A Model of Production

Chapter 4 of Macroeconomics by Charles I. Jones

Outline

- Introduction
- A model of production
  - Model's economic properties (using maths):
    - Cobb-Douglas Production function (math)
    - Constant Returns to Scale, CRS & Intensive form (math)
    - Allocating Resources: How firms allocate resources (math) using Marginal Productions of labor and capital (math)
    - Why Cobb-Douglas function?
    - Diminishing marginal product (math)
  - Solving the model: Deriving general equilibrium from labor market, capital market and production function (using 5 equations)
  - Interpreting the solution
- Analyzing the production model
  - Assuming equal TFP (parameter A), how does the model fit the data
  - Case study: Why doesn't capital flow from Rich to Poor Countries
  - Productivity (or TFP) differences: (to improve the model fit)
- Understand TFP differences: *what are the sources of TFP*?
  - Human capital, technology, institutions and misallocation
- Evaluating the production Model

These two show that TFP differences are crucial to explain cross-country differences

4.1 Introduction

4.1 Introduction

- In this chapter, we learn:
  - How to set up and solve a macroeconomic model
  - The purpose of a production function and its use for understanding differences in GDP per capita across countries.
  - The role of capital per person and technology in explaining differences in economic growth.
  - The relevance of "returns to scale" and "diminishing marginal products"
  - How to look at economic data through the lens of a macroeconomic model

Introduction

- A model:
  - A mathematical representation of a hypothetical world that we use to study economic phenomena: Growth, employment, inflation, business cycles, interest rate…
  - Consists of equations and unknowns with real-world interpretations
- Macroeconomists:
  - Document facts
  - Build a model to understand the facts
  - Examine the model to see how effective it is

4.2 Model of production

4.2 A Model of Production

- Vast ***oversimplifications*** of the real world in a model can still allow it to provide important insights.
- Consider the following model:
  - Single, closed economy: no trade with outside
  - One consumption good/representative good: a basket of good
- Inputs in the production process:
  - Labor ($\bar{L}$)
  - Capital ($\bar{K}$) *(The bar on top of L & K represents a fixed amount.)*
- Production function:
  - Shows how much output (*Y*) can be produced given any number of inputs

Production Function

$$Y = F(K,L) = \bar{A}K^{1/3}L^{2/3}$$

- $Y =$
  - Output
- $F(K,L)$
  - Function (Machine)
- $= \bar{A}$
  - Productivity Parameter
- $\underbrace{K}^{1/3}\underbrace{L}^{2/3}$
  - Inputs

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4.2.i Model's economic properties

Model

- Output growth corresponds to changes in Y.
- There are three ways that Y can change:
  1. Capital stock (*K*) changes
  2. Labor force (*L*) changes
  3. Ability to produce goods with given resources (*K*, *L*) changes
     - Technological advances occur (changes in *A*)
     - TFP is assumed to be exogenous in the Solow model

Cobb-Douglas Production Function

- The Cobb-Douglas production function is the particular production function that takes the form of:
  - $Y = K^{\alpha} L^{1-\alpha}$
  - α is assumed to be 1/3
- And $F(K,L)$ is increasing in both K and L
  - More inputs yield more output.
  - $\frac{\partial F}{\partial K} > 0$ and $\frac{\partial F}{\partial L} > 0$
- A production function exhibits constant returns to scale if doubling each input exactly doubles output.

Mathematic derivation (1)

- If $0 \leq \alpha \leq 1$, partial differentiating *F()* w.r.t *K*

$$\frac{\partial F}{\partial K} = \alpha K^{\alpha-1} L^{1-\alpha}$$

$$\Rightarrow \frac{\partial F}{\partial K} = \alpha \frac{K^{\alpha-1}}{L^{\alpha-1}}$$

$$\Rightarrow \frac{\partial F}{\partial K} = \alpha \left(\frac{K}{L}\right)^{\alpha-1} > 0$$

Mathematic derivation (2)

- Partial differentiating *F()* w.r.t *L*

$$\frac{\partial F}{\partial L} = (1 - \mathrm{\alpha})K^{\alpha}L^{1-\alpha-1}$$

$$\Rightarrow \frac{\partial F}{\partial \mathrm{L}} == (1 - \mathrm{\alpha})K^{\alpha}L^{-\alpha}$$

$$\Rightarrow \frac{\partial F}{\partial \mathrm{L}} = (1 - \mathrm{\alpha})\frac{K^{\alpha}}{L^{\alpha}} = (1 - \alpha)\left(\frac{K}{L}\right)^{\alpha} > 0$$

Constant Returns to Scale (CRS)

- If increase K and L by x%

  ➔ Y also increases by x%

- Mathematically,
  - $F(\beta K, \beta L) = \beta F(K, L)$
    - Homogeneous function (of degree 1)

- Standard replication argument

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Output per Person (Intensive Form)

- Divide output by the number of workers

$$\frac{Y}{L} = F\left(\frac{K}{L}, \frac{L}{L}\right) = F\left(\frac{K}{L}, 1\right)$$

  - per capita = per person = per worker
  - Lowercase letters denote per capita

- We can rewrite output per person as

$$y = f(k)$$

where $y = \frac{Y}{L}$ and $k = \frac{K}{L}$

Mathematic derivation (3)

Here is an example:

$$Y = F(K, L) = K^{\alpha} L^{1-\alpha}$$

Divide both sides by *L*

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

$$y = K^{\alpha} \frac{L^{1-\alpha}}{L}$$

$$y = K^{\alpha} L^{-\alpha}$$

$$y = \left(\frac{K}{L}\right)^{\alpha}$$

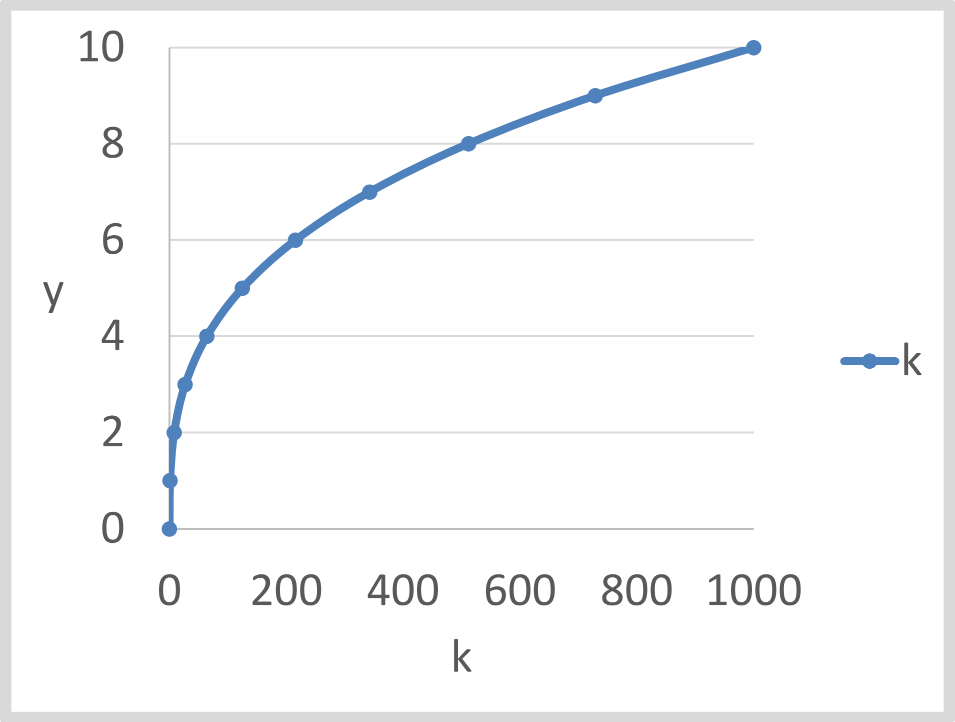
$$y = (k)^{\alpha}$$

Where:

