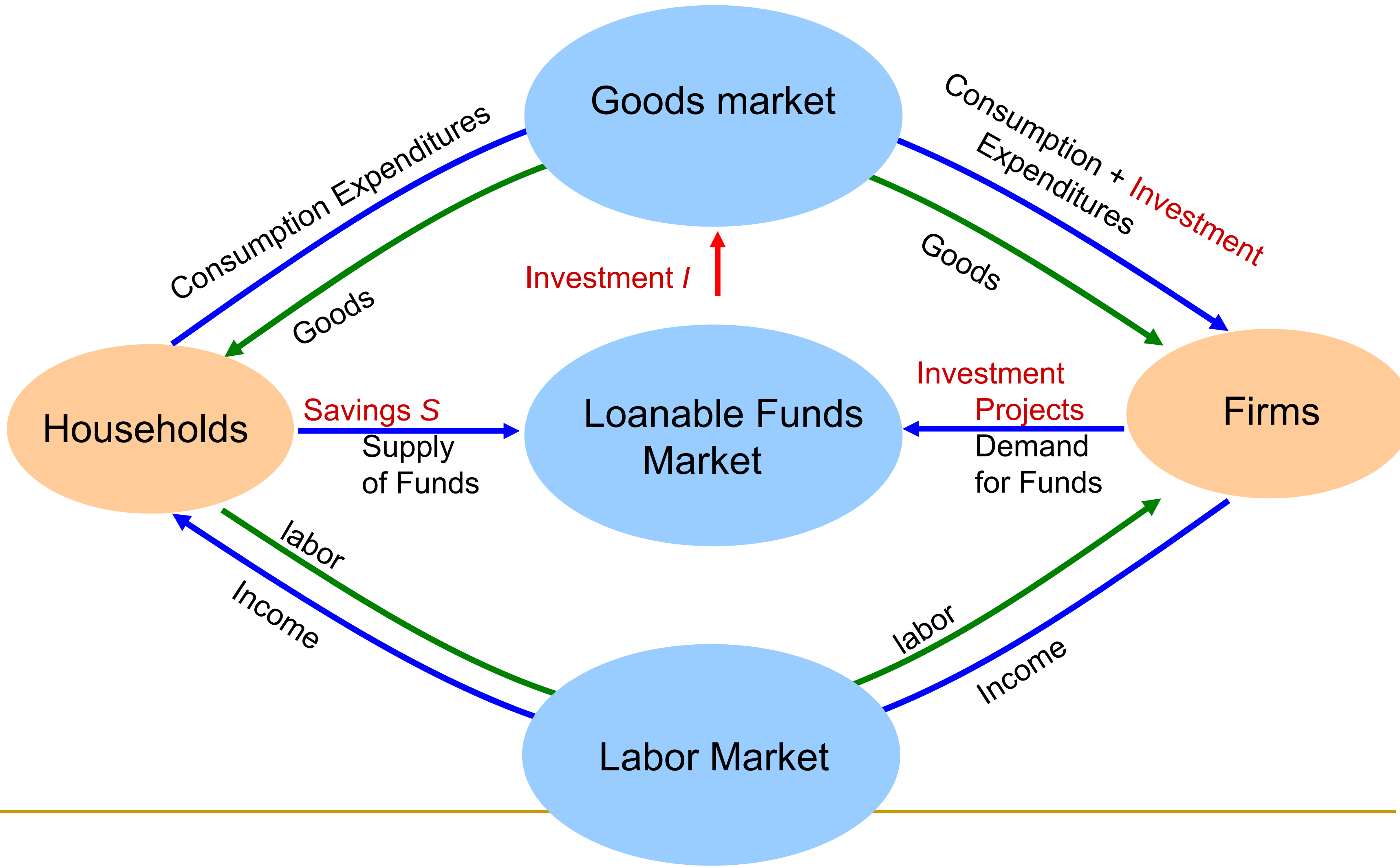
- Loanable funds market determines investment I



