Balanced Growth

Balanced Growth

- A steady state without technological change is one in which output and capital do not change.

Balanced Growth

- A steady state without technological change is one in which output and capital do not change.
- What happens in a steady state with technological change?

Balanced Growth

- A steady state without technological change is one in which output and capital do not change.

- What happens in a steady state with technological change?

- Answer: output and capital grow at a constant rate determined by the rate of technological change.

Endogenous and Exogenous Variables in the Solow Model

Endogenous and Exogenous Variables in the Solow Model

- The growth accounting equation again:

$$g^Y = g^A + \alpha g^K + (1 - \alpha)g^L.$$

Endogenous and Exogenous Variables in the Solow Model

- The growth accounting equation again:

$$g^Y = g^A + \alpha g^K + (1-\alpha)g^L.$$

- The rate of technological change (g^A) and the growth of the labor force (g^L) are exogenous in the Solow model.

Endogenous and Exogenous Variables in the Solow Model

▶ The growth accounting equation again:

$$g^Y = g^A + \alpha g^K + (1 - \alpha)g^L.$$

▶ The rate of technological change (g^A) and the growth of the labor force (g^L) are exogenous in the Solow model. That is, they are determined outside of the economic model.

Endogenous and Exogenous Variables in the Solow Model

- The growth accounting equation again:

$$g^Y = g^A + \alpha g^K + (1 - \alpha)g^L.$$

- The rate of technological change (g^A) and the growth of the labor force (g^L) are exogenous in the Solow model. That is, they are determined outside of the economic model.
- The growth rates of output (g^Y) and capital (g^K) are endogenous in the Solow model.

Endogenous and Exogenous Variables in the Solow Model

- The growth accounting equation again:

$$g^Y = g^A + \alpha g^K + (1 - \alpha)g^L.$$

- The rate of technological change (g^A) and the growth of the labor force (g^L) are exogenous in the Solow model. That is, they are determined outside of the economic model.

- The growth rates of output (g^Y) and capital (g^K) are endogenous in the Solow model. That is, they are determined by (or inside) the economic model.

Solving for the Growth Rate with Balanced Growth

Solving for the Growth Rate with Balanced Growth

▶ In a steady state, there is balanced growth.

Solving for the Growth Rate with Balanced Growth

- In a steady state, there is balanced growth. That is, output and capital grow at the same rate: call it g.

Solving for the Growth Rate with Balanced Growth

- In a steady state, there is balanced growth. That is, output and capital grow at the same rate: call it g.
- Set $g^Y = g^K = g$ in the growth accounting equation:

Solving for the Growth Rate with Balanced Growth

- In a steady state, there is balanced growth. That is, output and capital grow at the same rate: call it g.
- Set $g^Y = g^K = g$ in the growth accounting equation:

$$g = g^A + \alpha g + (1 - \alpha)g^L.$$

Solving for the Growth Rate with Balanced Growth

- In a steady state, there is balanced growth. That is, output and capital grow at the same rate: call it g.
- Set $g^Y = g^K = g$ in the growth accounting equation:

$$g = g^A + \alpha g + (1 - \alpha)g^L.$$

- Now solve for g to get:

Solving for the Growth Rate with Balanced Growth

- In a steady state, there is balanced growth. That is, output and capital grow at the same rate: call it g.
- Set $g^Y = g^K = g$ in the growth accounting equation:

$$g = g^A + \alpha g + (1 - \alpha)g^L.$$

- Now solve for g to get:

$$g = \frac{g^A}{1 - \alpha} + g^L.$$

Solving for the Growth Rate with Balanced Growth

- In a steady state, there is balanced growth. That is, output and capital grow at the same rate: call it g.

- Set $g^Y = g^K = g$ in the growth accounting equation:

$$g = g^A + \alpha g + (1 - \alpha)g^L.$$

- Now solve for g to get:

$$g = \frac{g^A}{1 - \alpha} + g^L.$$

- If $g^A = g^L = 0$ (neither technology nor the labor force is growing), then $g = 0$.