$$y = \frac{Y}{L}; \mathrm{k} = \frac{K}{L}$$

Typical Production Function

- Graph of $y = f(k) = k^{1/3}$
- Note: if $k = 0$ then $y = f(k) = 0$



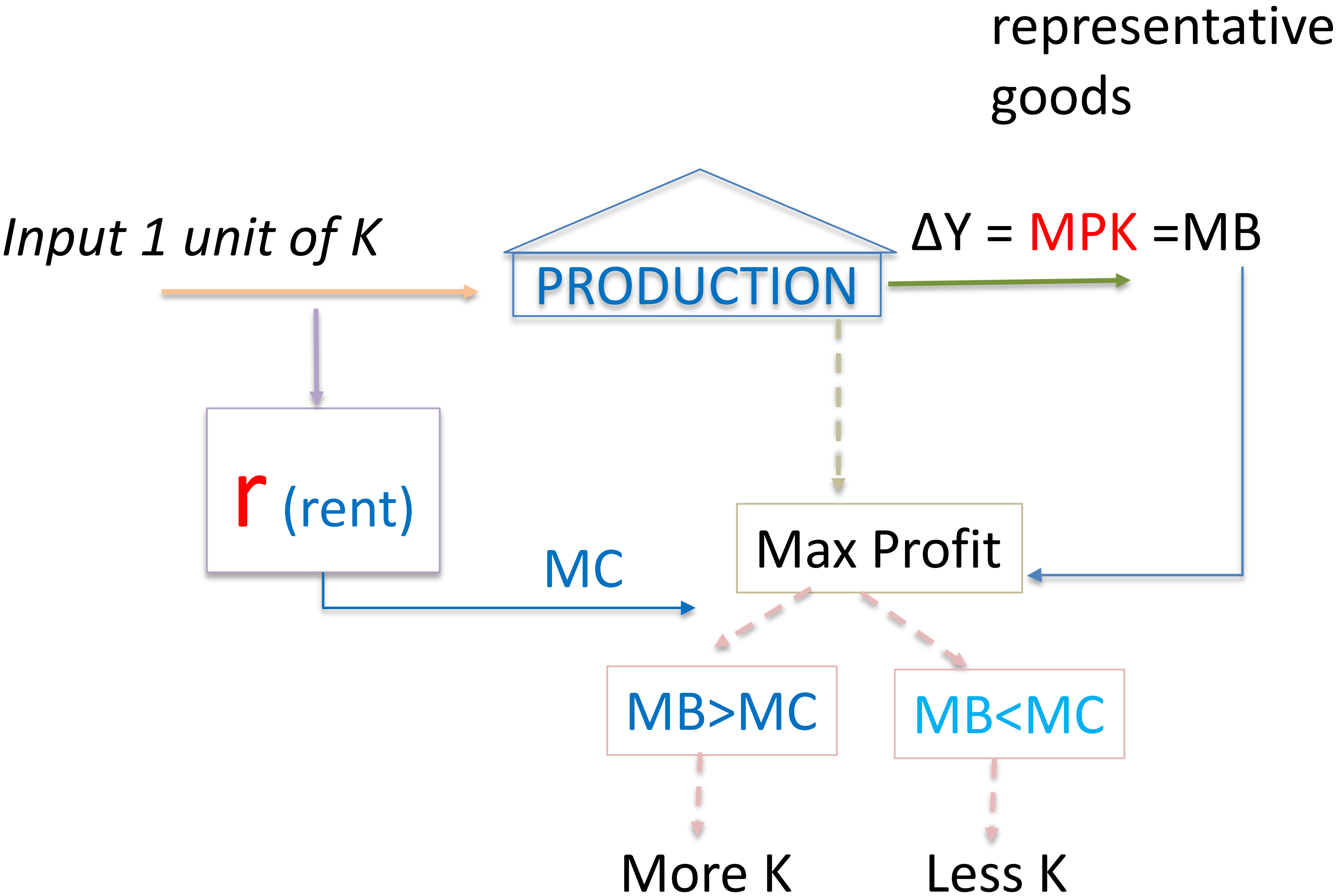
Returns to Scale Comparison (using Cobb-Douglas production)

- Sum of exponents
  - Sum to 1
  - Sum to > 1
  - Sum to < 1
- Result
  - Constant returns to scale
  - Increasing returns to scale
  - Decreasing returns to scale

Allocating Resources

- $$\max_{K,L} \Pi = F(K,L) - rK - wL$$
  - π: profits
  - r: rental rate of capital
  - w: wage rate
- The rental rate and wage rate are taken as given under perfect competition
  - Hire capital until the MPK = r
  - Hire labor until MPL = w
- For simplicity, the price of the output is normalized to one

Production firm



until MB=MC or MPK = r

In economics, agents maximize any kind of benefit following a rule: MB = MC

Mathematic derivation (4)

$$\max_{K,L} \pi = 1K^{\alpha}L^{1-\alpha} - rK - wL$$

- Take the partial derivatives and set equal to zero to find the maximum (where the tangent line has a zero slope).

Mathematatic derivation (4)

$$\boxed{\begin{aligned}\frac{\partial F}{\partial K} &= \alpha K^{\alpha-1}L^{1-\alpha} - r = 0\\ \frac{\partial F}{\partial L} &= (1-\alpha)K^{\alpha}L^{1-\alpha-1} - w = 0\end{aligned}}$$

- Solve for r and w.
- Note:

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

$$(1-\alpha)K^{\alpha}L^{1-\alpha-} = MPL$$

Marginal Products

- The marginal product of labor (MPL)
  - *(Definition)* The additional output that is produced when one unit of labor is added, holding all other inputs constant

$$MPL = \frac{2}{3}\bar{A}\left(\frac{K}{L}\right)^{1/3} = \left(\frac{2}{3}\right)\left(\frac{Y}{L}\right)$$

- The marginal product of capital (MPK)
  - *(Definition)* The additional output that is produced when one unit of capital is added, holding all other inputs constant

$$MPK = \frac{1}{3}\cdot\bar{A}\cdot\left(\frac{L}{K}\right)^{2/3} = \frac{1}{3}\cdot\frac{Y}{K}$$

Mathematic derivation (5)

$$MPL \cdot L = \frac{2}{3}\bar{A}\left(\frac{K}{L}\right)^{1/3} L = wL$$

$$= \frac{2}{3}\bar{A}K^{1/3}L^{2/3}$$

$$(Oh\ behold: \bar{A}K^{1/3}L^{2/3} = Y)$$

- So:

$$MPL \cdot L = \frac{2}{3}Y = wL$$

Important note: MPL is not the same with w. They are equal only when the firm maximizes the profit.

Mathematic derivation (5)

- $Similarly$:

$$MPK \cdot K = \frac{1}{3}\bar{A}\left(\frac{L}{K}\right)^{2/3} K = rK$$

$$= \frac{1}{3}\bar{A}L^{2/3}K^{1/3} = rK$$

$$rK = \frac{1}{3}Y$$

- <u>Important note: </u>MPK is not the same with r. They are equal only when the firm maximizes the profits.

Why Cobb-Douglas function?

- F(K,L) can be any function, but here, we specifically make use of Cobb-Douglas specification.

$$Y = F(K,L) = \underbrace{AK^{\alpha}L^{\beta}}_{\text{Cobb-Douglas form}}$$

- Cobb-Douglas by Charles Cobb and Paul Douglas (1927)

Why Cobb-Douglas function?