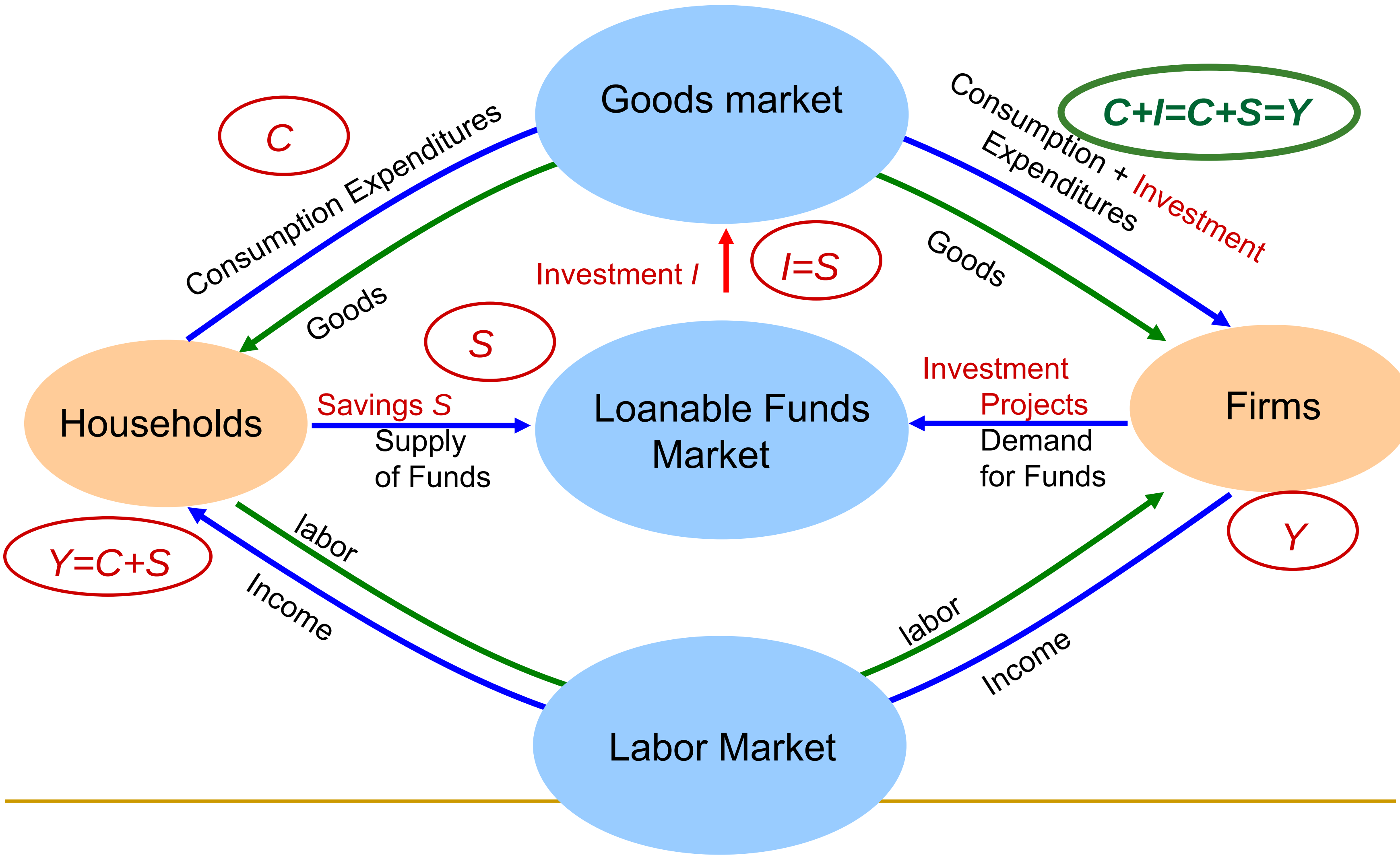
Say's Law: Spending Purchases Output

- In the classical model, all output gets sold automatically, and so C+I=Y
- We do not need to worry about the goods market
  - Follows from a simple accounting identity implied by the circular flows

Circular Flows in the Classical Model



Say’s Law: Outflows = Inflows



Say's Law: Outflows = Inflows

- Y flows from firms to households (by definition Y=C+S)
- On the expenditure side
  - S flows out
  - I flows in
  - Since in equilibrium in the loanable funds market S=I, outflows = inflows, and so C+I = Y

What Happens to Capital K?

- Today's K predetermined, but future K evolves with investment
  - Capital tomorrow = capital today – depreciation of capital + investment

$$K_{tomorrow} = (1-\delta)K_{today} + I$$

- Where δ is depreciation rate of capital (fraction of capital worn out in production)

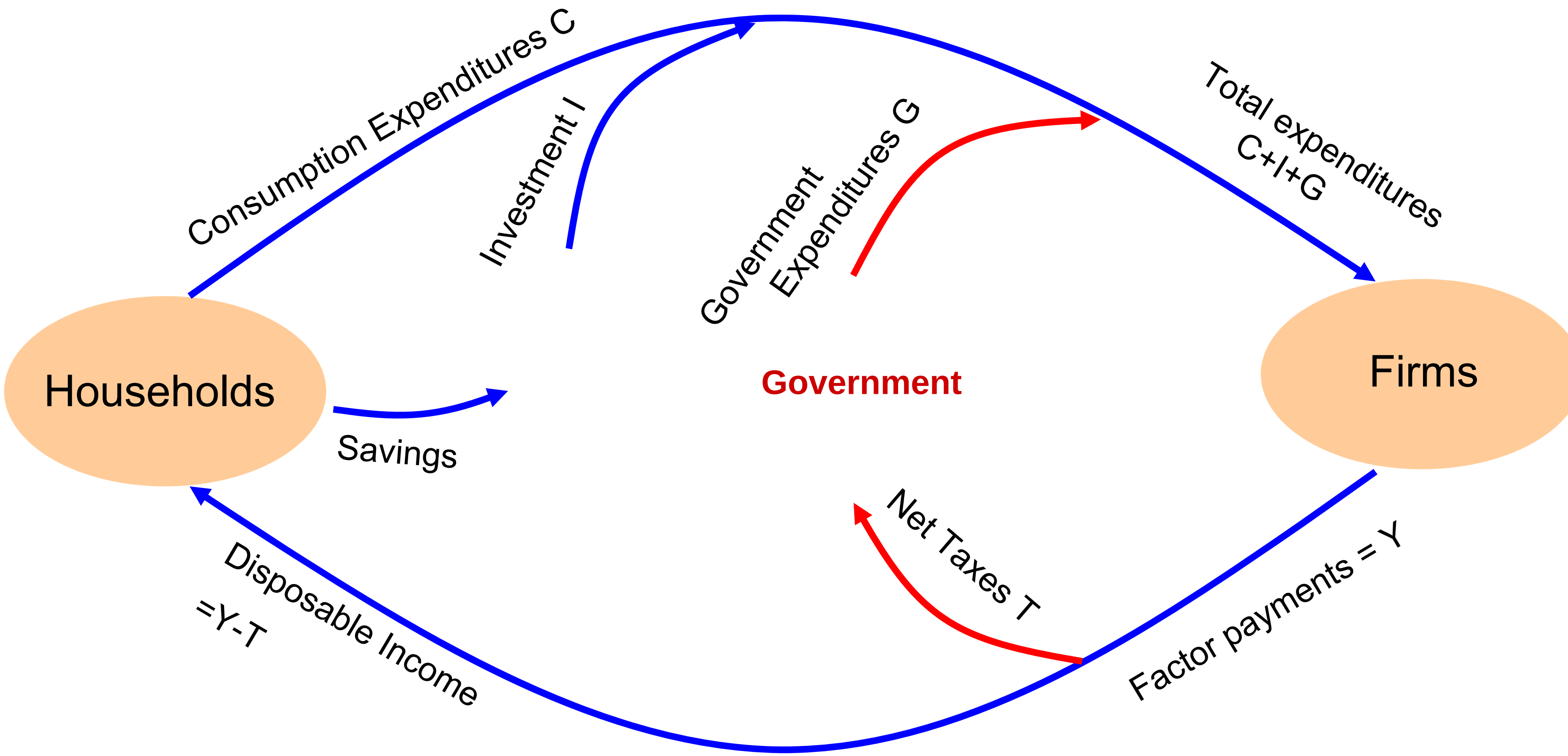
What Happens to Capital K?

