Chapter 4

A second proximate determinant of long-run growth: Population growth

Introduction

- ✓ Role of capital
- ➢ Role of population growth
- ➢ Role of other production factors
- ➢ Role of world trade
- ➢ Role of productivity
  - ➢ Technology
  - ➢ Efficiency

Introduction

If labor were the sole input to production:

- What type of returns to scale would we have?
- Would that help us explain historical and between country growth experiences?

Workers use capital to produce.

Introduction

Imagine for a second that capital were *non-rival*, just like an idea.

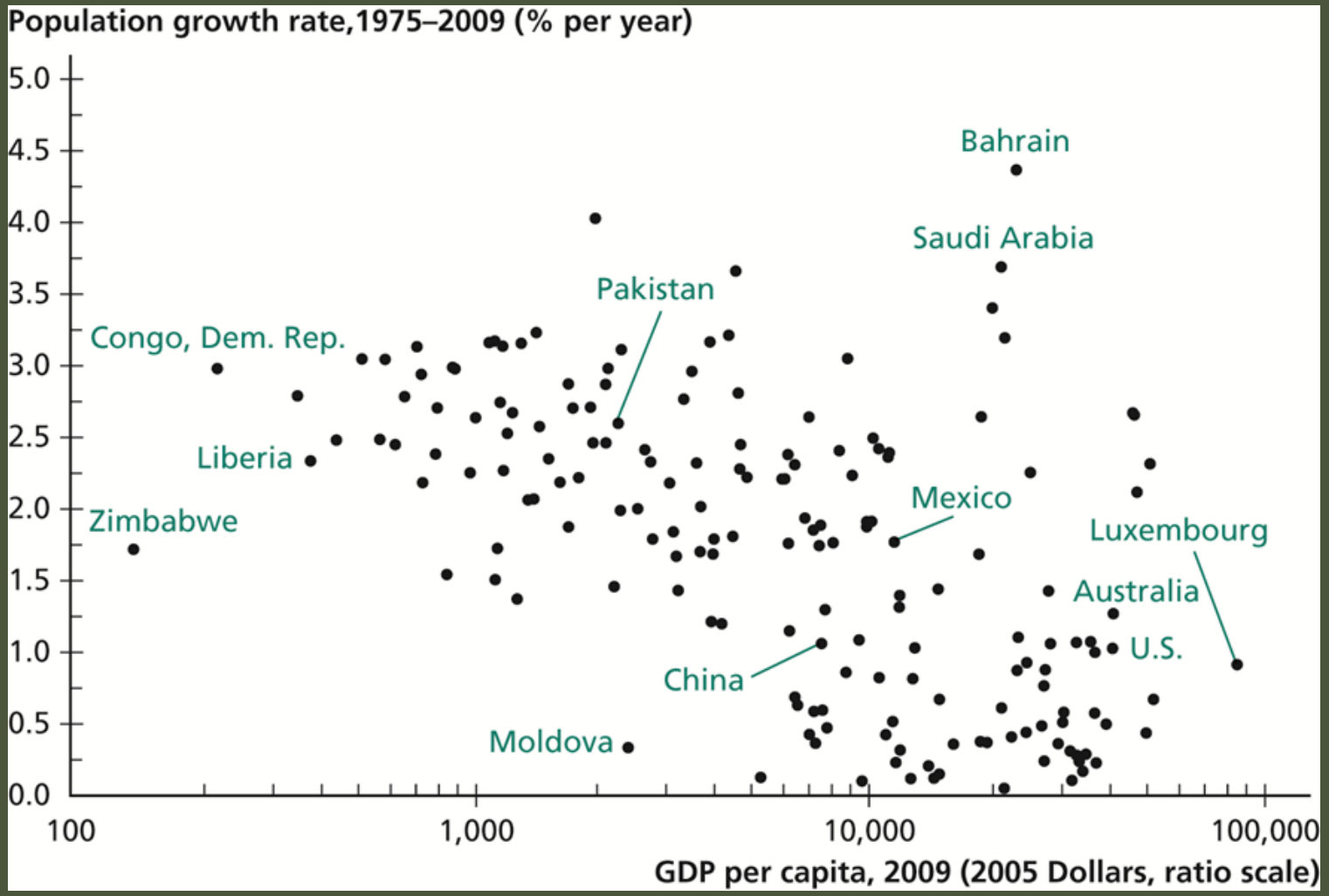
- How would the marginal productivity curve of labor look like?
- What does that imply for the effect of population growth on per-capita income?
- What if this non-rival capital could move freely between countries, just like ideas?