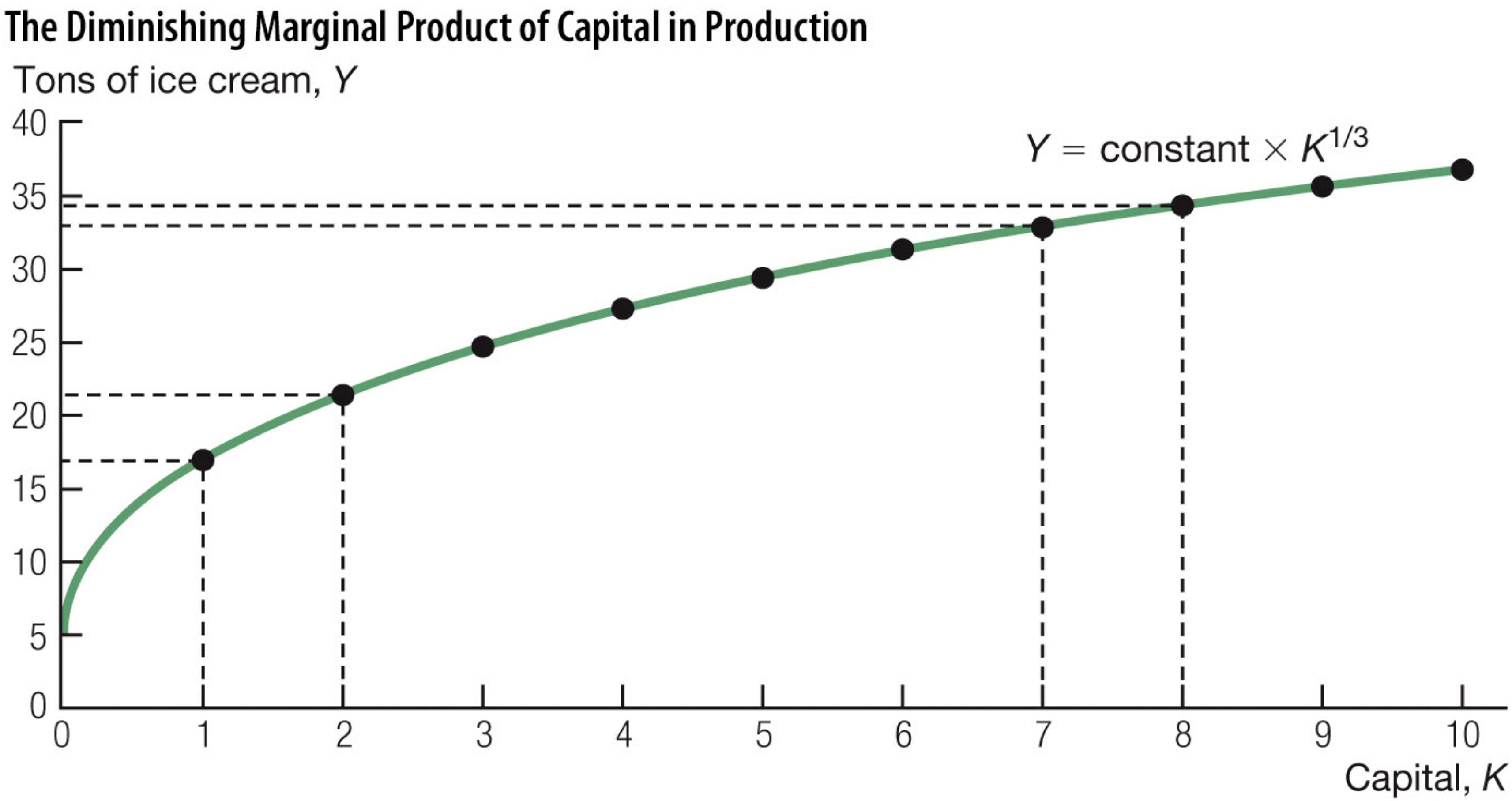
- Applying logarithmic on both sides:

$$\ln(Y) = \ln(A) + \alpha \ln(K) + \beta \ln(L)$$

- If you have data for $K, L\ and\ Y$, we can run a regression of $\ln(Y)\ on\ \ln(K)\ and\ \ln(L)$, then the coefficients of the regressions are $\ln(A), \alpha, \beta$.

- This Cobb-Douglas specification is used widely in economics (e.g. utility)

Diminishing Marginal Product of Capital in Production



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Diminishing Returns

- Formally:

$$\frac{\partial^2 F}{\partial K^2} < 0 \quad \frac{\partial^2 F}{\partial L^2} < 0$$

Mathematatic derivation (6)

$$\frac{\partial F}{\partial K} = \alpha K^{\alpha-1} L^{1-\alpha}$$

$$\frac{\partial^2 F}{\partial K^2} = \alpha(\alpha - 1) K^{\alpha-1-1} L^{1-\alpha}$$

- If $0 < \alpha < 1$, then $\alpha(\alpha - 1) < 0$ and

$$\frac{\partial^2 F}{\partial K^2} = \alpha(\alpha - 1) K^{\alpha-1-1} L^{1-\alpha} < 0$$

Mathematic derivation (6)

$$\frac{\partial F}{\partial L} = (1 - \alpha)K^{\alpha}L^{-\alpha}$$

$$\frac{\partial^2 F}{\partial L^2} = -\alpha(1 - \alpha)K^{\alpha}L^{-\alpha-1}\alpha$$

$$\frac{\partial^2 F}{\partial L^2} = -\alpha(1 - \alpha)K^{\alpha}L^{-\alpha-1}\alpha < 0$$

4.2.ii Solving the model

Solving the Model: General Equilibrium—1

- ***Five Endogenous Variables***
  - Output (Y)
  - The amount of capital (K)
  - The amount of labor (L)
  - The wage (w)
  - The rental price of capital (r)

Five Equations

- The production function
- The rule for hiring capital
- The rule for hiring labor
- Supply equals the demand for labor
- Supply equals the demand for capital

Five equations (what are they)

- The production function

$$Y = F(K, L) = AK^{\alpha}L^{\beta}$$

(So far, we assume $\beta = 1 - \alpha$)

- The rule for hiring capital:

$$MPK = r$$

- The rule for hiring labor:

$$MPL = w$$

Five equations (what are they)

- Supply equals the demand for labor

$$L = \bar{L}$$

($\bar{\ }$ stands for fixed amount)

- Supply equals the demand for capital

$$K = \bar{K}$$

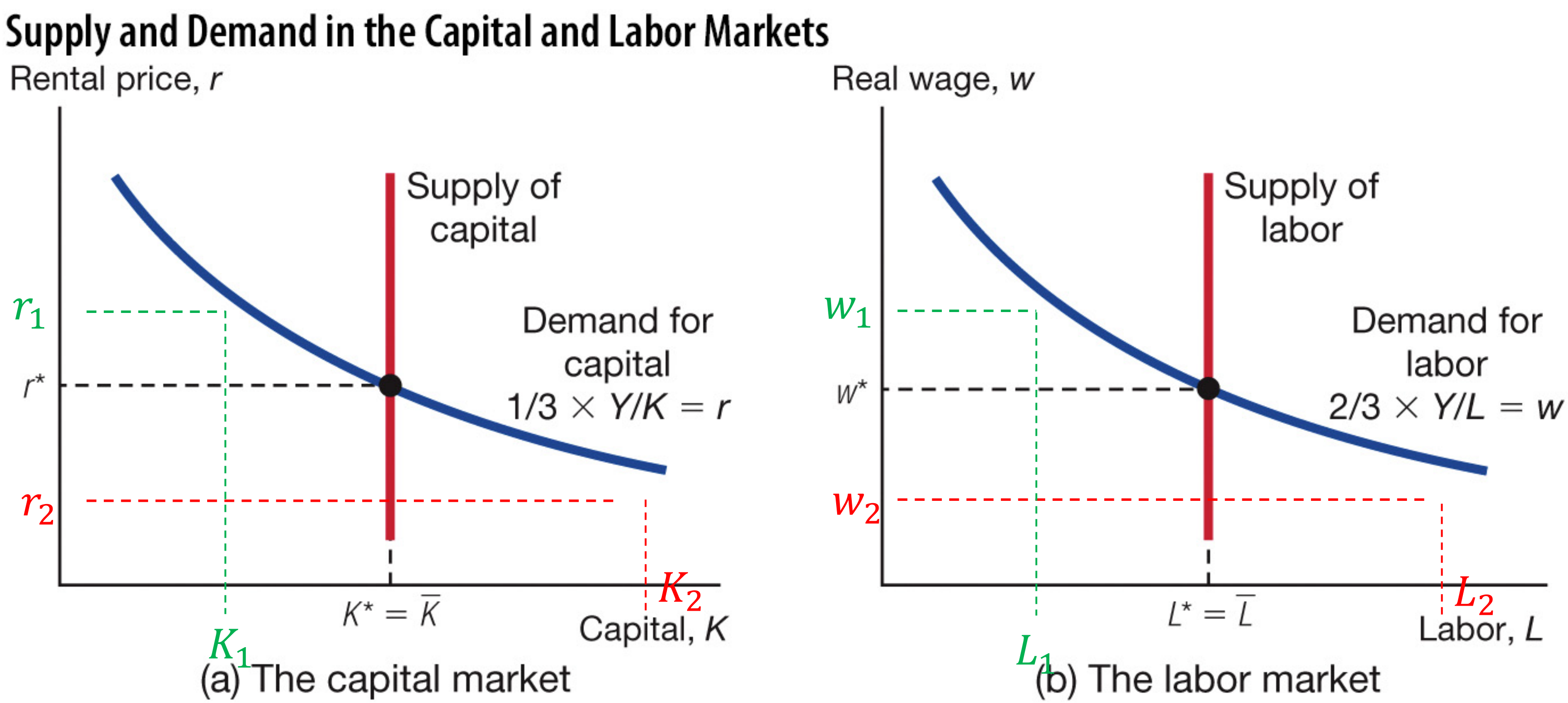
($\bar{\ }$ stands for fixed amount)