- Our equilibrium is a static equilibrium
  - Given capital, we pin down investment, employment and output
- It raises questions where the economy is heading in the future
  - Will make capital part of our analysis soon

Adding Government to the Model

- Key assumptions:
  - Government takes away net taxes T from households factor income Y and spends G in the goods market on goods and services

Adding Government to the Model



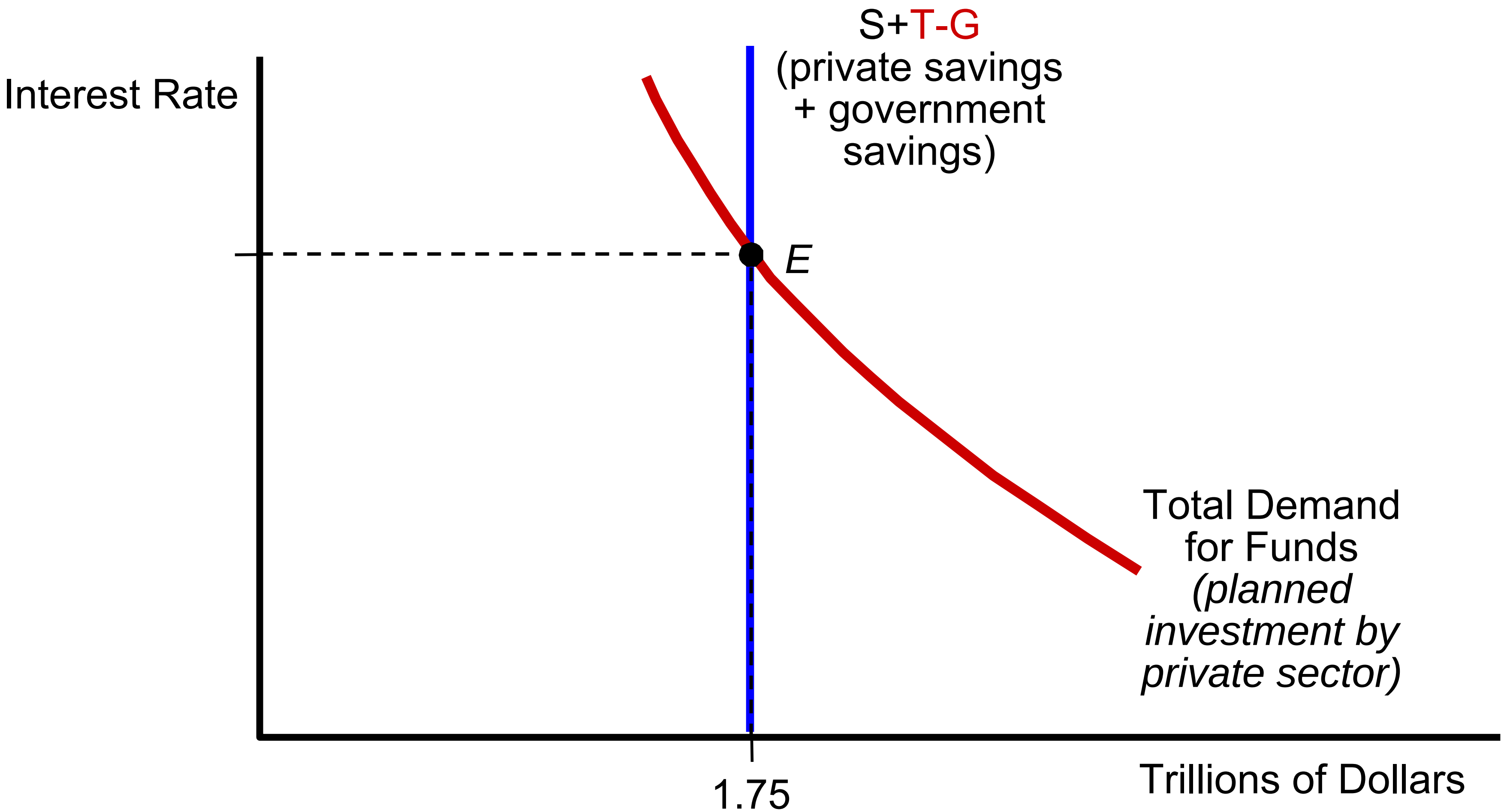
Key Modifications

- Government savings T-G (or deficit if negative) *affects* the loanable funds market
  - When T-G>0, governments saves and supplies funds to the LF market
  - When T-G<0, government borrows from the private sector and takes away funds from LF market
- Households' after tax income is *Y-T*

Budget Deficit and Surplus

- Budget deficit is a situation when government spending exceeds net tax receipts $G\text{-}T>0$
  - Government borrows in the loanable funds market
- Budget surplus is a situation when government net tax receipts exceeds spending $T\text{-}G>0$
  - Government saves in the loanable funds market

