DEVELOPMENT ECONOMICS

PRODUCTIVITY AND FACTOR (MIS)ALLOCATION

This Lecture

- We will talk about productivity.
  - What is it?
  - How can it be measured?
  - What is its role in explaining cross-country income differences?
  - What are its determinants?
    - Efficiency.
    - Technology.

- Reading:
  - Weil book: Chapter 7 and Chapter 10 (section 10.3)
  - Paper by Hsieh-Klenow (sections 2, 4, and 5)

The Proximate Causes of Growth

- In the previous class we saw that differences in physical capital and human capital could not explain all the income differences across countries.

- What this means in practice: even if poor countries had the capital and education that the USA has, they would still be poorer than the USA.
  - Why? The USA has more **productivity.**
  - **Productivity is the ability to make more output with the same factors of production (capital, human capital, labor).**
    - The "A" of our production function.
    - Also called "total factor productivity" or TFP.

FIGURE 7.1

Possible Sources of Differences in Output per Worker

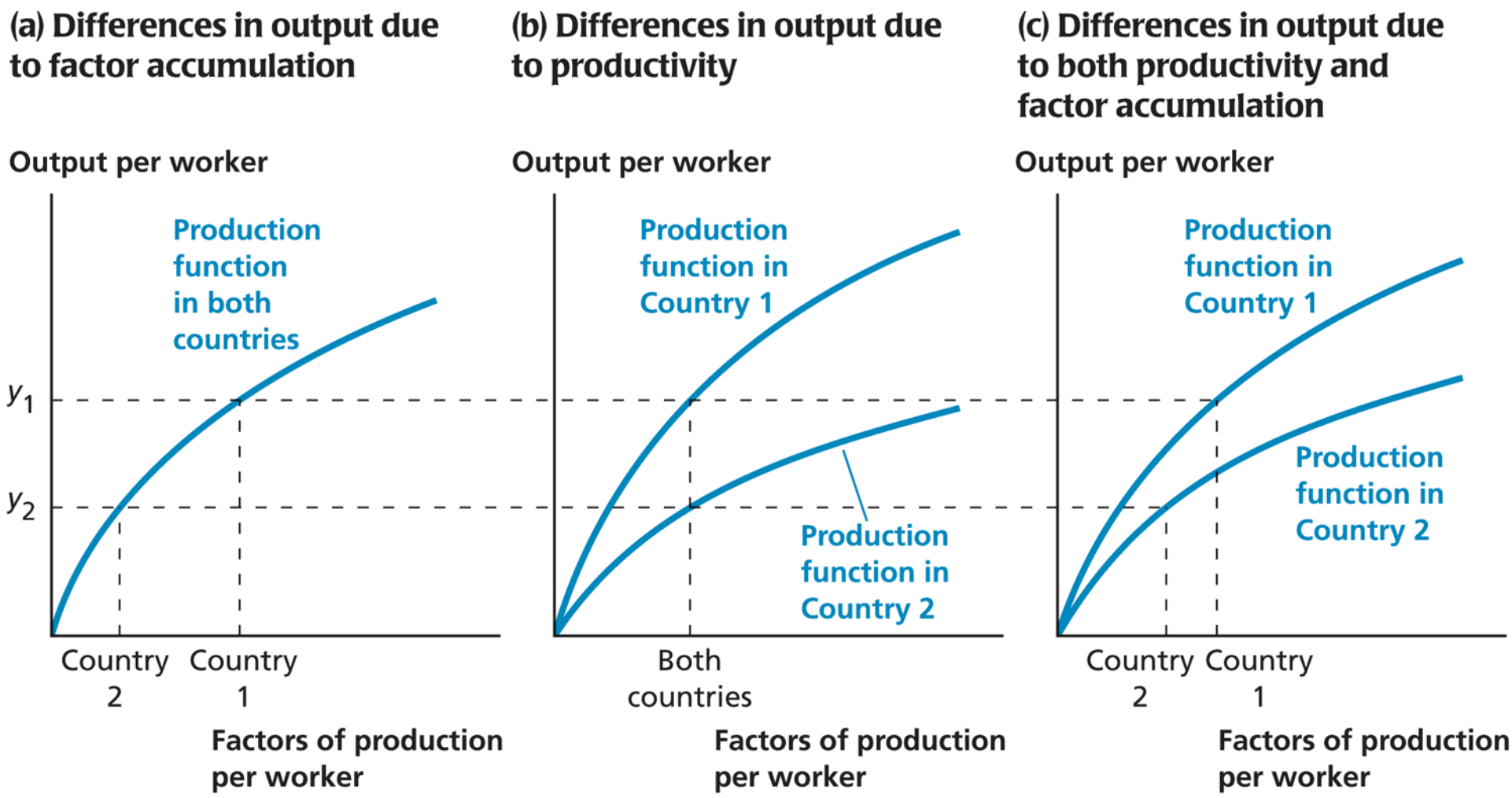
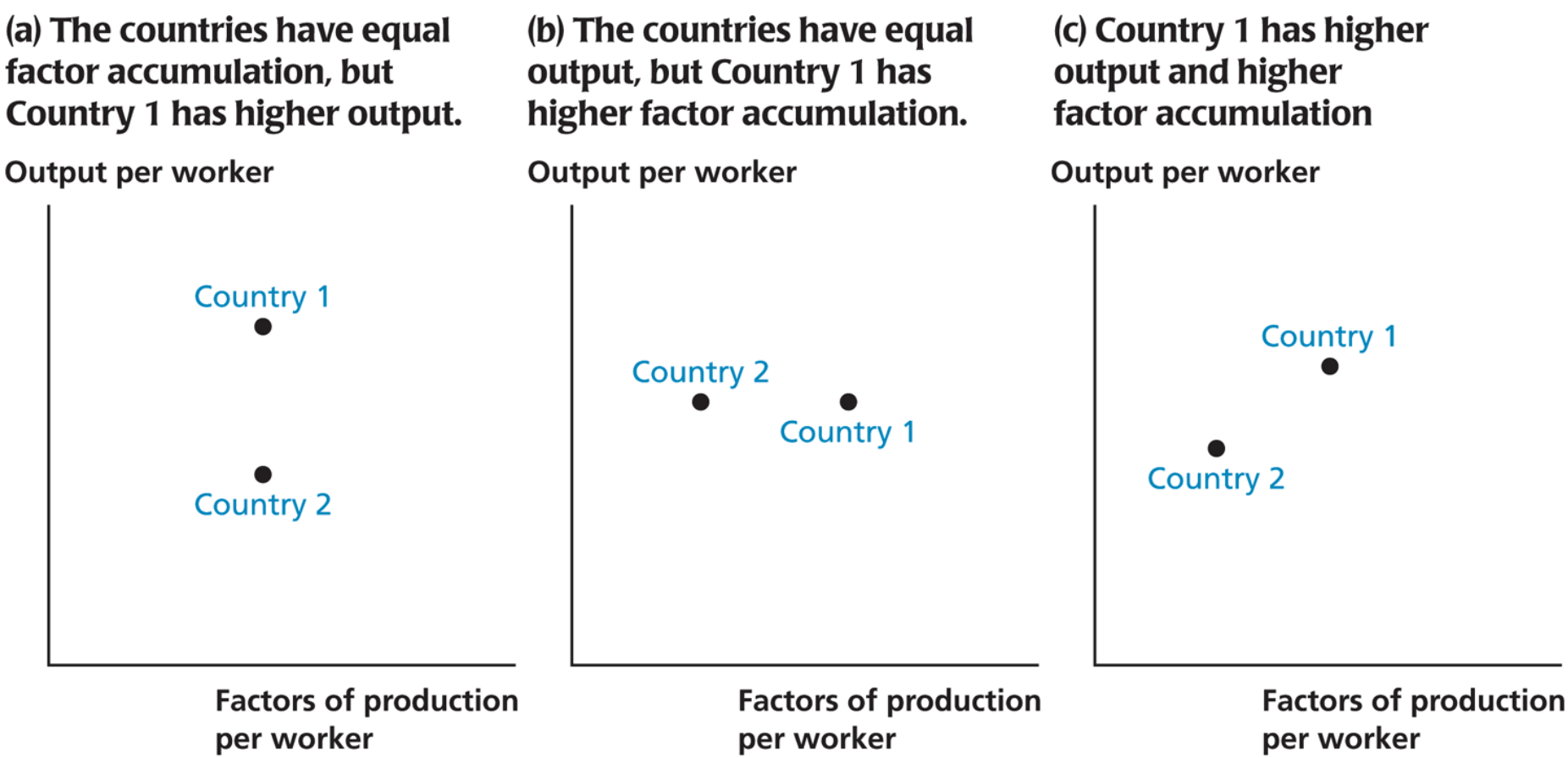