So we have 5 equations with 5 unknown to solve for

Solution—1

- A solution to the model
  - A new set of equations that express the five unknowns in terms of the parameters and exogenous variables
- General equilibrium
  - *(definition)* Solution to the model when more than a single market clears
  - In this context, there are two markets: capital and labor

Supply and Demand in the Capital and Labor Markets



Comments on demand curves

- The demand curves for capital and labor are based on the hiring rules:
  - *they trace out exactly the marginal product schedules for K and L*
- If the firm is offer rental rate r_1, the amount of capital they wish to rent is K_1.
- If the firm is offer rental rate r_2, the amount of capital they wish to rent is K_2.
- Tracing all the combinations of (r, K) we have the demand curve for capital. Similar for the labor demand curve.

Solution—2 for $\alpha = \frac{1}{3}$ and $\beta = \frac{2}{3}$

The production function	$Y^* = \bar{A}K^{1/3}L^{2/3}$
The rule for hiring capital	$r^* = \left(\frac{1}{3}\right)\left(\frac{Y^*}{K^*}\right) = \frac{1}{3}\bar{A}\left(\frac{\bar{L}}{\bar{K}}\right)^{2/3}$
The rule for hiring labor	$w^* = \left(\frac{2}{3}\right)\left(\frac{Y^*}{L^*}\right) = \frac{2}{3}\bar{A}\left(\frac{\bar{K}}{\bar{L}}\right)^{1/3}$
Supply equals the demand for labor	$L^* = \bar{L}$
Supply equals the demand for capital	$K^* = \bar{K}$

4.2.iii Interpreting the solution

In This Model…

- The solution implies:
  - firms employ all the supplied capital and labor in the economy
  - the production function is evaluated with the given supply of inputs

$$Y^* = F(\bar{K}, \bar{L}) = \bar{A}\bar{K}^{1/3}\bar{L}^{2/3}$$

  - $w = MPL$ evaluated at the equilibrium values of *Y*, *K*, and *L*
  - $r = MPK$ evaluated at the equilibrium values of *Y*, *K*, and *L*

Interpreting the Solution

- The equilibrium wage is proportional to output per worker
  - Output per worker = (Y/L)

$$\boxed{w^\star = \frac{2}{3} \cdot \frac{Y^\star}{L^\star}}$$

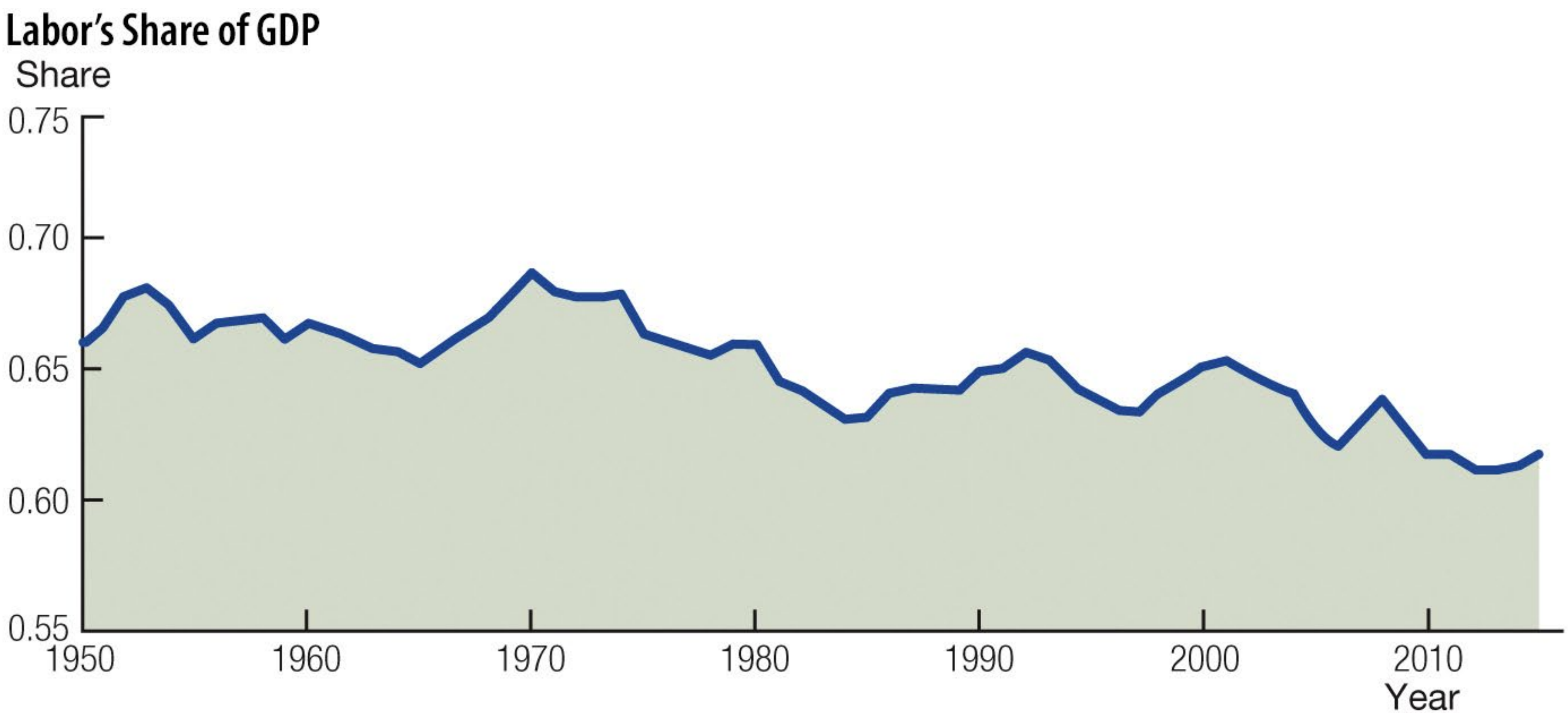
- The equilibrium rental rate is proportional to output per capital
  - Output per capital = (Y/K)

$$\boxed{r^\star = \frac{1}{3} \cdot \frac{Y^\star}{K^\star}}$$

- In the United States, empirical evidence shows:
  - ${}^{2}/_{3}$ of production is paid to labor
  - ${}^{1}/_{3}$ of production is paid to capital
  - The factor shares of the payments are equal to the exponents on the inputs in the Cobb-Douglas function.

$$\boxed{\frac{w^* L^*}{Y^*} = \frac{2}{3} \text{ and } \frac{r^* K^*}{Y^*} = \frac{1}{3}}$$

Labor's Share of Income



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Equilibrium

- All income is paid to capital or labor.
  - Results in zero profit in the economy
  - This verifies the assumption of perfect competition.
  - Also verifies that production equals spending equals income.

$$\underbrace{w^*L^*}_{\text{Labour Share}} + \underbrace{r^*K^*}_{\text{Capital Share}} = Y^*$$