Modified Loanable Funds Market

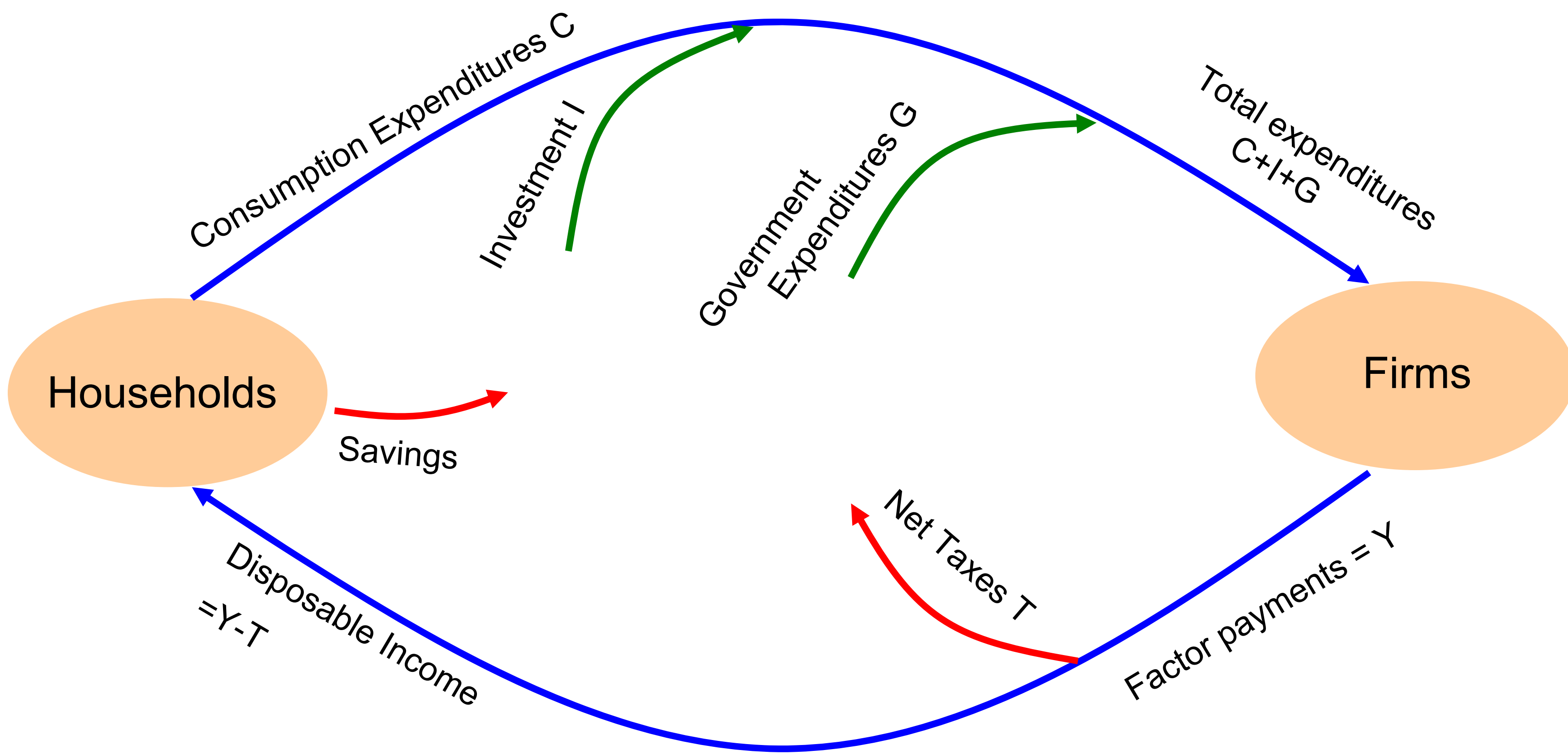


S+T-G=I

Say's Law Holds with Government

- Again, think in terms of inflows and outflows
  - Y flows from firms to households
  - S and T flows out
  - I and G flows in
  - S+T-G=I in equilibrium in loanable funds market
- So, again, what flows out S+T, flows in as I+G, and so C+I+G=Y
  - Algebraically, C+I+G=C+S+T-G+G=C+S+T=Y

Say's Law Holds: Red = Green



Numerical Example

- Suppose, G=0, T=0, s=.2, L=10, K=10, and $Y=K^{1/2}L^{1/2}$, calculate output and investment in the equilibrium of the classical model
- Assume depreciation rate of capital = 10% (10% of capital stock wears out each period due to aging). What will be the level of capital next period?
- Is it more or less than today?

Solution

- $Y=K^{1/2}L^{1/2}=10$
- S=s(Y-T)=.2x10=2
  - In equilibrium, I=S+T-G, and so I=2
- K tomorrow = .9K today + 2 = .9x10+2=11
- 11>10, K is growing
  - K today = 10
  - K tomorrow = 11

Dynamic (Long-run) Equilibrium

Dynamic Equilibrium

- So far, silent about K
  - Given predetermined capital K, determined: output, investment and employment
  - In other words, determined static equilibrium (within a period)…but not dynamic (across periods)
- Our goal: Find out where the economy is heading in the future?

Basic Idea

- Future output, investment and employment depends on today's investment
- Evolution of capital from one period to the next critical to determine where the economy is heading

Evolution of Capital

- Recall our assumption:

$$K_{tomorrow} = (1-\delta)K_{today} + I$$

- IMPLIES: Future capital depends how investment *I* compares to depreciation δK

$$K_{tomorrow} = (1-\delta)K_{today} + I = K_{today} - \delta K_{today} + I,$$

and so, $K_{tomorrow} - K_{today} = I - \delta K_{today}$

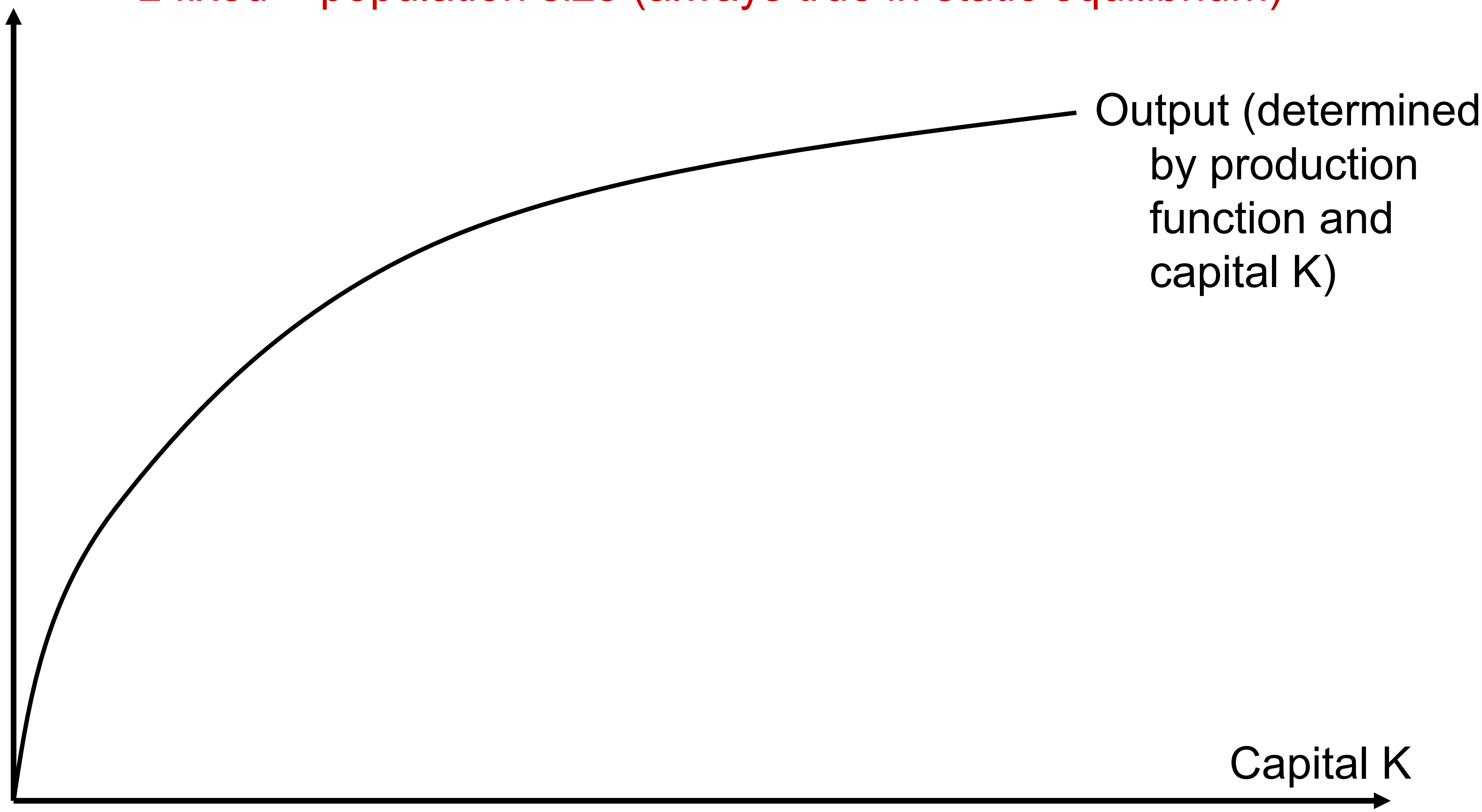
Evolution of Capital

$$K_{tomorrow} - K_{today} = I - \delta K$$

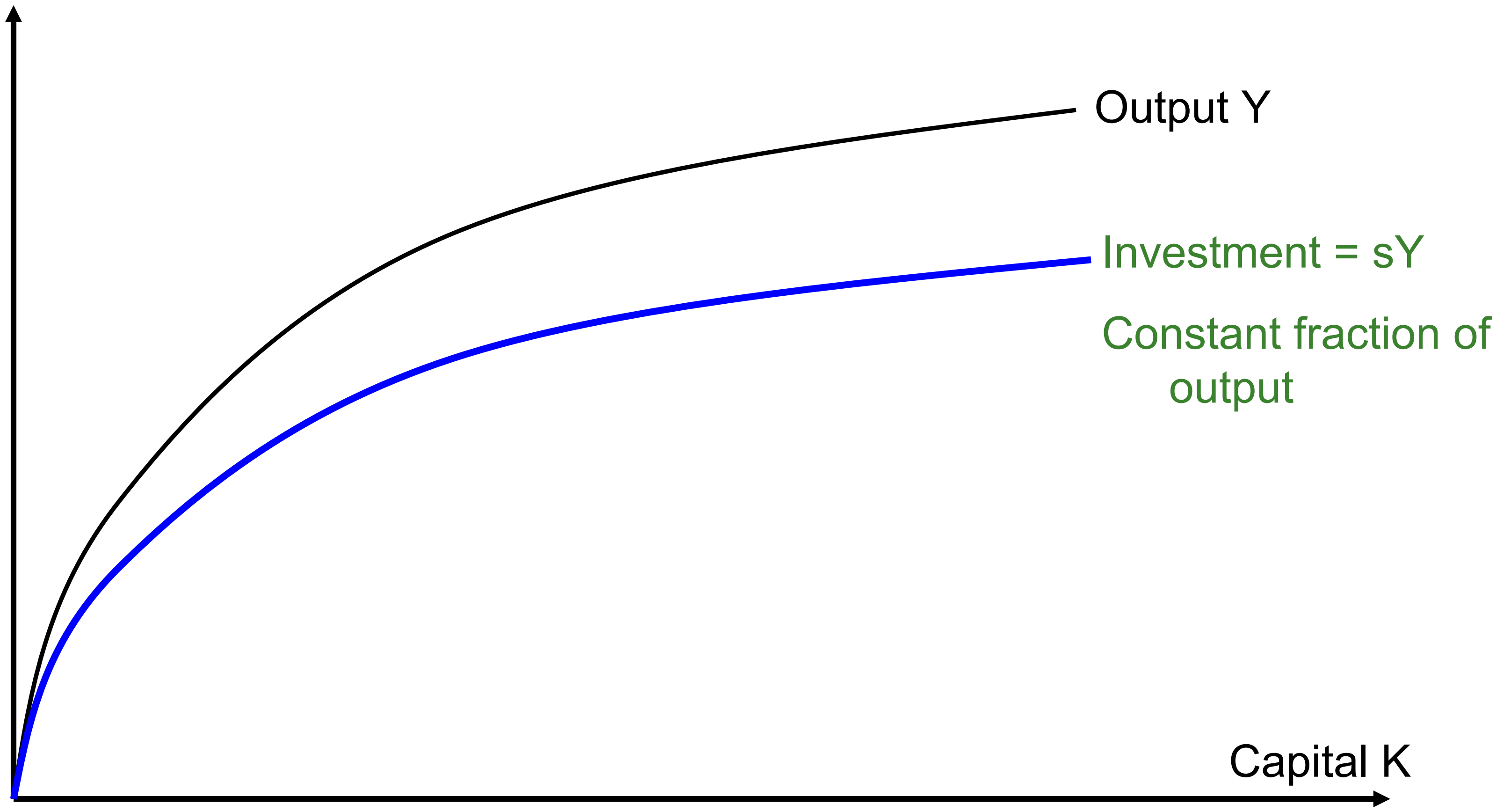
- The above equation implies:
  - $I > \delta K_{today}$ → capital K *grows*
  - $I < \delta K_{today}$ → capital K *falls*
  - $I = \delta K_{today}$ → capital K remains *unchanged*

Finding Out Where Economy Is Heading

L fixed = population size (always true in static equilibrium)



Finding Out Where Economy Is Heading



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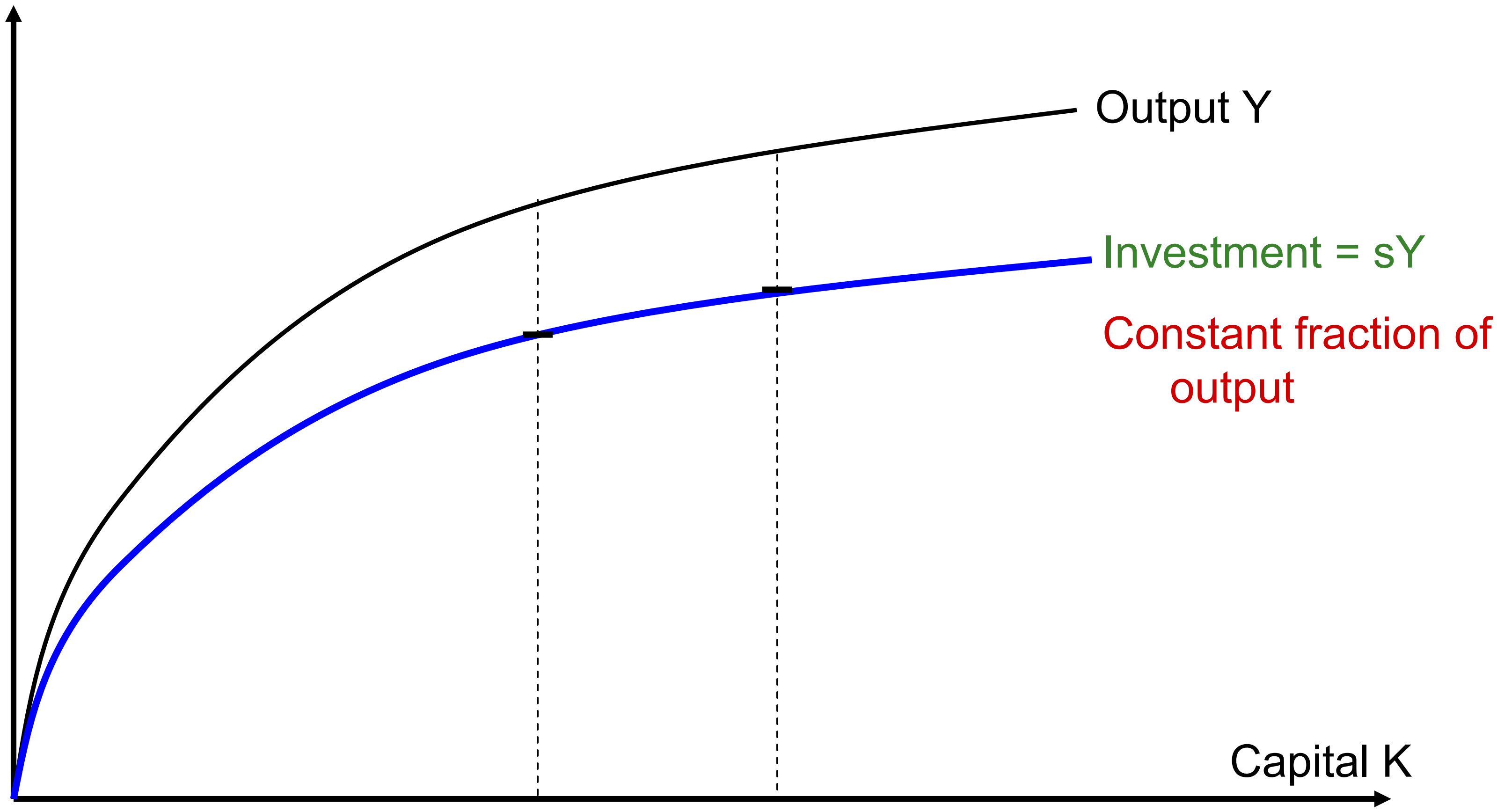