FIGURE 7.2
Inferring Productivity from Data on Output and Factor Accumulation



Development accounting

- $Y = AK^{\alpha}(hL)^{1-\alpha}$
  - In output per worker: $y = Ak^{\alpha}h^{1-\alpha}$
  - *A* measures (total factor) productivity.

- Plugging values of y, k, h, and α to back out A is known as **development accounting**.

- We can directly measure y, k, h, and α in the data.
  - But what about A?
  - It cannot be measured: it is calculated as a “residual”.
    - Sometimes referred to as the “Solow residual”.

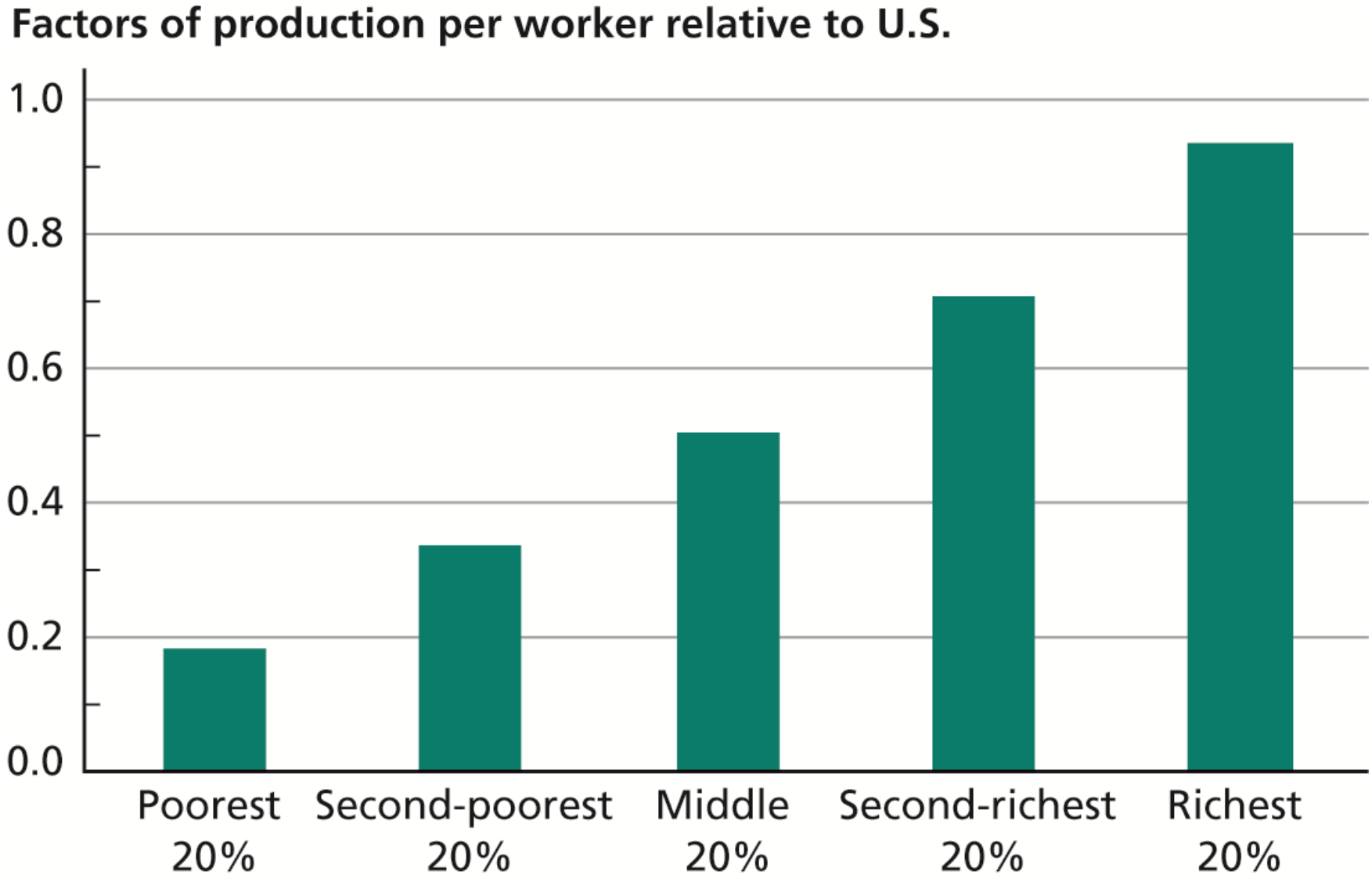
Measuring factors of production

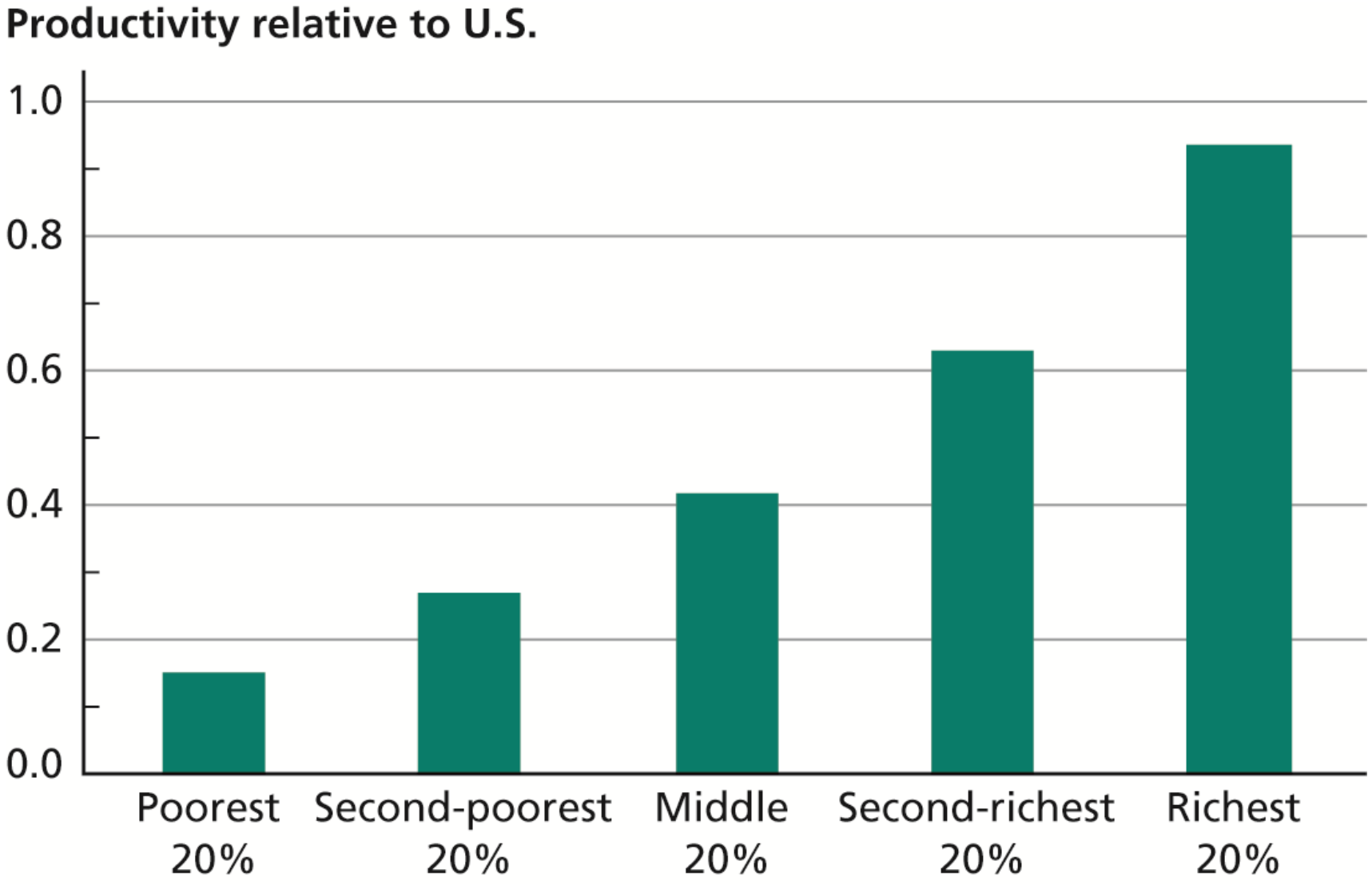
- From previous classes, we estimate that $\alpha = 1/3$.
- How to measure k, h?
  - h: we saw that in the education lecture how to get this from average years of schooling and the returns to education.
    - But is this a good measure?
    - Two important issues: quality of schooling and externalities.
  - k: impossible to measure directly (how would we count the value of all the stuff in the economy?)
    - We use a method called **perpetual inventory.**
    - We observe **investment:** changes to K.
    - Using the capital accumulation formula, a reasonable depreciation rate, a long time series of investment, and an initial guess for K, we would know current K.