Income=production

4.3 Analyzing the Production Model

4.3 Analyzing the Production Model

- Development accounting:
  - The use of a model to explain differences in incomes across countries

$$y^* = \bar{A}\bar{k}^{1/3}$$

  - Setting the productivity parameter $\left(\bar{A} = 1\right)$

$$y^* = \bar{k}^{1/3}$$

4.3.i Empirical fit of the Production function

The Empirical Fit of the Production Function

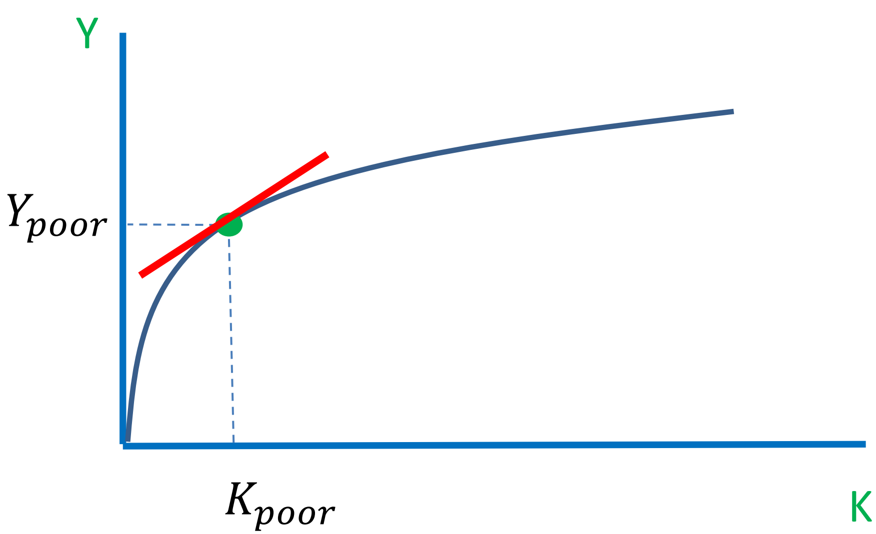
- If the productivity parameter is 1 $(A = 1)$, *the model <u>over-predicts</u> GDP per capita.*

- Diminishing returns to capital implies that:
  - Countries with low *K* will have a high MPK
  - Countries with a lot of *K* will have a low MPK, and cannot raise GDP per capita by much through more capital accumulation

Assume A = 1, our model says:

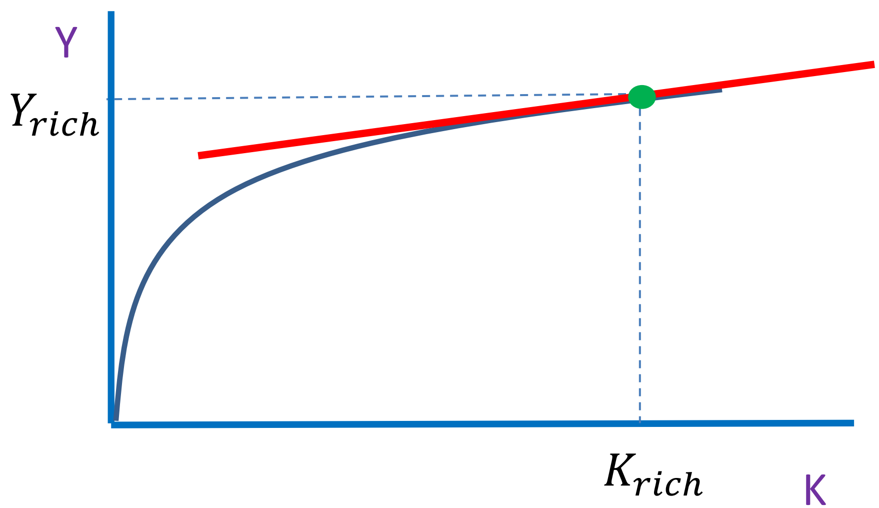
Poor Country:

Larger slope at K_{poor} → higher rental



Rich Country:

Smaller slope at K_{rich} → lower rental



Should we observe the flow of funds from rich to poor to seek for higher return?

The Model's Prediction for Per Capita GDP (United States = 1)

TABLE 4.3

The Model's Prediction for Per Capita GDP (U.S. = 1)

Country	Observed capital per person, $\bar{k}$	Predicted per capita GDP $y = \bar{k}^{1/3}$	Observed per capita GDP
United States	1.000	1.000	1.000
Switzerland	1.416	1.123	1.147
Japan	1.021	1.007	0.685
Italy	1.124	1.040	0.671
Spain	1.128	1.041	0.615
United Kingdom	0.832	0.941	0.733
Brazil	0.458	0.771	0.336
China	0.323	0.686	0.241
South Africa	0.218	0.602	0.232
India	0.084	0.437	0.105
Burundi	0.007	0.192	0.016

Predicted per capita GDP is computed as $\bar{k}^{1/3}$, that is, assuming no differences in productivity across countries. Data correspond to the year 2014 and are divided by the values for the United States.
Source: Penn World Tables, Version 9.0.

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Using our model, assuming same $\bar{A} = 1$ for all countries

$$y_{us}^{*} = \bar{A}k_{us}^{1/3} \quad \text{(for US)}$$

$$y_{chi}^{*} = \bar{A}k_{chi}^{1/3} \quad \text{(for China)}$$

$$\Longrightarrow \frac{y_{chi}^{*}}{y_{us}^{*}} = \frac{\bar{A}k_{chi}^{1/3}}{\bar{A}k_{us}^{1/3}} = \frac{k_{chi}^{1/3}}{k_{us}^{1/3}}$$

Using capital data (k) from previous slide:

$$\frac{y_{chi}^{*}}{y_{us}^{*}} = \frac{k_{chi}^{1/3}}{k_{us}^{1/3}} = \frac{0.323^{1/3}}{1^{1/3}} = 0.686$$

$*$ *is to denote that predicted value. So y^* is the predicted ouput*

$\mathbf{0.686}$ *is the GDP per capita of China relative to that of US*

Using our model, assuming same $\bar{A}$ for all countries

Since y^*_{us} *is 1 using the proposed model (ie.* $y^*_{us} = {k^*_{us}}^{1/3} = 1, \because k^*_{us} = 1)$