Solving for the Growth Rate with Balanced Growth

- In a steady state, there is balanced growth. That is, output and capital grow at the same rate: call it g.

- Set $g^Y = g^K = g$ in the growth accounting equation:

$$g = g^A + \alpha g + (1 - \alpha)g^L.$$

- Now solve for g to get:

$$g = \frac{g^A}{1 - \alpha} + g^L.$$

- If $g^A = g^L = 0$ (neither technology nor the labor force is growing), then $g = 0$. This is the case we studied previously.

ANNUAL GROWTH RATES IN FIVE RICH COUNTRIES

	$g^Y - g^L$			$g^A/(1-\alpha)$			GDP per capita, 2000/
	1950–1973	1973–1987	$\triangle$	1950–1973	1973–1987	$\triangle$	1950
France	4.0	1.8	−2.2	4.9	2.3	−2.6	3.9
Germany	4.9	2.1	−2.8	5.6	1.9	−3.7	4.7
Japan	8.0	3.1	−4.9	6.4	1.7	−4.7	11.4
U.K.	2.5	1.8	−0.7	2.3	1.7	−0.6	3.0
U.S.	2.2	1.6	−0.6	2.6	0.6	−2.0	2.6
Average	4.3	2.1	−2.2	4.4	1.6	−2.8	3.7

The last column reveals *convergence* between the levels of GDP per capita in these five countries. What accounts for it?

Understanding Growth in Five Rich Countries

Understanding Growth in Five Rich Countries

- ▶ Along a balanced growth path, growth in labor productivity is driven by growth in technology:

Understanding Growth in Five Rich Countries

- Along a balanced growth path, growth in labor productivity is driven by growth in technology:

$$g^Y - g^L = \frac{g^A}{1 - \alpha}.$$

Understanding Growth in Five Rich Countries

▶ Along a balanced growth path, growth in labor productivity is driven by growth in technology:

$$g^Y - g^L = \frac{g^A}{1 - \alpha}.$$

▶ Post-World War II data for five rich countries suggests that these countries have been experiencing balanced growth since 1950:

Understanding Growth in Five Rich Countries

▶ Along a balanced growth path, growth in labor productivity is driven by growth in technology:

$$g^Y - g^L = \frac{g^A}{1 - \alpha}.$$

▶ Post-World War II data for five rich countries suggests that these countries have been experiencing balanced growth since 1950: changes in the growth rate of GDP per capita move (more or less) one-for-one with changes in the rate of technological progress.

Understanding Growth in Five Rich Countries

▶ Along a balanced growth path, growth in labor productivity is driven by growth in technology:

$$g^Y - g^L = \frac{g^A}{1 - \alpha}.$$

▶ Post-World War II data for five rich countries suggests that these countries have been experiencing balanced growth since 1950: changes in the growth rate of GDP per capita move (more or less) one-for-one with changes in the rate of technological progress.

▶ Lesson:

Understanding Growth in Five Rich Countries

- Along a balanced growth path, growth in labor productivity is driven by growth in technology:

$$g^Y - g^L = \frac{g^A}{1 - \alpha}.$$

- Post-World War II data for five rich countries suggests that these countries have been experiencing balanced growth since 1950: changes in the growth rate of GDP per capita move (more or less) one-for-one with changes in the rate of technological progress.

- Lesson: The gap between Japanese GDP per capita and U.S. GDP per capita has grown smaller since 1950 because the rate of technological progress in Japan has been higher.

The Catch-Up Effect

The Catch-Up Effect

▶ Countries with low capital (i.e., countries which are below the balanced growth path) grow faster than countries on the balanced growth path because the marginal product of capital is relatively high.

The Catch-Up Effect

► Countries with low capital (i.e., countries which are below the balanced growth path) grow faster than countries on the balanced growth path because the marginal product of capital is relatively high. This is called the catch-up effect.

The Catch-Up Effect

- Countries with low capital (i.e., countries which are below the balanced growth path) grow faster than countries on the balanced growth path because the marginal product of capital is relatively high. This is called the catch-up effect.
- The catch-up effect helps to explain 10% annual growth rates of GDP in France immediately after World War II (30% of France's physical capital was destroyed during the war).