- Using data from 78 countries for which all the data is available, we can measure the ratios of productivity and factor accumulation.
  - Here is an example for a subset of them:

Country	Output per Worker, y	Physical Capital per Worker, k	Human Capital per Worker, h	Factors of Production, $k^{1/3}h^{2/3}$	Productivity, A
United States	1.00	1.00	1.00	1.00	1.00
Norway	1.12	1.32	0.98	1.08	1.04
United Kingdom	0.82	0.68	0.87	0.80	1.03
Canada	0.80	0.81	0.96	0.91	0.88
Japan	0.73	1.16	0.98	1.04	0.70
South Korea	0.62	0.92	0.98	0.96	0.64
Turkey	0.37	0.28	0.78	0.55	0.68
Mexico	0.35	0.33	0.84	0.61	0.56
Brazil	0.20	0.19	0.78	0.48	0.42
India	0.10	0.089	0.66	0.34	0.31
Kenya	0.032	0.022	0.73	0.23	0.14
Malawi	0.018	0.029	0.57	0.21	0.087

Sources: Output per worker: Heston, Summers, and Aten (2011); physical capital: author's calculations; human capital: Barro and Lee (2010). The data set used here and in Section 7.3 is composed of data for 90 countries for which consistent data are available for 1975 and 2009.


Factors of production per worker relative to U.S.
1.0
0.8
0.6
0.4
0.2
0.0
Poorest 20%
Second-poorest 20%
Middle 20%
Second-richest 20%
Richest 20%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Reading the previous graphs

- Figure “factors”: if countries had the same productivity, that would be their income relative to the USA.
- Figure “productivity”: if countries had the same capital and education, that would be their income relative to USA
- Usually both productivity and factors go hand-in-hand.
  - E.g. A country in the middle group has 51% of factors and 41% of productivity vis-à-vis the US.
  - Combined effect on output is 21%.

Development Accounting: Conclusions

- Economists usually say that about half of the variation in income per capita across countries come from factors of production, and the other half from productivity.
  - Using logs and variances…

- The numbers may not be exactly right, given all the issues in measuring capital and education.
  - But the main result is fairly robust: a large part of cross-country income differences come from differences in productivity.

Growth Accounting

- Same thing, but across time instead of across countries.

- USA: 1975-2009
  - Output per worker grew 1.34% per year.
  - Physical capital per worker grew 2.2% per year.
  - Human capital per worker grew 0.11% per year.
    - This means that TFP grew 0.54% per year in the period.
    - So growth in TFP explains 0.54/1.34=40% of American growth.

- In the mid-1990s, Alwyn Young applied growth accounting to Hong Kong, Singapore, South Korea, and Taiwan (1965-1990).
  - His conclusion: while GDP growth was huge, TFP growth was not.
    - All the growth was coming from accumulating capital.
    - So it is unlikely they could keep growing at that speed much longer.

What is behind productivity ?

- We think mainly of two things:

- Technology.
  - Better tools.
  - Capital does not fully "pick up" this effect.
    - A $1000 dollar computer today is better than a $1000 computer from 1990. But we still count both as a $1000 addition to the capital stock. Also note this has nothing to do with inflation.

- (Allocative) efficiency.
  - Are we allocating capital and labor to the most productive firms and sectors?

Why technology cannot fully explain cross-country income differences

- Suppose TFP is all technology.
  - The "A" in the production function.

- Suppose the "A" in the production function is all technology.
  - We know (from growth accounting) that the "A" growth for USA is such that it doubled in the 20th Century.
    - $A^{US}_{1900}/A^{US}_{2000} = 0.50$
  - We know (from development accounting) that the "A" ratio between India and USA is 0.31.
    - $A^{India}_{2000}/A^{US}_{2000} = 0.31$

- If A is only technology, than it means that India's technology should be (way more) than 100 years behind the USA.
  - That sounds unreasonable.