$$\frac{y^*_{chi}}{1} = 0.686 \Longrightarrow y^*_{chi} = 0.686$$

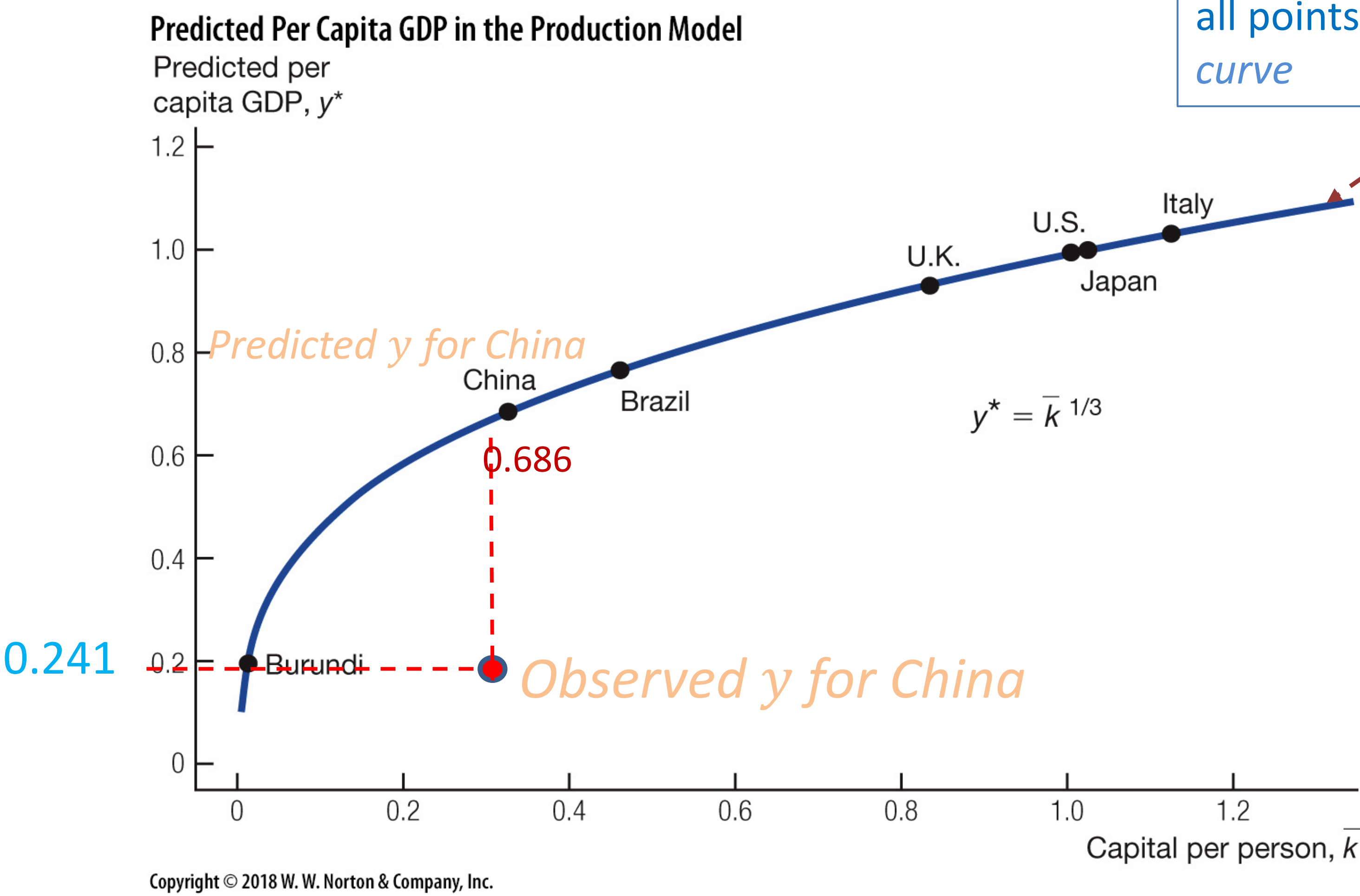
$$(under\ our\ model)$$

<u>Note:</u> *Note that* $y^*_{chi} = 0.686$ *is using our model assumption (A=1).*

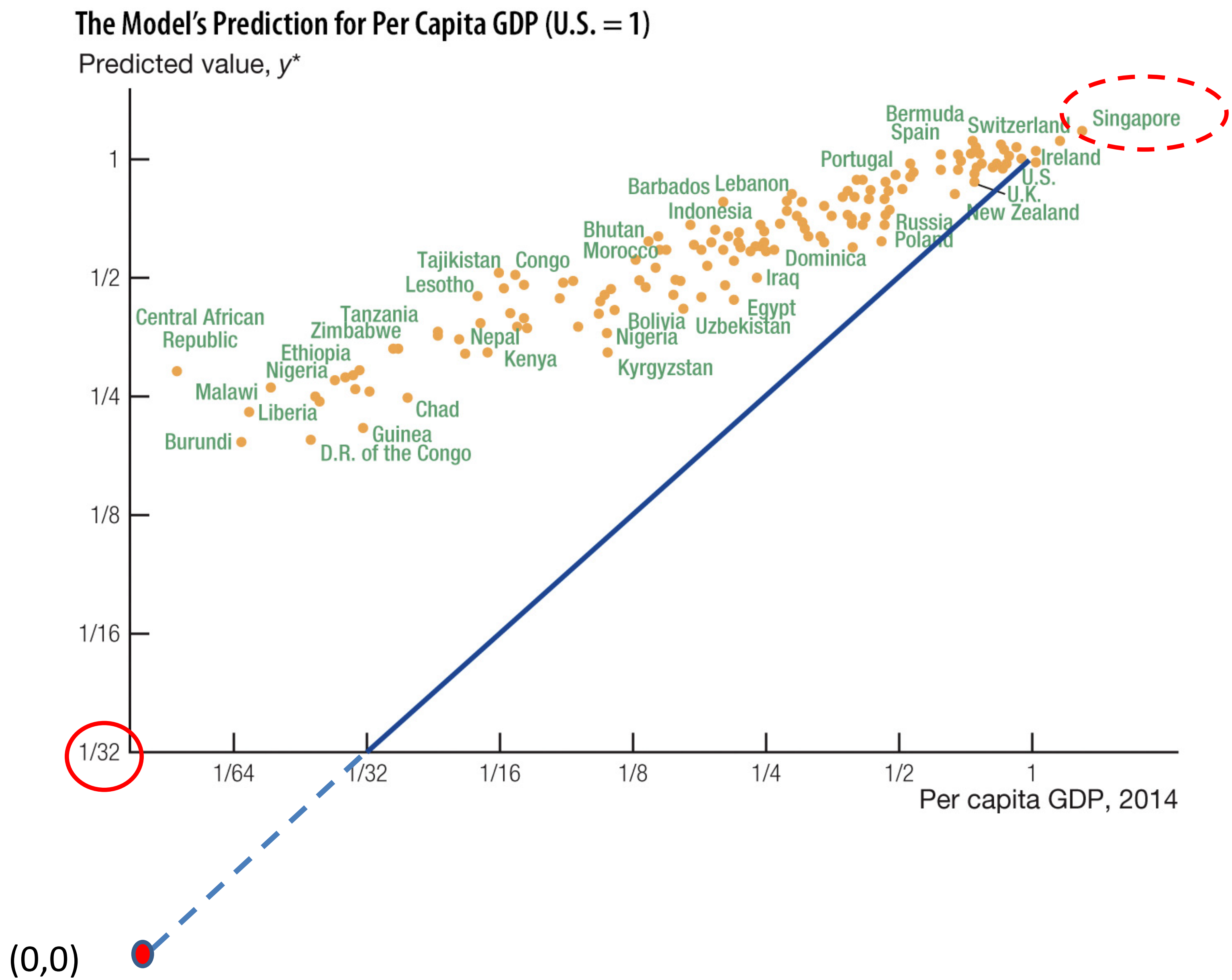
But what is the actual y_{chi}*? Only 0.241. The model* ***<u>over-estimates</u>*** *the output*

Predicted Per Capita GDP in the Production Model

For this curve, we assumed, $\bar{A} = 1$, so all points are on *same curve*



The Model's Prediction for Per Capita GDP



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Comment on previous slide

- If the model were successful in explaining incomes,
  - Countries should lie close to the solid 45 degree line.

- Instead, the <u>model predicts </u>that most countries **should be substantially richer** than they are.

4.3.ii Case Study

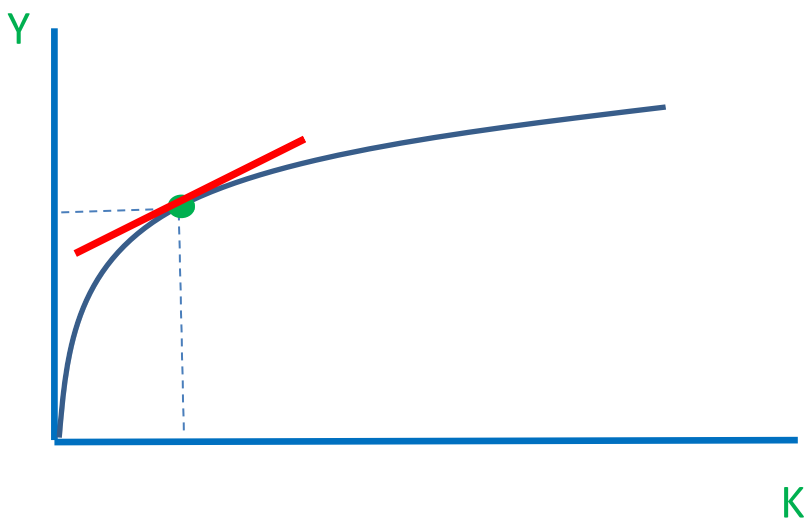
Case Study: Why Doesn't Capital Flow from Rich to Poor Countries?