The Catch-Up Effect

- Countries with low capital (i.e., countries which are below the balanced growth path) grow faster than countries on the balanced growth path because the marginal product of capital is relatively high. This is called the catch-up effect.

- The catch-up effect helps to explain 10% annual growth rates of GDP in France immediately after World War II (30% of France's physical capital was destroyed during the war).

- The catch-up effect also helps to explain South Korean growth rates of 6% during 1960 to 1990.

Region	Population		Life expectancy at birth (years)	Per capita GDP*		Education Youth illiteracy rate (% ages 15–24)	Technology Personal computers (per 1,000 persons)
	Number, 2001 (millions)	Growth rate, 1980–2001 (%)		Dollars	Growth, 1980–2000 (% per year)		
East Asia and Pacific (China, Indonesia, . . .)	1,823	1.4	69	3,790	6.2	3	19
Eastern Europe and Central Asia (Russia, Poland, . . .)	475	0.5	69	6,320	−0.8	1	52
Latin America and Caribbean (Brazil, Mexico, . . .)	524	1.8	71	6,900	0.7	5	59
Middle East and North Africa (Egypt, Iran, . . .)	301	2.6	68	5,430	−0.1	20	32
South Asia (India, Pakistan, . . .)	1,378	2.0	63	2,570	3.6	33	5
Sub-Saharan Africa (Nigeria, Ethiopia, . . .)	674	2.7	46	1,750	−0.7	23	10

*Data on per capita incomes use purchasing-power-parity valuation of incomes to reflect what incomes in the countries can actually buy.

TABLE 28-1. Important Indicators for Different Country Groups
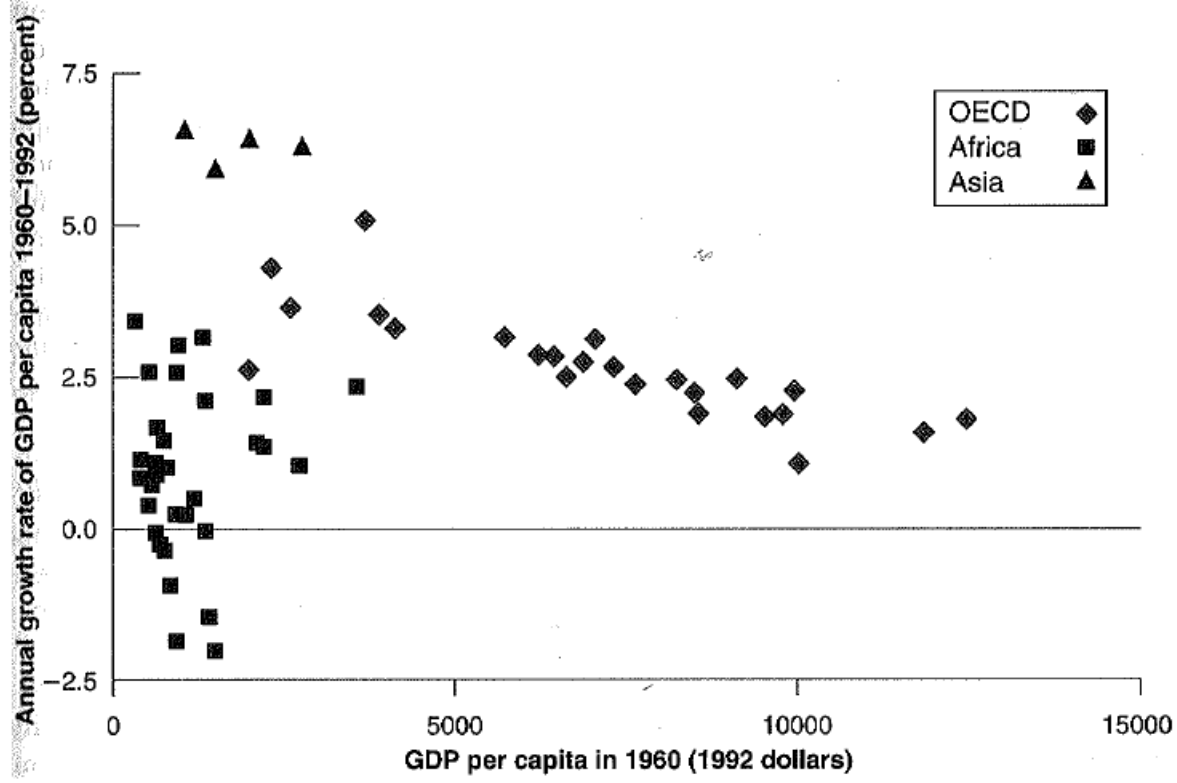
Growth Rate of GDP per Capita, 1960–1992, Versus GDP per Capita in 1960; OECD, Africa, and Asia.