Allocative efficiency

- Factors of production need to be allocated to distinct parts (sectors, firms, regions) of the economy.
- What if they are not allocated in the best way?
  - We have "misallocation".
- Easiest way to think is of an economy with 2 sectors and one factor (labor).
  - If there are diminishing marginal returns to labor, there is an efficient allocation (that maximizes output) in which both sectors use some amount of labor.

FIGURE 10.3
Efficient Allocation of Labor Between Sectors

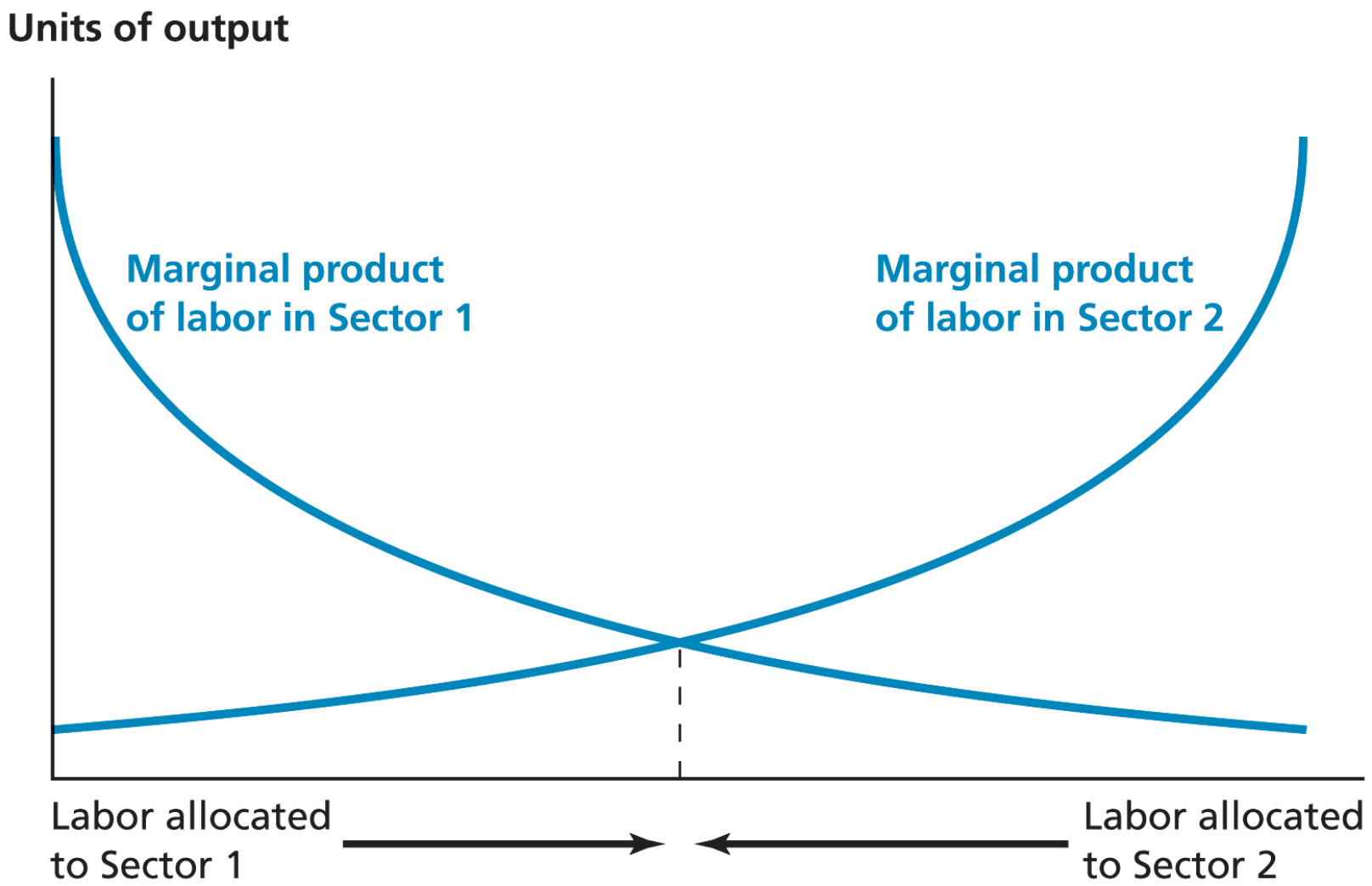
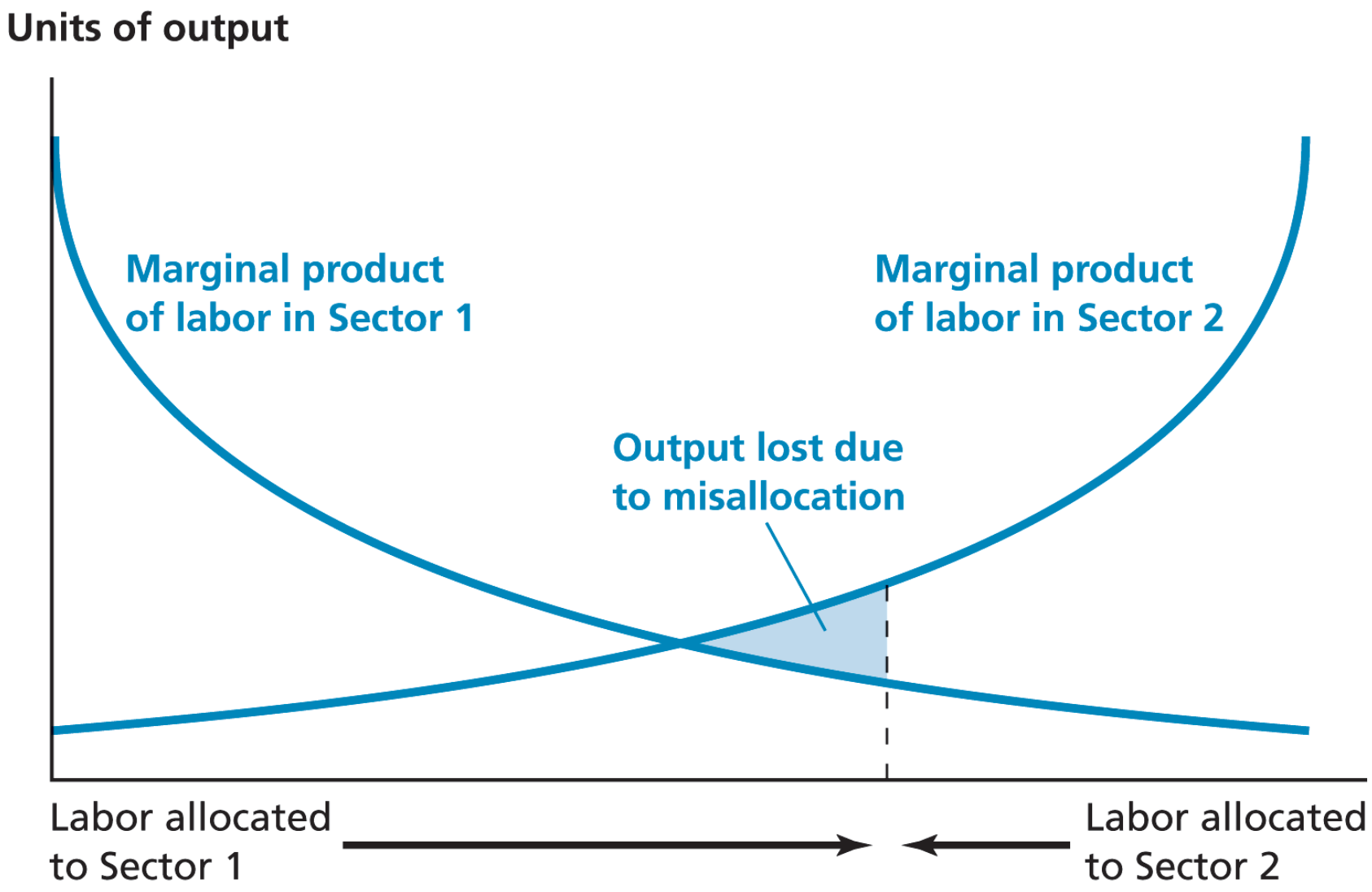


