Recitation 2

Intermediate Macroeconomics

Output per person?

- Define y=Y/L and k = K/L:

$$y^* = \frac{Y^*}{L^*} = \frac{\bar{A}\bar{K}^{1/3}\bar{L}^{2/3}}{\bar{L}} = \bar{A}\bar{k}^{1/3}$$

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

- Determined by two factors:
  - Productivity
  - Capital per person

    (Diminishing returns to capital per person)

Taking the Model to the Data

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

- This is an empirical implication of the model
- Using this equation to try to account for differences in output across countries is called development accounting
- What data do we need check this implication?
  - Output, Capital, Labor
  - Technology

Taking the Model to the Data

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

- We can measure output, capital and population (This is hard but we can try)
- Harder to measure $\bar{A}$

Taking the Model to the Data

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

- Let's assume that all countries have the same level of technology: $\bar{A}_X = \bar{A}_{US}$
- Then $\bar{A}$ drops out when we take ratios of two countries:

$$\frac{y_X^*}{y_{US}^*} = \left(\frac{\bar{k}_X}{\bar{k}_{US}}\right)^{1/3}$$

- How do we evaluate this equation using data?

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	1.287	1.088	0.870
Japan	1.173	1.055	0.713
Italy	0.927	0.975	0.672
Spain	0.908	0.968	0.733
United Kingdom	0.661	0.871	0.750
Brazil	0.134	0.512	0.225
China	0.127	0.502	0.183
South Africa	0.098	0.461	0.244
India	0.044	0.352	0.089
Burundi	0.003	0.149	0.015

TABLE 4.3 The Model's Prediction for Per Capita GDP (U.S. = 1)