Asian countries are converging to OECD levels. There is no evidence of convergence for African countries.

Productivity Gaps

Productivity Gaps

- ▶ Why aren't underdeveloped countries in many parts of the world (for example, sub-Saharan Africa) catching up to developed countries?

Productivity Gaps

▶ Why aren't underdeveloped countries in many parts of the world (for example, sub-Saharan Africa) catching up to developed countries?

▶ Recall that:

$$\frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha}.$$

Productivity Gaps

- Why aren't underdeveloped countries in many parts of the world (for example, sub-Saharan Africa) catching up to developed countries?

- Recall that:

$$\frac{Y}{L} = A \left(\frac{K}{L} \right)^{\alpha}.$$

So either the capital-labor ratio (K/L) must be lower (workers have less capital to work with),

Productivity Gaps

- Why aren't underdeveloped countries in many parts of the world (for example, sub-Saharan Africa) catching up to developed countries?

- Recall that:

$$\frac{Y}{L} = A \left(\frac{K}{L} \right)^{\alpha}.$$

So either the capital-labor ratio (K/L) must be lower (workers have less capital to work with), or there is a gap in total factor productivity (A is lower in underdeveloped countries than in developed countries).

Productivity Gaps

- Why aren't underdeveloped countries in many parts of the world (for example, sub-Saharan Africa) catching up to developed countries?

- Recall that:

$$\frac{Y}{L} = A \left(\frac{K}{L} \right)^{\alpha}.$$

  So either the capital-labor ratio (K/L) must be lower (workers have less capital to work with), or there is a gap in total factor productivity (A is lower in underdeveloped countries than in developed countries).

- Most studies conclude that gaps in TFP (total factor productivity) are important in making sense of cross-country differences in GDP per capita.

Explanations for Differences in TFP

Explanations for Differences in TFP

- Differences in human capital (education, health).

Explanations for Differences in TFP

- Differences in human capital (education, health).
- Barriers to trade (openness encourages growth).

Explanations for Differences in TFP

- Differences in human capital (education, health).
- Barriers to trade (openness encourages growth).
- Lack of incentives to innovate (unenforceable contracts, weak patent and copyright law).

Explanations for Differences in TFP

- **Differences in human capital** (education, health).
- **Barriers to trade** (openness encourages growth).
- **Lack of incentives to innovate** (unenforceable contracts, weak patent and copyright law).
- **Political instability** (property rights insecure).