FIGURE 10.4
Overallocation of Labor to Sector 1



Why does misallocation exist and persist?

- Why are factors not re-allocated to the more efficient region, firm and sector?
  - There are barriers to mobility across regions.
  - Policy related distortions.
    - Some sectors are protected.
  - Labor market frictions
    - Farms in developing countries pay workers average product
    - Firms have "monopsony power" and pay workers below marginal product
  - Financial frictions
    - Think about how a small and productive firm would get more L and K.
    - It would probably need to get a loan to do this.
    - Hence the importance of **finance** in generating more efficient allocations.

Hsieh and Klenow (QJE, 2009)

- Can misallocation in the factors of production (K and L) explain variation in TFP across countries?
  - Section 2 of the paper describes a model of monopolistic competition with heterogeneous firms
  - We can show the gist of the argument using a simpler model

- This paper shows that
  - Differences in estimated marginal products of labor and capital across firms in India and China are much larger than in the US.
  - When capital and labor are *hypothetically* reallocated to equalize marginal products to the extent observed in the US, TFP would increase by 30%–50% in China and 40%–60% in India.

Sketch of the Model

- There is a final product Y
- Inputs from M intermediate firms that produce *differentiated* products

$$Y = \left(\sum_{i=1}^{M} Y_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

- Each intermediate firm acts as a monopolist
- Technology of each intermediate firm is Cobb-Douglas

$$Y_i = A_i K_i^{\alpha} L_i^{1-\alpha}$$

Distortions as « Wedges »

- HK assume that there are firm-specific « wedges » affecting total production and capital
  - Think about those as taxes
  - In China: availability of credit and favors to the politically connected firms
- No distortions in labor market: every firms set the same wage
- Nominal profits for firm i:

$$\pi_i = \underbrace{\left(1 - \tau_{Y_i}\right)}_{\text{Lowers Profit}} P_i Y_i - wL_i - \underbrace{\left(1 + \tau_{k_i}\right)}_{\text{Higher cost}} rK_i$$

- As a result
  - Firms produce different amounts than what would be dictated by their productivity
  - Firms have different capital-labor ratios

Labor Wedges

- Differentiate profits with respect to L and set result to 0

$$\underbrace{(1-\alpha)\,P_i \frac{A_i K_i^{\alpha} L_i^{1-\alpha}}{L_i}}_{\text{true MRPL}} = \frac{w}{(1-\tau_{Y_i})} \geq w$$

- If $\tau_{y\_i} > 0$, marginal product of labor exceeds the wage
  - The firm employs not enough labor

$$\downarrow \tau_{y_i} \rightarrow \downarrow w/(1-\tau_{y_i}) \rightarrow \uparrow L_i, Y_i \rightarrow \downarrow P_i.$$