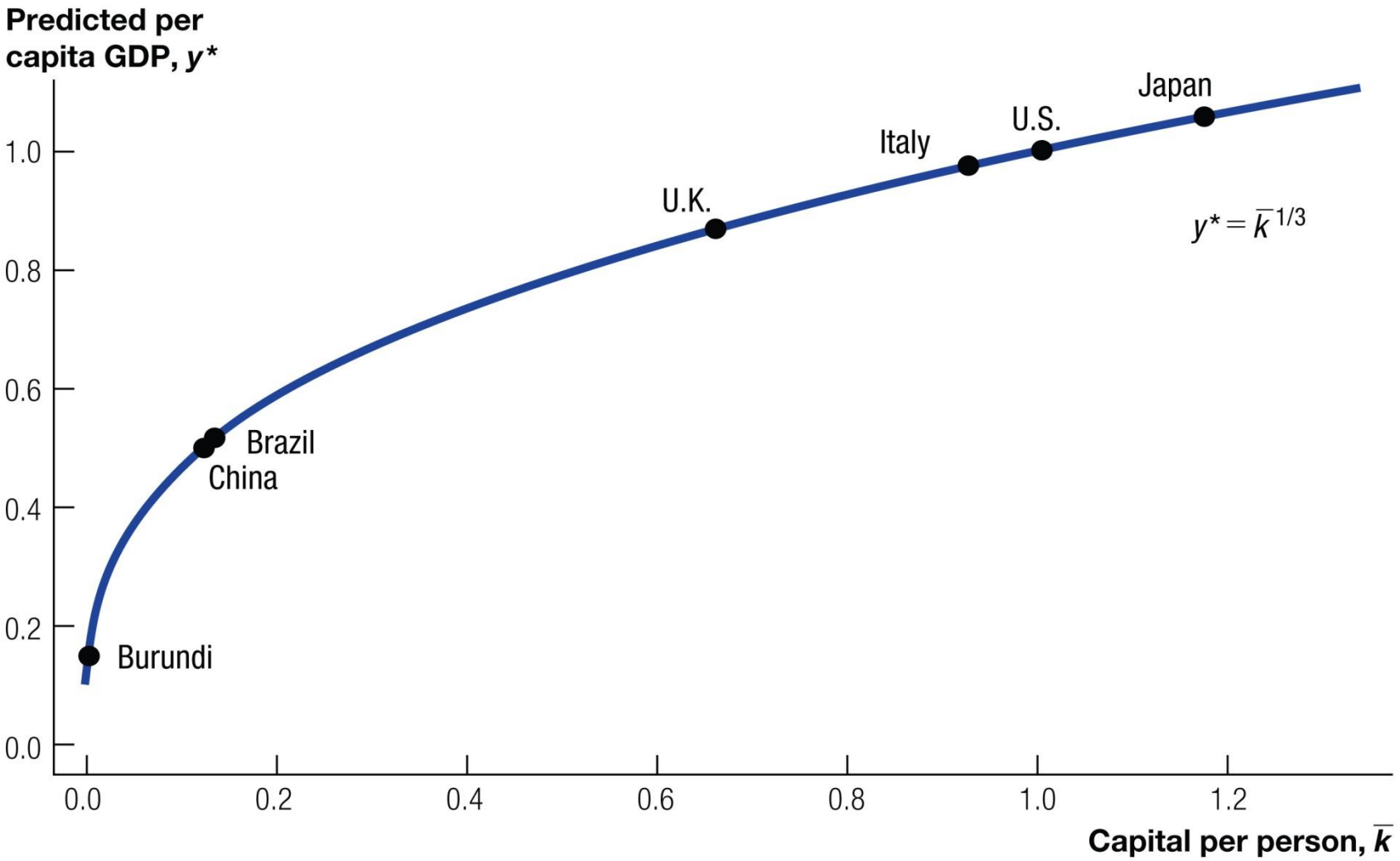

FIGURE 4.4 Predicted Per Capita GDP in the Production Model

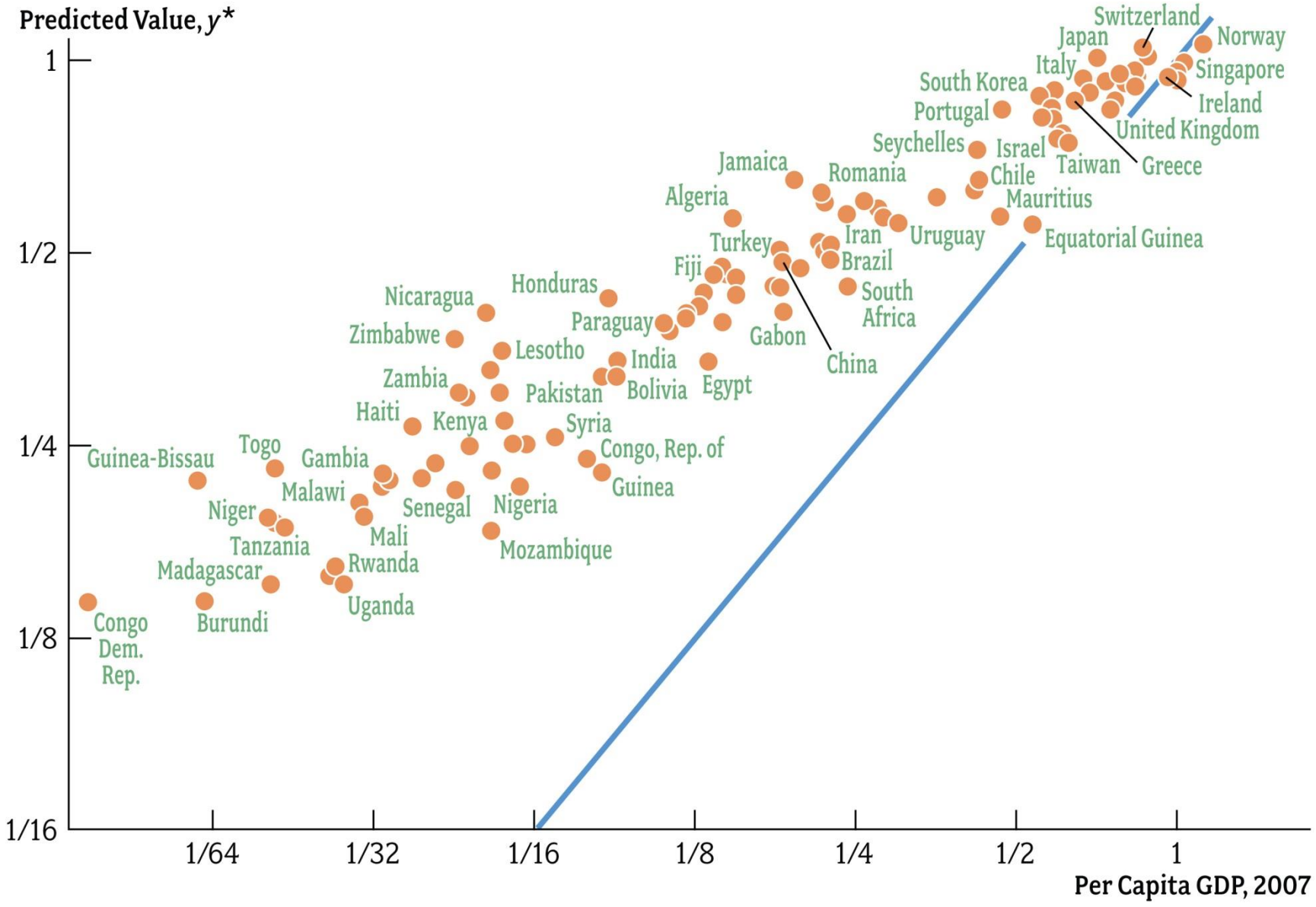

FIGURE 4.5 **The Model's Prediction for Per Capita GDP (U.S. = 1)**

Macroeconomics, 2nd Ed

Taking the Model to the Data

- Model fits poorly!!
  - It systematically overestimates output in poor countries
  - Poor countries produce less than their capital stocks + our model suggest should be the case
- Model gets direction right:
  - Poorer countries have less capital per person
- But it doesn't get the magnitudes right

Taking the Model to the Data

- What are possible reasons for model's bad fit?
  - We might be mismeasuring output, capital, labor
    - E.g., Very hard to measure capital
  - Assumptions of model might be wrong (which ones?)
    - Functional form of production function
      - Is all labor the same? Skilled vs. unskilled
      - Maybe some critical inputs are missing (O-ring Theory)
    - Same level of technology in all countries

Technology

- What is technology?
  - Efficiency of production

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

- We have been assuming all countries have same level of technology
- We can instead pick $\bar{A}$ for each country to match the data.

How “Efficient” Are Different Countries?

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

- If we take this equation for two different countries and divide one by the other and solve for the ratio of technology in the two country we get

$$\frac{A_X}{A_{US}} = \frac{{}^{y_X}/_{y_{US}}}{\left({}^{k_X}/_{k_{US}}\right)^{1/3}}$$

Country	Per capita GDP (y)	$\bar{k}^{1/3}$	Implied TFP ($\bar{A}$)
United States	1.000	1.000	1.000
Switzerland	0.870	1.088	0.800
United Kingdom	0.750	0.871	0.861
Spain	0.733	0.968	0.757
Japan	0.713	1.055	0.676
Italy	0.672	0.975	0.689
South Africa	0.244	0.461	0.530
Brazil	0.225	0.512	0.439
China	0.183	0.502	0.365
India	0.089	0.352	0.253
Burundi	0.015	0.149	0.101