Explanations for Differences in TFP

- Differences in human capital (education, health).
- Barriers to trade (openness encourages growth).
- Lack of incentives to innovate (unenforceable contracts, weak patent and copyright law).
- Political instability (property rights insecure).
- Corruption (foreign direct investment expropriated by gov't officials, resources diverted to rent-seeking and bribery).
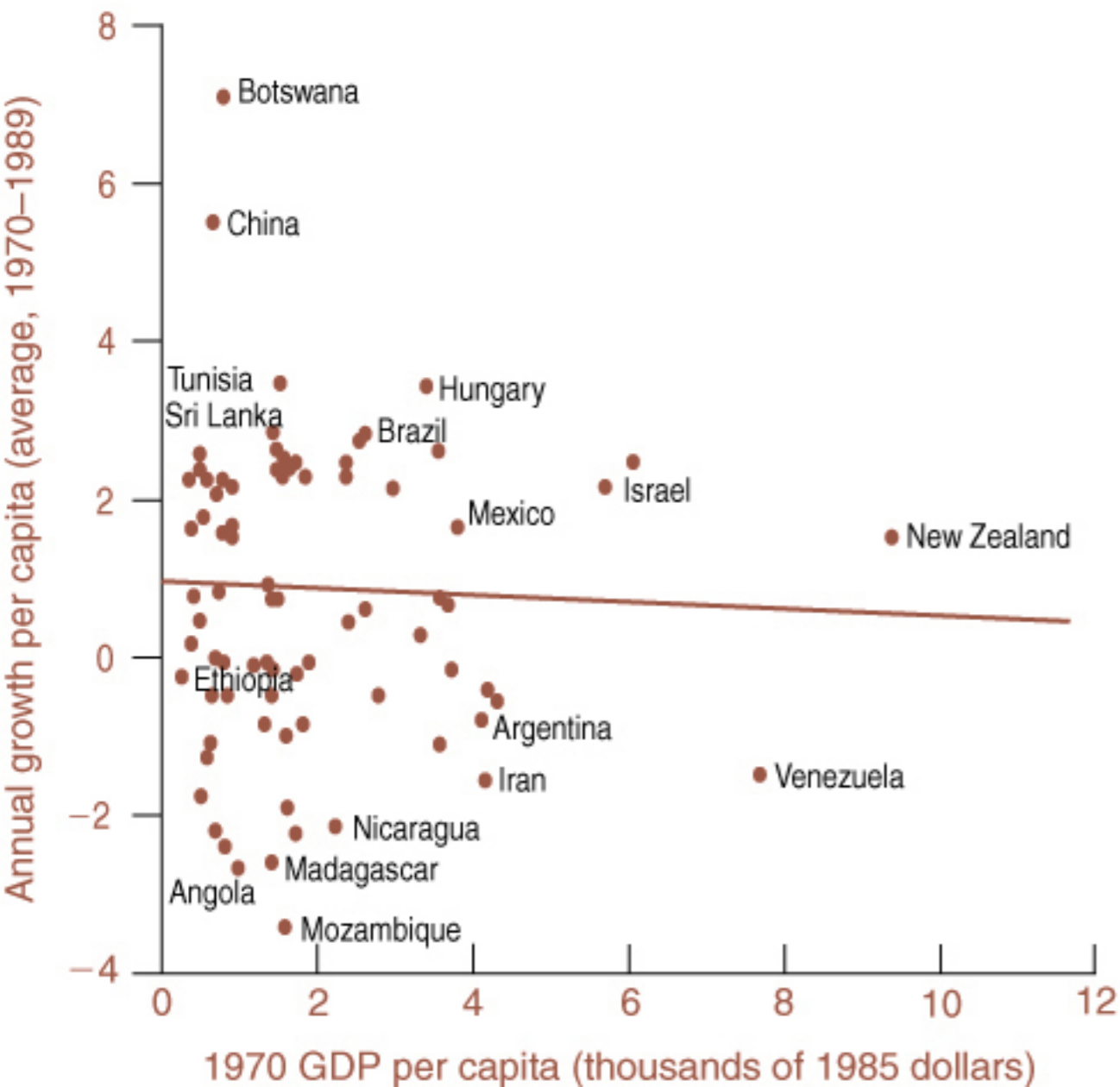
Explanations for Differences in TFP