- If MPK is higher in poor countries with low *K*, why doesn't capital flow to those countries?
  - Short Answer: Simple production model with no difference in productivity across countries is misguided
  - We must also consider the productivity parameter *(see next slide)*

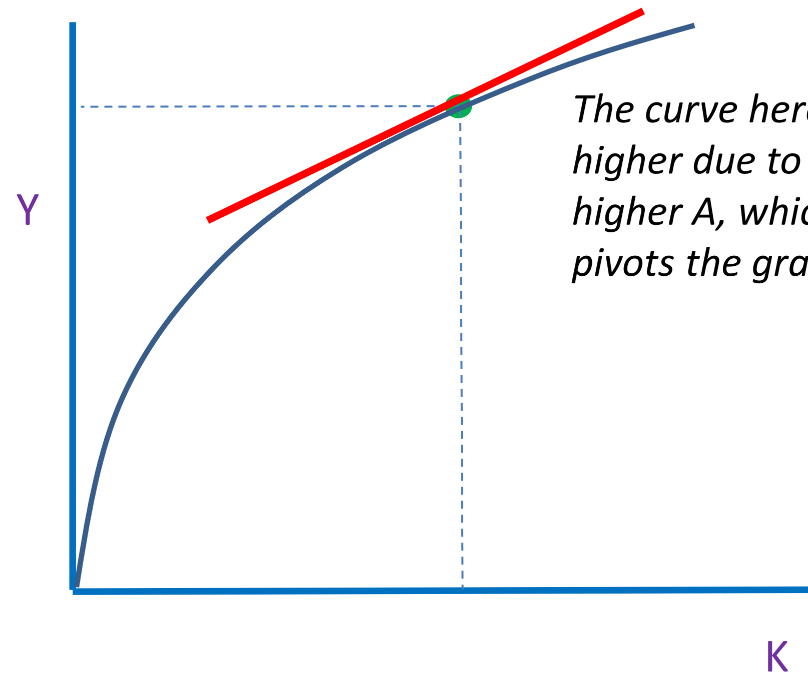
Assume $\mathrm{A}_{poor} \neq A_{rich}$

$Y = \bar{A}\mathrm{F}(\mathrm{K}, \mathrm{L})$

Poor Country A_{poor}:



Rich Country A_{rich}:



The curve here is higher due to higher A, which pivots the graph up

No fund transfer from one to another because both have same rental rate for capital

4.3.iii Productivity Differences: Improving the Fit of the Model

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Productivity Differences: Improving the Fit of the Model

- The productivity parameter measures how efficiently countries are using their factor inputs.
- Total factor productivity (TFP)
- If TFP is ≠ to 1 → better model

Total Factor Productivity

$y = \bar{A}\mathrm{f}(\mathrm{k})$

- Data on TFP is not collected.
  - It can be calculated because we have data on output and capital per person.
  - TFP is referred to as the "residual."
  - **That is:** if we know Y, K and $L,$ we can infer $\bar{A}$ using the functional specification (e.g. $Y = \bar{A}K^{1/3}L^{2/3}$)
- A lower level of TFP
  - implies that *workers produce less output for any given level of capital per person*.

Measuring TFP So the Model Fits Exactly—1

TABLE 4.4

Measuring TFP So the Model Fits Exactly

Country	Per capita GDP (y)	$\bar{k}^{1/3}$	Implied TFP ($\bar{A}$)
United States	1.000	1.000	1.000
Switzerland	1.147	1.123	1.022
United Kingdom	0.733	0.941	0.779
Japan	0.685	1.007	0.680
Italy	0.671	1.040	0.646
Spain	0.615	1.041	0.590
Brazil	0.336	0.771	0.436
South Africa	0.232	0.602	0.386
China	0.241	0.686	0.351
India	0.105	0.437	0.240
Burundi	0.016	0.192	0.085

Calculations are based on the equation $y = \bar{A}\bar{k}^{1/3}$. Implied productivity $\bar{A}$ is calculated from data on y and $\bar{k}$ for the year 2010, so that this equation holds exactly as $\bar{A} = y/\bar{k}^{1/3}$.

Using our model, assuming $y = \overline{A}\ k^{*\ 1/3}$ form with different A's for different economies

$$y_{us} = \overline{A_{us}} k_{us}^{1/3} \text{(for US)}$$

$$y_{chi} = \overline{A_{chi}}\ k_{chi}^{\ \ 1/3} \quad \text{(for China)}$$

$$\Rightarrow \frac{y_{chi}}{y_{us}} = \frac{\overline{A_{chi}} k_{chi}^{\ \ 1/3}}{\overline{A_{us}} k_{us}^{1/3}}$$

Note: We took out the * in y_{us} *and* y_{chi} because these are the actual outputs

Using per-capita capital data (k) and per-capita output data (y)from tables 4.3 and 4.4:

$$\frac{0.241}{1} = \frac{\overline{A_{chi}} 0.323^{1/3}}{1 \times 1^{1/3}}$$

$$(\because A_{us} = 1, k_{us} = 1, k_{chi} = 0.323, y_{chi} = 0.241, y_{us} = 1)$$

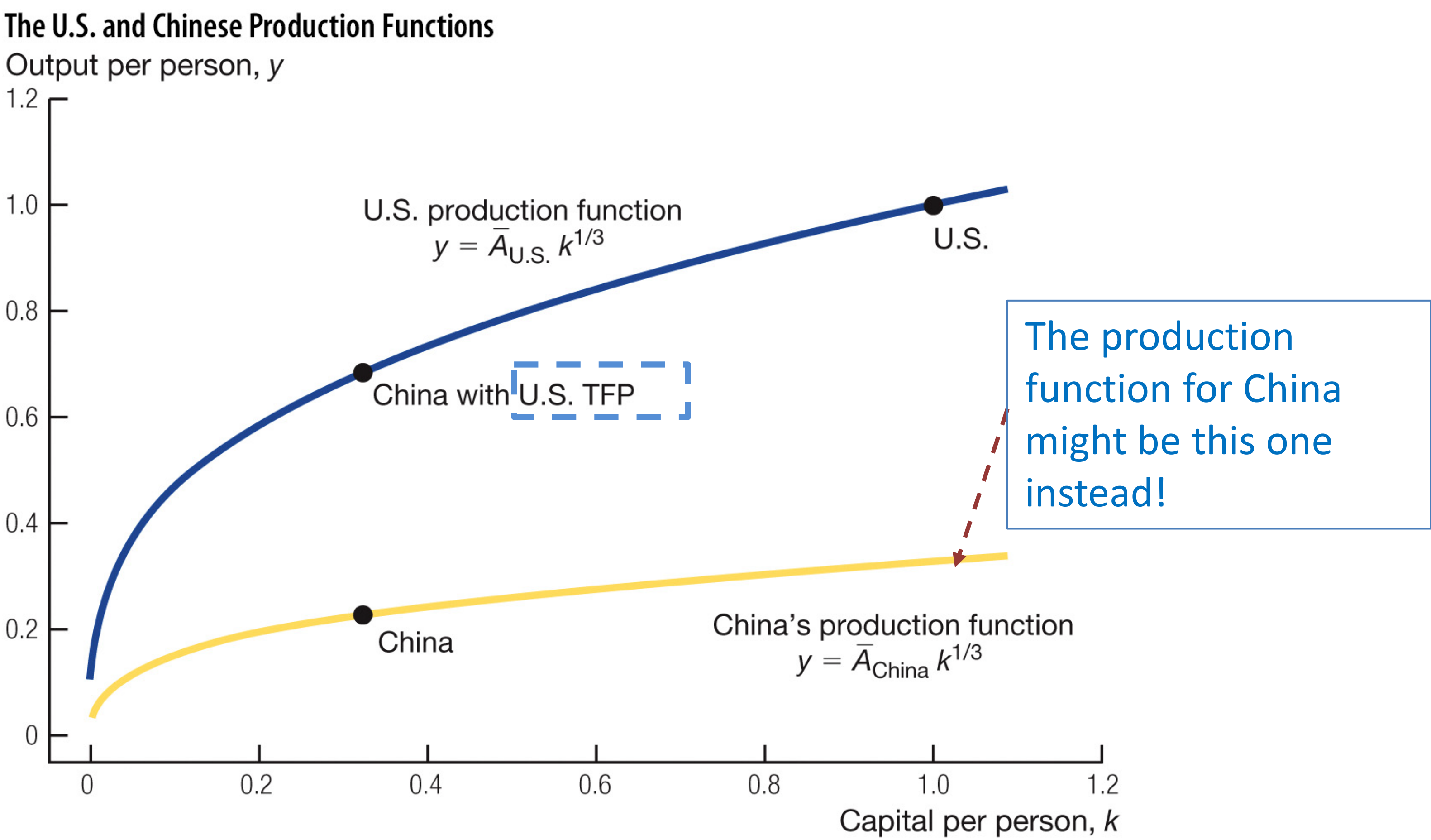
Using our model, assuming $y = \overline{A}\ k^{*\ 1/3}$ form with different A's for different economies