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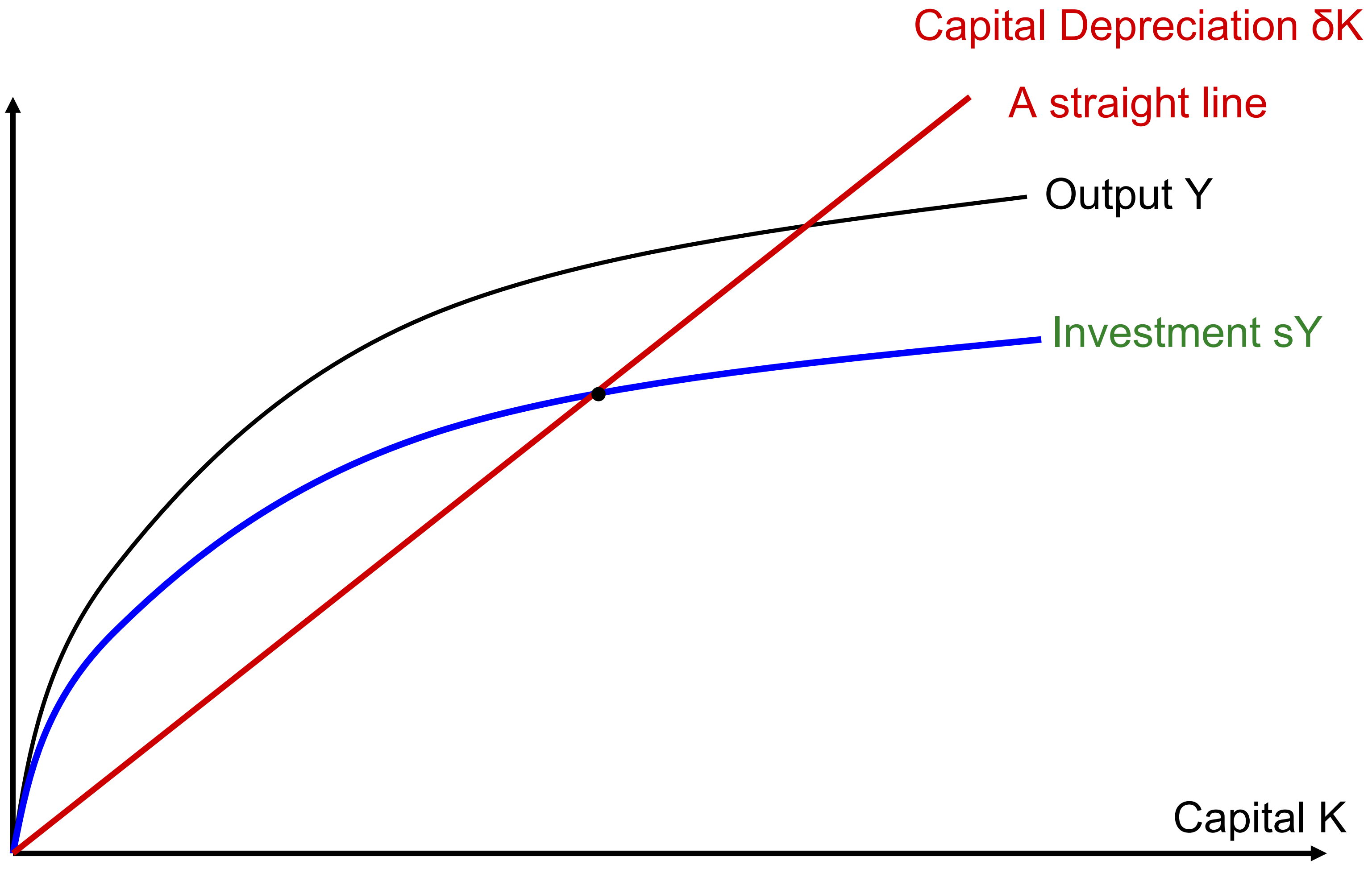