- Differences in human capital (education, health).
- Barriers to trade (openness encourages growth).
- Lack of incentives to innovate (unenforceable contracts, weak patent and copyright law).
- Political instability (property rights insecure).
- Corruption (foreign direct investment expropriated by gov't officials, resources diverted to rent-seeking and bribery).
- Insufficient investment in research and development.
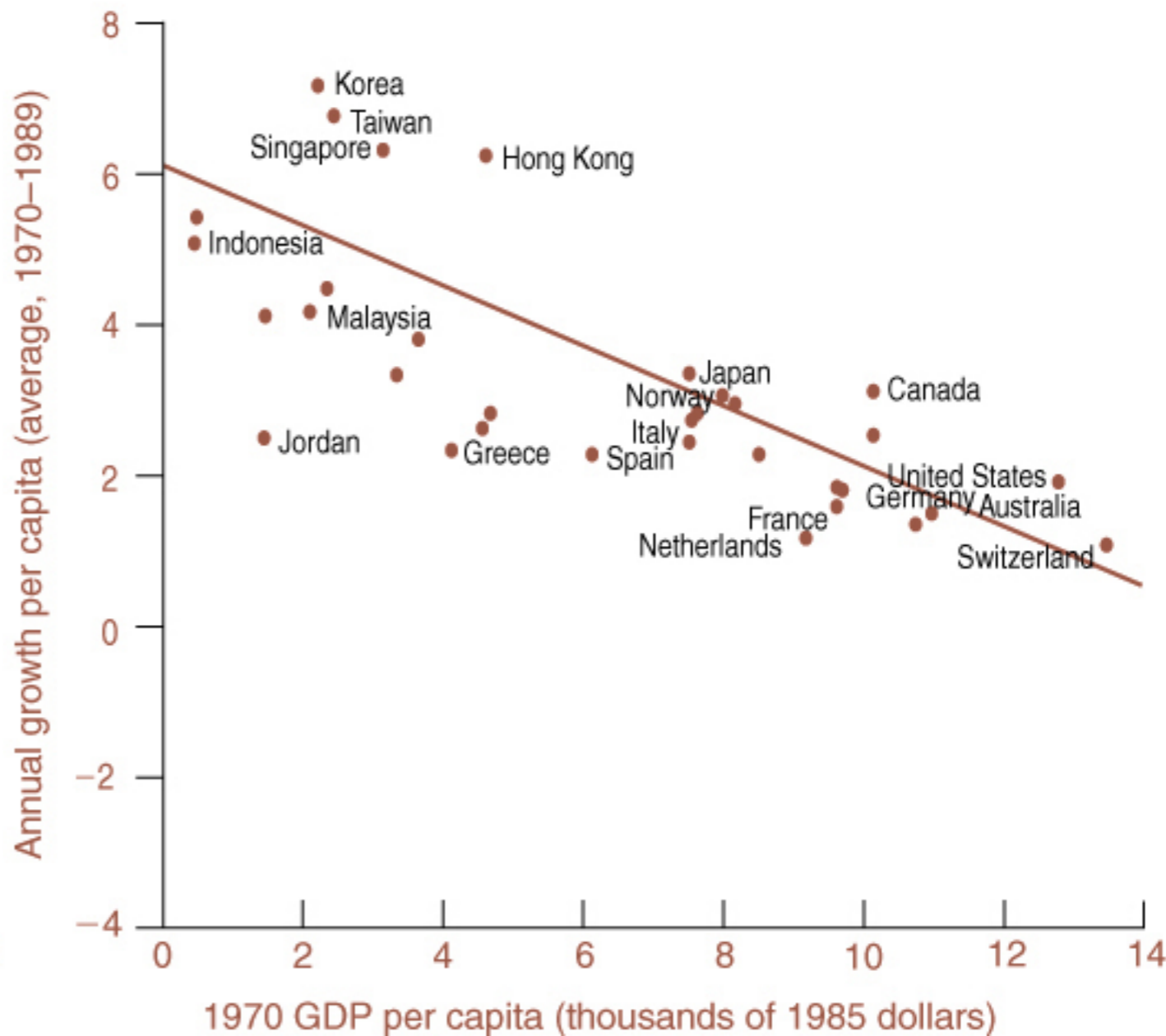
Explanations for Differences in TFP

- **Differences in human capital** (education, health).
- **Barriers to trade** (openness encourages growth).
- **Lack of incentives to innovate** (unenforceable contracts, weak patent and copyright law).
- **Political instability** (property rights insecure).
- **Corruption** (foreign direct investment expropriated by gov't officials, resources diverted to rent-seeking and bribery).
- **Insufficient investment in research and development**.