Introduction

- Because workers use capital to produce, capital/worker ratio is important to explain income.
- Combine that with the fact that capital is a rival factor to conclude that:

Population size is important to explain income differences.

X-country comparison

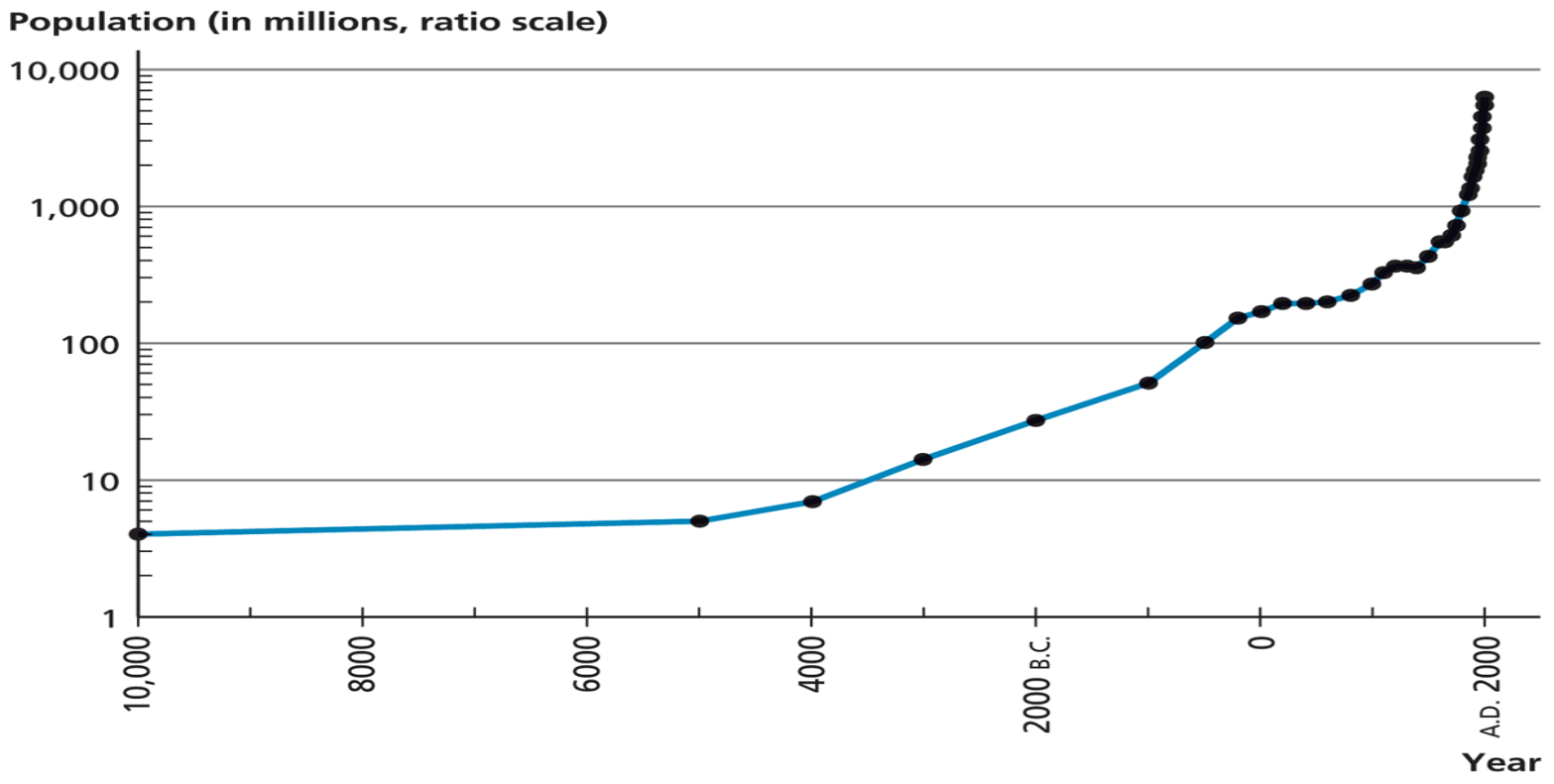


X-country comparison

- **Negative correlation has many possible explanations:**
  1. **Higher population growth increases poverty.**
  2. **Poverty increases population growth.**
  3. **Two-way causality.**
  4. **No causality (missing variable)**

X-time evolution

FIGURE 4.2
World Population, 10,000 B.C. to A.D. 2000



Source: Kremer (1993).