  - The change in A_i is whatever is necessary to maintain equality: A will increase

Capital Wedges

- Similar story with capital. Differentiate with respect to K_i, set the result to 0

$$\underbrace{\alpha P_i \left(1-\tau_{Y_i}\right) \frac{A_i K_i^{\alpha} L_i^{1-\alpha}}{K_i}}_{\text{true MRPK}} = \left(1+\tau_{k_i}\right) r \geq r$$

- P_i should be proportional to 1/A_i, implying that TFPR (=P*A) should be constant across firms/plants within a sector
- Unless firms face capital and/or output distortions

From Wedges to Misallocation

- TFPR is proportional to the two marginal products

$$\mathrm{TFPR}_{si} \propto (\mathrm{MRPK}_{si})^{\alpha_s} (\mathrm{MRPL}_{si})^{1-\alpha_s} \propto \frac{(1+\tau_{Ksi})^{\alpha_s}}{1-\tau_{Ysi}}.$$

- High TFPR is a sign that the firm confronts barriers that raises MPK/MPL, rendering the plant smaller than optimal.

- Variation of TFPR within a sector can be viewed as a measure of misallocation
  - Intuitively, the extent of misallocation is worse when there is greater dispersion of marginal products.

From Wedges to Misallocation

- Closed form expression for aggregate TFP

$$\log \mathrm{TFP}_s = \frac{1}{\sigma - 1} \log \left(\sum_{i=1}^{M_s} A_{si}^{\sigma - 1} \right) - \frac{\sigma}{2} \mathrm{var} \left(\log \mathrm{TFPR}_{si} \right).$$

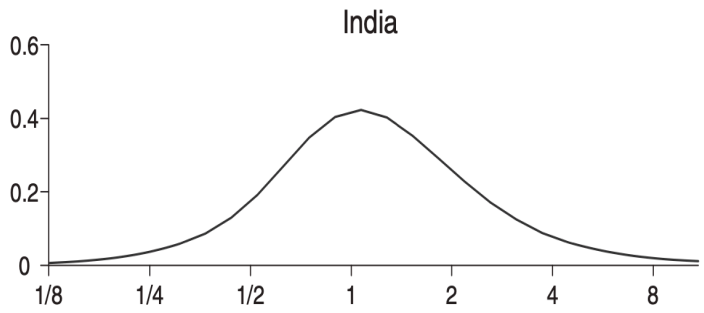
- The negative effect of distortions on aggregate TFP can be summarized by the variance of log TFPR

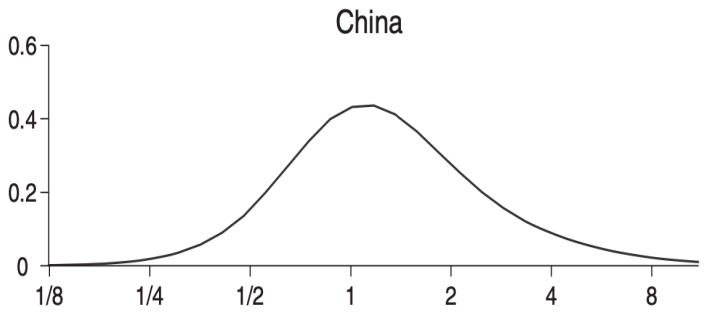
Empirical Implementation

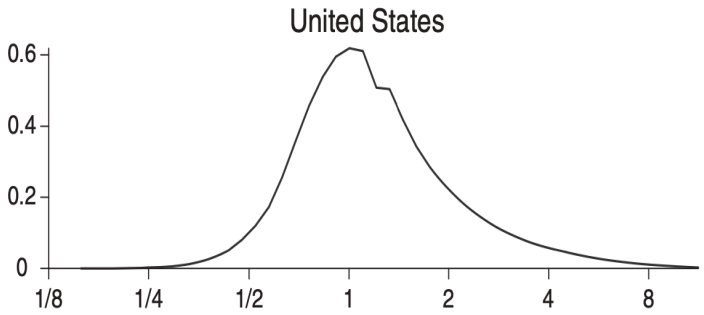
- HK compute TFPR on Chinese, Indian, and US manifacturing data
- Key (strong?) assumptions
  - Rental cost of capital, R=10% (5% interest rate and 5% depreciation)
  - For each industry m=1,…,M use industry capital shares from the US
  - The elasticity of substitution between plant value-added is $\sigma = 3$
- They find greater dispersion of TFPR in India and China than in the US
  - The p90-p10 ratio is 1.59 in China, 1.60 in India and 1.19 in the US

Distributions of TFPR

- Heavier left tail in China/India
  - They have higher percentage of low TFP firms than US.
- An example: government grants monopoly power to a firm. But monopolist doesn't produce enough.
  - The lower output lowers TFP.