(a) High Barriers

Annual growth per capita (average, 1970–1989) vs. 1970 GDP per capita (thousands of 1985 dollars)

Labeled points: Botswana, China, Tunisia, Sri Lanka, Hungary, Brazil, Mexico, Israel, New Zealand, Ethiopia, Argentina, Iran, Venezuela, Nicaragua, Madagascar, Angola, Mozambique

(b) Low Barriers

Annual growth per capita (average, 1970–1989) vs. 1970 GDP per capita (thousands of 1985 dollars)

Labeled points: Korea, Taiwan, Singapore, Hong Kong, Indonesia, Malaysia, Jordan, Greece, Norway, Japan, Italy, Spain, Canada, France, Netherlands, Germany, United States, Australia, Switzerland

Are There Limits to Growth?

Are There Limits to Growth?

- ▶ Malthus thought that the long-run fate of economies was "misery and vice:"

Are There Limits to Growth?

- ▶ Malthus thought that the long-run fate of economies was "misery and vice:" "The power of population is infinitely greater than the power in the earth to produce subsistence for man."

Are There Limits to Growth?

- Malthus thought that the long-run fate of economies was "misery and vice:" "The power of population is infinitely greater than the power in the earth to produce subsistence for man."

- But Malthus failed to account for the demographic transition (drops in fertility rates) and for immense technological change in agriculture.

Are There Limits to Growth?

▶ Malthus thought that the long-run fate of economies was "misery and vice:" "The power of population is infinitely greater than the power in the earth to produce subsistence for man."

▶ But Malthus failed to account for the demographic transition (drops in fertility rates) and for immense technological change in agriculture.

▶ Fertility rates drop because the opportunity cost of bearing and raising children increases as economies develop.

Are There Limits to Growth?

- ▶ Malthus thought that the long-run fate of economies was "misery and vice:" "The power of population is infinitely greater than the power in the earth to produce subsistence for man."

- ▶ But Malthus failed to account for the demographic transition (drops in fertility rates) and for immense technological change in agriculture.

- ▶ Fertility rates drop because the opportunity cost of bearing and raising children increases as economies develop. Parents trade off quantity of children for quality (education).

Are There Limits to Growth?

- Malthus thought that the long-run fate of economies was "misery and vice:" "The power of population is infinitely greater than the power in the earth to produce subsistence for man."

- But Malthus failed to account for the demographic transition (drops in fertility rates) and for immense technological change in agriculture.

- Fertility rates drop because the opportunity cost of bearing and raising children increases as economies develop. Parents trade off quantity of children for quality (education).

- The Club of Rome in 1970's also made dire predictions for the world economy, none of which came true.

Are There Limits to Growth?

- Malthus thought that the long-run fate of economies was "misery and vice:" "The power of population is infinitely greater than the power in the earth to produce subsistence for man."

- But Malthus failed to account for the demographic transition (drops in fertility rates) and for immense technological change in agriculture.

- Fertility rates drop because the opportunity cost of bearing and raising children increases as economies develop. Parents trade off quantity of children for quality (education).

- The Club of Rome in 1970's also made dire predictions for the world economy, none of which came true. For example, prices of natural resources actually fell between 1980 and 1990.

Are There Limits to Growth?

- Malthus thought that the long-run fate of economies was "misery and vice:" "The power of population is infinitely greater than the power in the earth to produce subsistence for man."

- But Malthus failed to account for the demographic transition (drops in fertility rates) and for immense technological change in agriculture.

- Fertility rates drop because the opportunity cost of bearing and raising children increases as economies develop. Parents trade off quantity of children for quality (education).

- The Club of Rome in 1970's also made dire predictions for the world economy, none of which came true. For example, prices of natural resources actually fell between 1980 and 1990.

- Will technological change help to deal with the economic effects of global warming?

Commodity Prices (inflation adjusted)

Legend: Chromium, Copper, Nickel, Tin, Tungsten, Average