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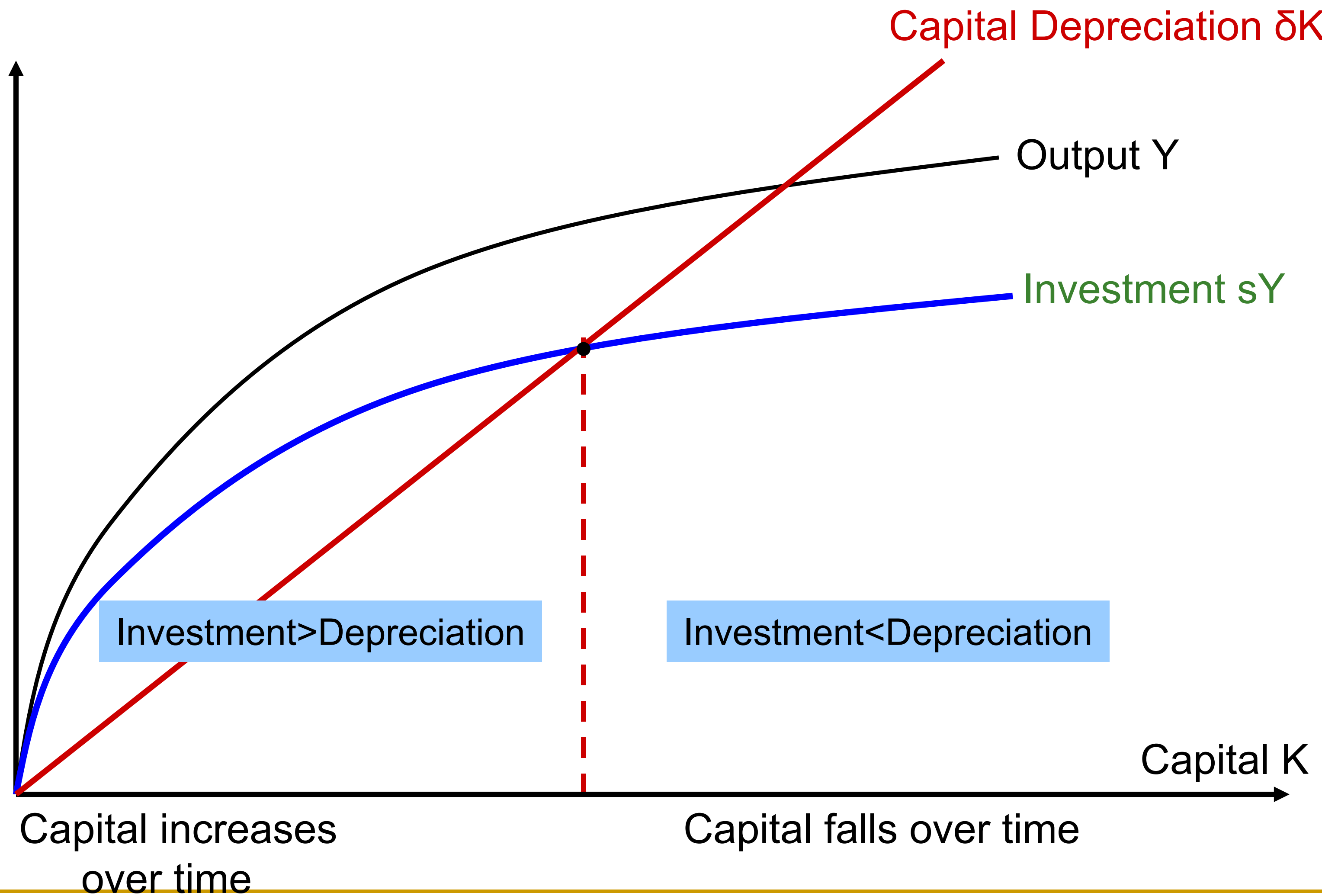

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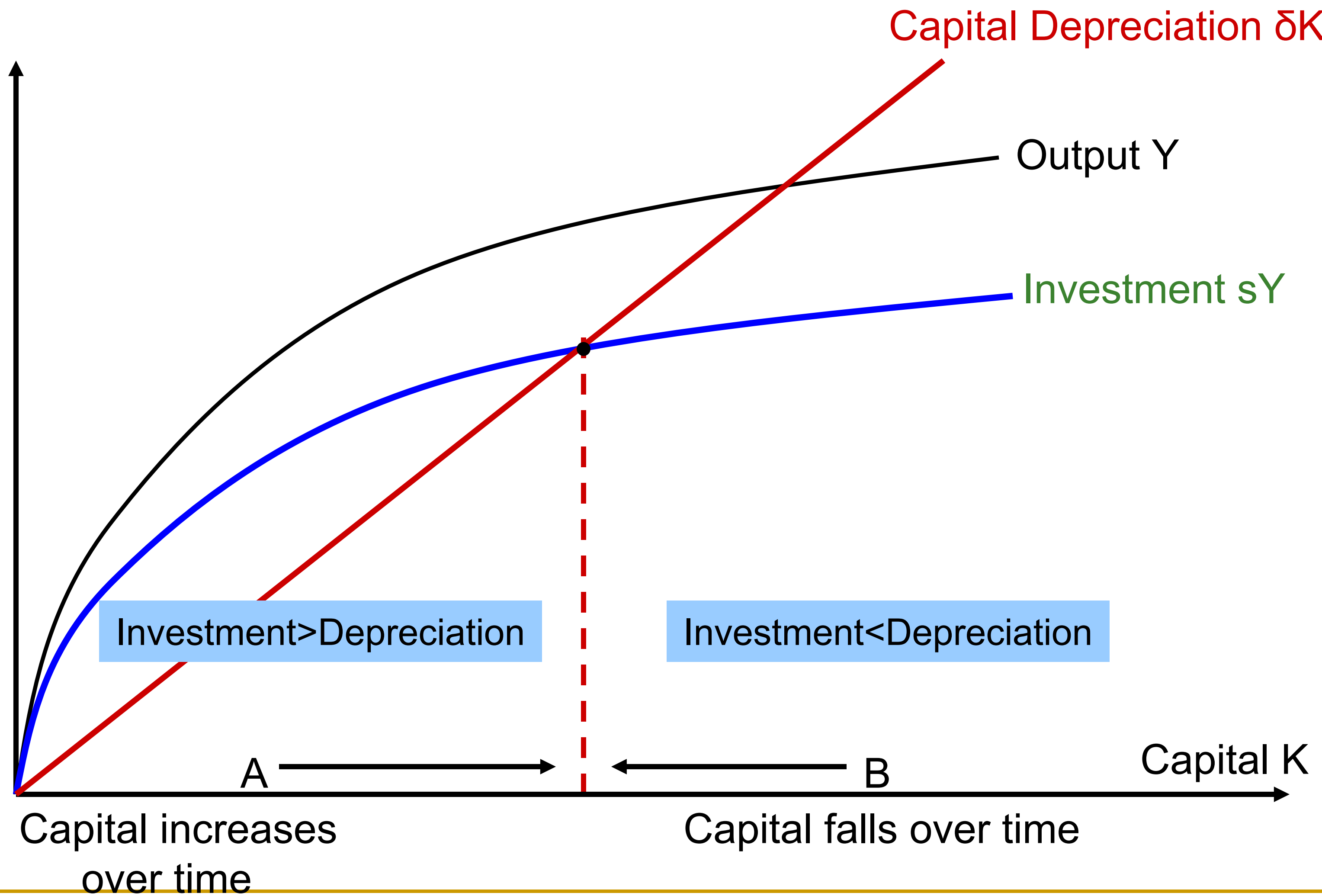