TABLE 4.4 Measuring TFP So the Model Fits Exactly

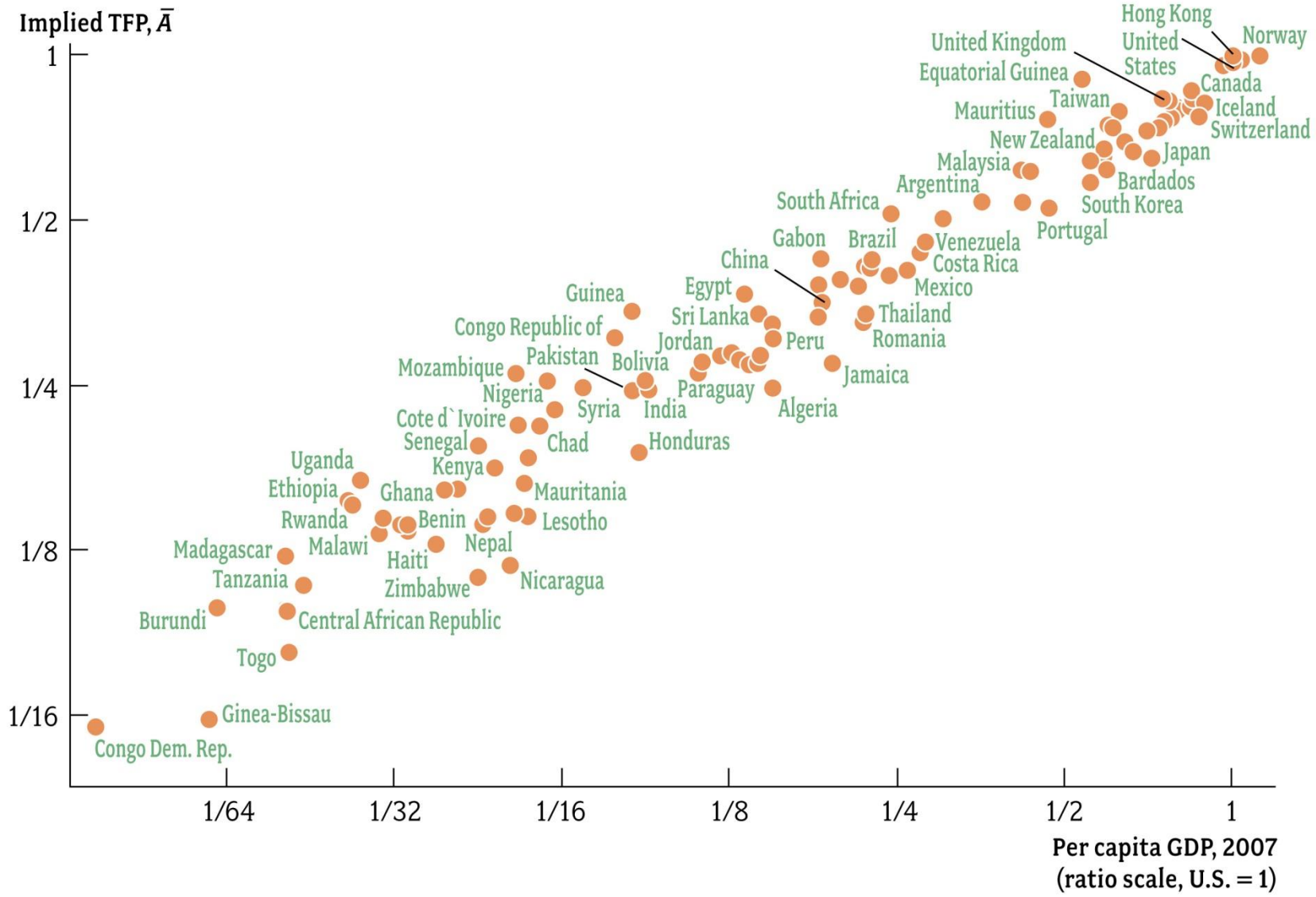

FIGURE 4.7 Measuring TFP So the Model Fits Exactly

Taking Model to the Data

- Does this mean we have explained differences in output per person?
  - No!!!
  - We didn't have independent data on TFP
- Differences in capital could explain a (small) fraction of differences in output per capita
- Part we assign to TFP is

  "a measure of our ignorance"
- TFP difference: factor of 10
- Need to explain TFP differences

How Much Have We Explained?

- Five richest and five poorest in 2000:

$$\underbrace{\frac{y^*_{\text{rich}}}{y^*_{\text{poor}}}}_{45} = \underbrace{\frac{\bar{A}_{\text{rich}}}{\bar{A}_{\text{poor}}}}_{10} \cdot \underbrace{\left(\frac{\bar{k}_{\text{rich}}}{\bar{k}_{\text{poor}}}\right)^{1/3}}_{4.5}$$

- Crucial question:
  - Why does TFP (the measure of our ignorance) differ so much across countries?

(Optional)

Taking Model to the Data II (Lucas)

- Firm optimization implies:

$$a\bar{A}K^{a-1}L^{1-a} = r \quad \text{or} \quad a\bar{A}k^{a-1} = r$$

and also

$$y = \bar{A}k^{a}$$

a little bit of algebra yields

$$r = a\bar{A}^{1/a}y^{(a-1)/a}$$

- If technology is the same across countries:

$$\frac{r_X}{r_{US}} = \left(\frac{y_X}{y_{US}}\right)^{(a-1)/a}$$

(Optional)

Return on Capital in Developing World

$$\frac{r_X}{r_{US}} = \left(\frac{y_X}{y_{US}} \right)^{(a-1)/a}$$

- Consider the case of India:
  - Output per worker was about 15 times lower in India than in U.S. in 1990
  - Returns to capital should be 15^2=225 times higher
- What should this imply?
  - Capital should flow from rich countries to poor countries!!!!

(Optional)

Capital Flows

- In 1990:
  - Richest 20% of countries received 88% of private capital inflows
  - Poorest 20% of countries received 1% of private capital inflows
- Lucas (1990): Why doesn't capital flow from rich to poor countries?
- Perhaps technology is not the same

Understanding TFP Differences

- Human Capital
- Technology
- Institutions
- Misallocations

Review of Calculus of Variations

- Refer to Lecture Slides