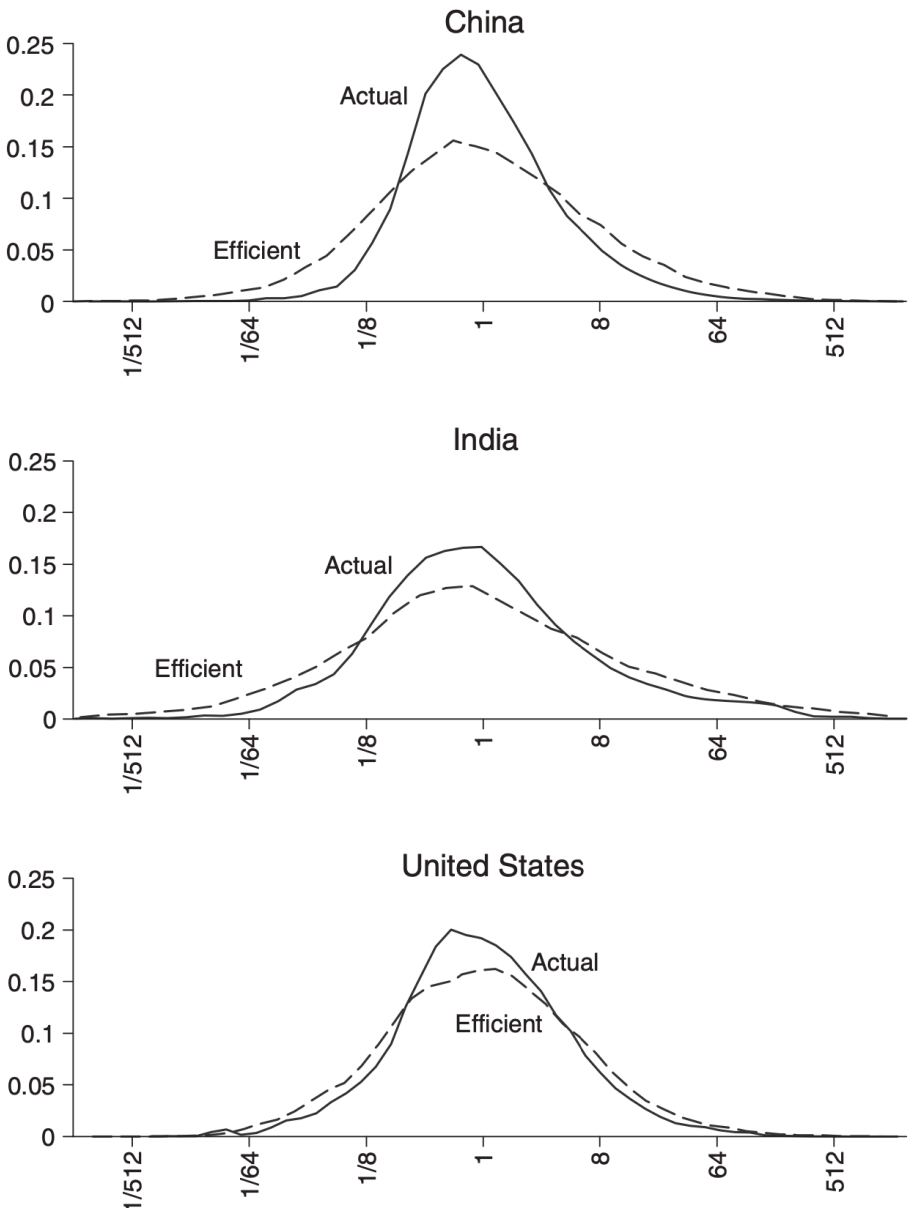


Gains from Equalizing TFPR Within Industries

China	1998	2001	2005
%	115.1	95.8	86.6
India	1987	1991	1994
%	100.4	102.1	127.5
United States	1977	1987	1997
%	36.1	30.7	42.9

Efficient Vs. Actual Size Distributions of Firms

- Efficient output is where you equalize marginal products across plants by reallocating labor and capital within an industry
- Firms that are too small and too large are the most distorted



TFP Gains from Equalizing TFPR Relative to 1997 US Gains

- Maybe the truly efficient reallocation is not feasible. How about getting to US efficiency?

China	1998	2001	2005
%	50.5	37.0	30.5
India	1987	1991	1994
%	40.2	41.4	59.2

- It would result in a 30-50% improvement in TFP in China and in 40-60% improvement in TFP in India

Is this really misallocation?

- Part of the variation in TFP may be due to measurement error
  - Some firms/sectors have a different factor shares, which will show up as differences in TFP
  - Especially the case since sectors are very aggregated, and are made up of lots of subsectors, with very different production functions.

- Monopoly markups and wedges are indistinguishable
  - Firms and sectors with greater markups will appear as if they have greater wedges. Is this misallocation?

TFP and Plant Ownership

- TFPR is systematically related to ownership in China and India

	TFPR
China	
State	−0.415
	(0.023)
Collective	0.114
	(0.010)
Foreign	−0.129
	(0.024)
India	
State (central)	−0.285
	(0.082)
State (local)	−0.081
	(0.063)
Joint public/private	−0.162
	(0.037)

- The omitted group for China is privately owned domestic plants, whereas in India it is privately owned plants because of no information on foreign ownership.

TFP and Plant Exit

- Lower TFPR is associated with a higher probability of plant exit in all three countries

China	
Exit on TFPR	−0.011
	(0.003)
Exit on TFPQ	−0.050
	(0.002)
India	
Exit on TFPR	−0.019
	(0.005)
Exit on TFPQ	−0.027
	(0.004)
United States	
Exit on TFPR	−0.011
	(0.003)
Exit on TFPQ	−0.039
	(0.002)

Wrapping Up on Hsieh-Klenow

- TFP varies enormously across countries
- HK shows that factor misallocation can explain a large portion of these differences
- Two potential omissions:
  - The model does not explain firms exit (CES structure with no fixed costs)
  - Why aren't less efficient firms becoming more efficient? Innovation and productivity improvements (e.g. China: rapid reallocation from rural to urban sectors and from SOE to private firms)