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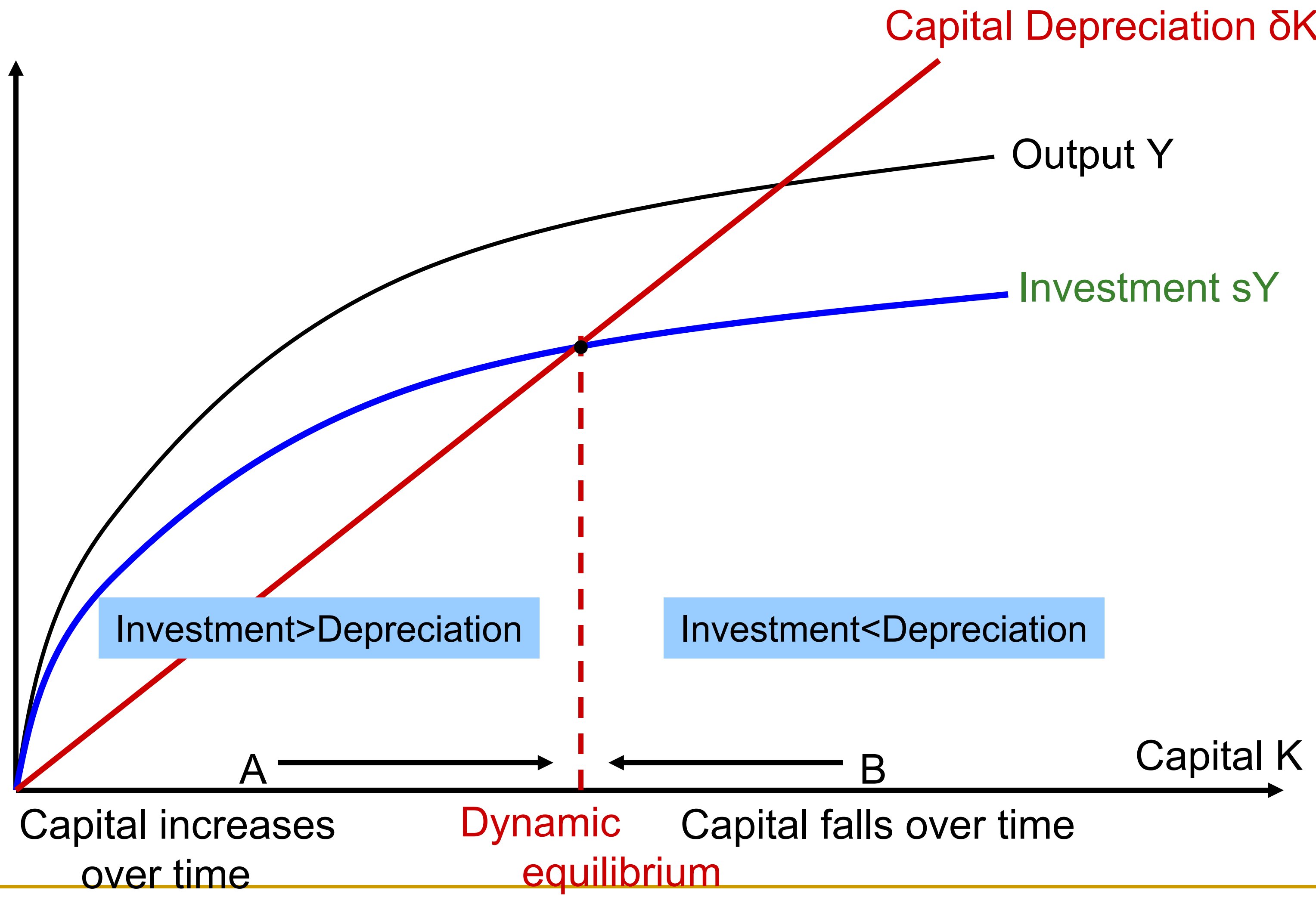


What Is Dynamic Equilibrium?

- Recall: Given predetermined level of capital K, static equilibrium is employment, output and investment such that all three market are in equilibrium
- Dynamic equilibrium is the level of capital K such that in the underlying static equilibrium investment *I* = depreciation of capital δK

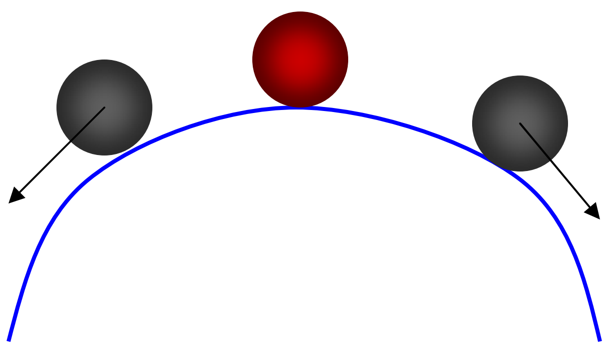
Key Properties of Dynamic Equilibrium

- Dynamic equilibrium is an equilibrium as there are no internal forces to produce a change
  - You start there, you stay there forever
- But, it is also a stable equilibrium
  - No matter where you start, internal forces bring you back to this this point

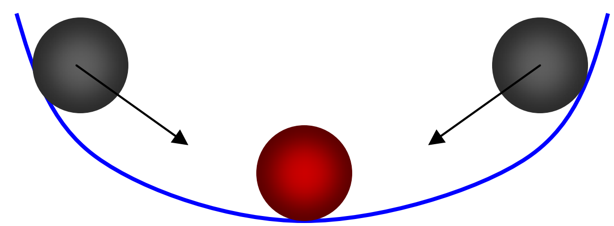
Stable Equilibrium

- Stable equilibrium of a system is an equilibrium such that the system automatically returns to it, if disturbed

This is *not* a stable equilibrium (the ball falls, if disturbed)



This is a stable equilibrium (the ball automatically returns, if disturbed)



Numerical Example Continued

- Suppose, G=0, T=0, s=.2, L=10, K=10, and $Y=K^{1/2}L^{1/2}$
  - Assuming depreciation rate of capital = 10%, find the dynamic equilibrium

Solution

- Need to find K such that in the underlying static equilibrium $I=\delta K$
- In any static equilibrium, L=10, I=s(Y-T)+T-G= $=.2K^{1/2}L^{1/2}=.2K^{1/2}10^{1/2}$
  - Thus, need K such that $.2K^{1/2}10^{1/2}=\delta K$ (*)
- Calculating, we obtain $K=40$
  - *HINT: Divide both sides of (*) by the square root of K, and then raise both sides to the square. Compute K.*