$$\frac{0.241}{1} = \frac{\overline{A_{chi}}\,0.323^{1/3}}{1 \times 1^{1/3}}$$

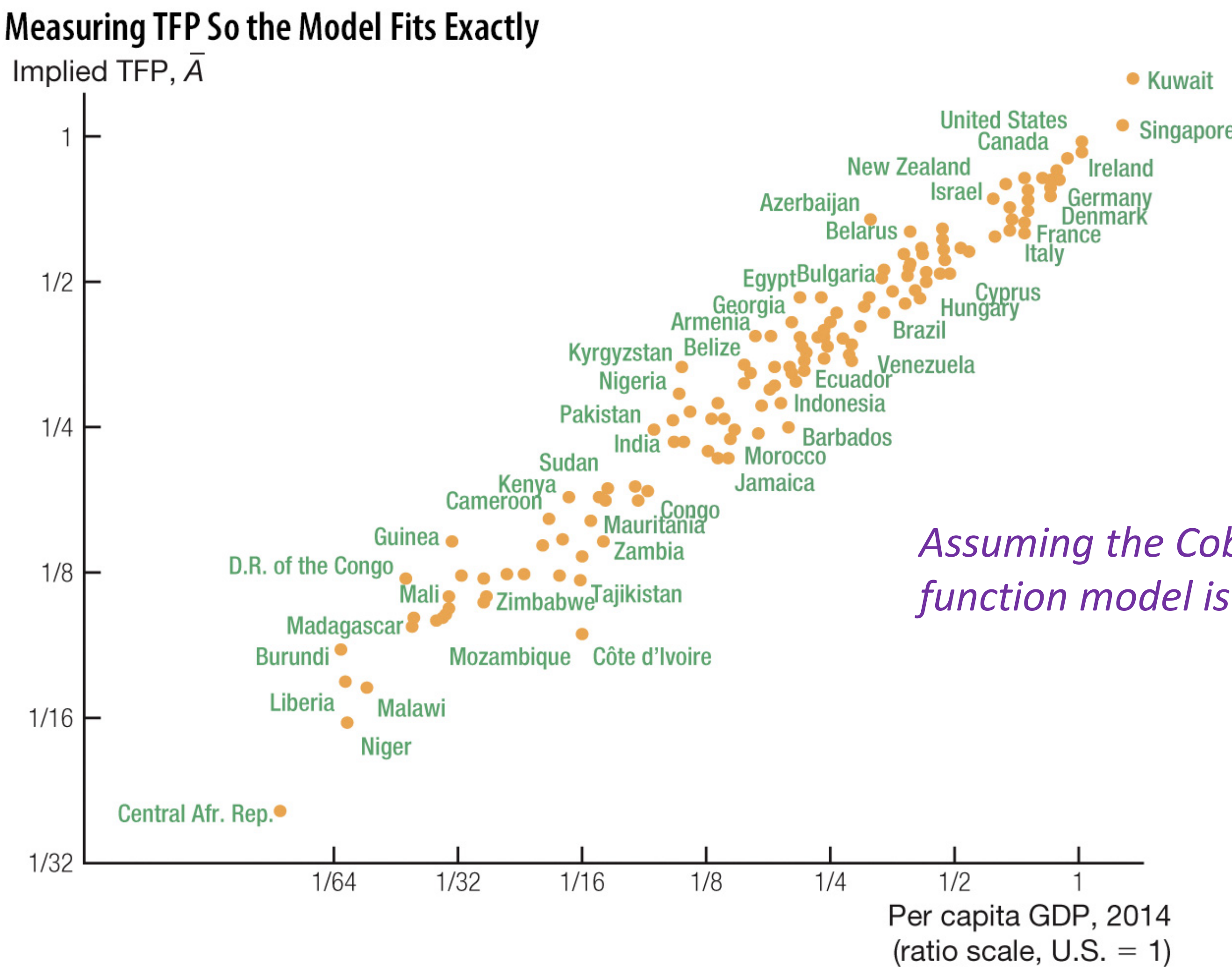
$$\Longrightarrow \bar{A}_{chi} = \frac{0.241}{0.323^{\frac{1}{3}}} = 0.351$$

**Please note again that $\bar{A}_{chi} = 0.351$ is the implied TFP of China relative to that of US ($\bar{A}_{us}$)*

United States and Chinese Production Functions



Measuring TFP So the Model Fits Exactly—2



Assuming the Cobb-Douglas function model is correct

4.4 Understanding TFP Differences

4.4 Understanding TFP Differences

- Output differences between the richest and poorest countries?
  - <u>Differences in capital per person</u> explain about ***one-third*** of the difference.
  - TFP explains the remaining ***two-thirds***.
- Thus, rich countries are rich because:
  - They have **more capital per person**.
  - More importantly, they **use labor and capital more efficiently**.
  - Why are some countries more efficient at using capital and labor?

Understanding TFP Differences

- Human capital
- Technology
- Institutions
- Misallocation

Human Capital

- Human capital
  - Stock of skills that individuals accumulate to make them more productive
  - Education and training
    - people attend college
    - 1st graders learn to read
    - construction workers learn to operate a tower crane
    - doctors master a new surgical technique

Human Capital

- In the United States each year of education seems to increase future wages by 7 percent.
- A four-year education may raise wages by about 28 percent (over entire lifetime).
- In developing countries, returns can be even higher—up to 10 percent or even 13 percent per year.
- The typical student learning the basic skills associated with literacy and arithmetic may have higher returns than a college education.

Technology

- Richer countries may use more modern and efficient technologies than poor countries.
  - Increases productivity parameter
- Goods such as state-of-the-art computer chips, software, new pharmaceuticals, supersonic military jets, and skyscrapers are much more prevalent in rich countries than in poor.
  - As well as production techniques such as just-in-time inventory *methods*, *information technology*, and tightly *integrated transport networks*.

Institutions

- Even if human capital and technologies are better in rich countries, why do they have these advantages?
- Institutions are in place to foster human capital and technological growth.
  - Property rights
  - The rule of law
  - Government systems
  - Contract enforcement

Institutions

- Some challenges in countries with uncertain institutions:
  - No well-defined set of laws to follow to establish business
  - Rules are not the same for everyone
  - Licensing fees and taxes may vary over time and without warning
  - Corruption and bribes
  - Imports may be challenging to receive
  - Profits may be “taxed” away or stolen due to insufficient property rights
  - A coup or war could change the environment overnight

Misallocation

- Misallocation
  - Resources not being put to their best use
- Examples
  - Inefficiency of state-run resources
    - State-owned companies (SOE) versus Foreign-Joint Ventures
    - Funds are not allocated to the more-productive channels
  - Political interference

4.5 Evaluating the Production Model

- Per capita GDP is higher if capital per person is higher *and* if factors are used more efficiently.
- Constant returns to scale imply that output per person *can be written* as a function of capital per person.
- Capital per person is subject to strong diminishing returns because the exponent is much less than one.

Weaknesses of the Model

- In the absence of TFP, the production model incorrectly predicts differences in income.

- The model ***does not provide an answer as to why countries have different TFP levels***.