Facts to explain

1. Why did population growth keep on increasing through human history?
2. Why is population growth today so much higher in poor than rich countries?
3. Why was per-capita income essentially constant through time and places before 1800?
4. Why did per-capita income increase so much after?

A theory linking population growth and income levels will help us understand.

Plan

1. Malthusian growth
2. Population growth in the Solow model
   a. Qualitative analysis
   b. Quantitative analysis
3. Explaining population growth
   a. The demographic transition
   b. Explaining fertility

MALTHUSIAN GROWTH

Explaining constant income levels

Malthusian Growth

- Thomas Malthus: English 1766-1834
- Under favorable circumstances, i.e. resource abundance, population grows rapidly.
- Population growth is constrained by resource availability; here,

Agricultural land

Malthusian growth

- A high land/population ratio causes population to grow.
- A high population/land ratio causes population to decline.
- A purely biological model. Analogous models for fish populations.
- **(take note)**

Stationary state (steady state)

- There is a stationary state with constant population size.
- The stationary state is stable.

- This model is useful to analyze variations in some important variables such as
  - Worker productivity
  - Fertility rates

Effects of productivity improvements

1. New irrigation system
2. New seed variety
3. Land clearing

- Assume that for a given population size, labor productivity increases.

- **(take note)**

Increased productivity

- Higher income per capita in the short run.
- No change of income per capita in the long run.
- Such predictions are surprisingly consistent with world history before 1800:
  - Low population growth is linked with slow technological progress.
  - Living conditions did not change much around the

subsistence level.

Increased productivity

China around 1000:

- Even though China was technologically more advanced, the population's living conditions were not much better than those of Europe at the time.

Ireland around 1750:

- Introduction of potato crop multiplies productivity by a factor of three.
- After 1750, population size is multiplied by three in 100 years.
- Not much improvements in living conditions over the long run.

Improving standards of living

Malthus' prescriptions

- For Malthus, increasing productivity will never improve the human condition.
- His solution?

Moral abstinence

- For any income level, population growth is lower, i.e. the population growth curve shifts down.

The Malthusian model breaks down

- The model is good at explaining per capita income growth before 1800.
- It is not good at explaining what happened afterwards:

Rich countries now have lower population growths.

- Irony:

Malthus' model started to lose its relevance precisely at the same time that he was developing it.

The Malthusian model breaks down

Two failing assumptions:

1. Even with a fixed quantity of land, larger population does not necessarily lead to lower income.

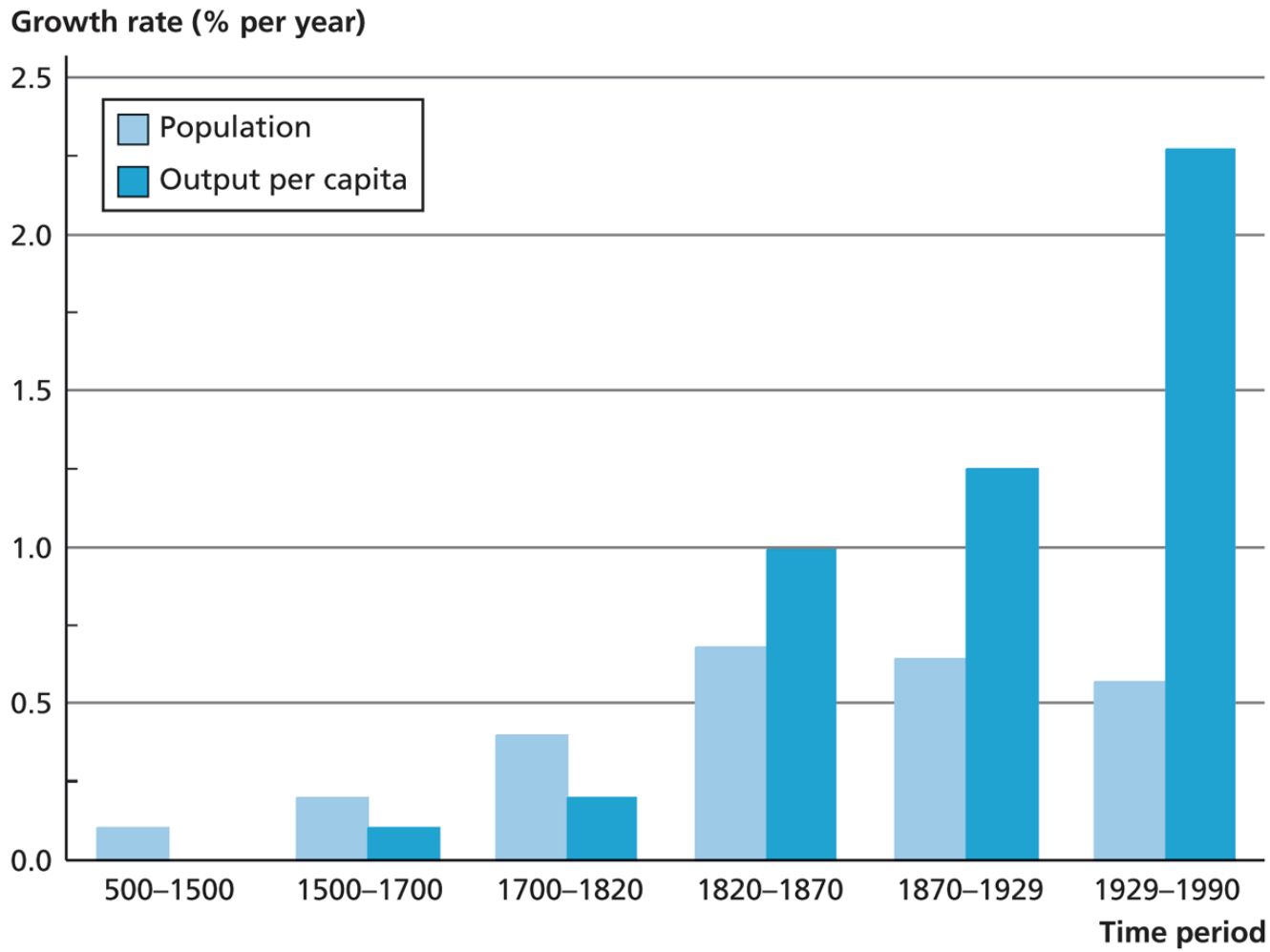
Technological progress

2. A higher income does not necessarily lead to higher population growth.

New phenomenon at end of 19th century:

Higher income growth is accompanied by falling population growth.

FIGURE 4.6
Breakdown of the Malthusian Model in Western Europe



Source: Galor and Weil (2000).

Breakdown of the Malthusian model

- With increasing per-capita income, population growth increases initially, but falls subsequently while per-capita income continues to rise. This phenomenon is not unique to Western Europe.
- In order to explain economic growth, it is of crucial importance to understand the complex link between population growth and income per capita.
- Before that, let us see how population growth enters the Solow model.

(take notes)

POPULATION GROWTH IN THE SOLOW MODEL

Solow v. Malthus

- With Malthus, the supply of land is fixed. (Holds generally for natural resource endowments.)
- Today, natural resources can play a role, but it is not so central.
- Physical capital is at least as important to explain per capita income. This makes a big difference because

  the supply of physical capital is not fixed.
- The Solow model is useful to understand the effect of population growth on income per capita.
- Instead of population size, it considers population growth.
- With Solow, the supply of capital is endogenous.

Population growth in the Solow model

- *Capital dilution:* If population increases while the stock of capital remains constant, there is less capital per capita and income per capita goes down.
- If investment increases to compensate, this additional burden lowers consumption.
- To illustrate, imagine that population increases by 1% while depreciation is nil.
- In order to make up, the investment needs to increase by 1% of the initial stock of capital.
- Without investment, the stock of capital per capita decreases by 1%.

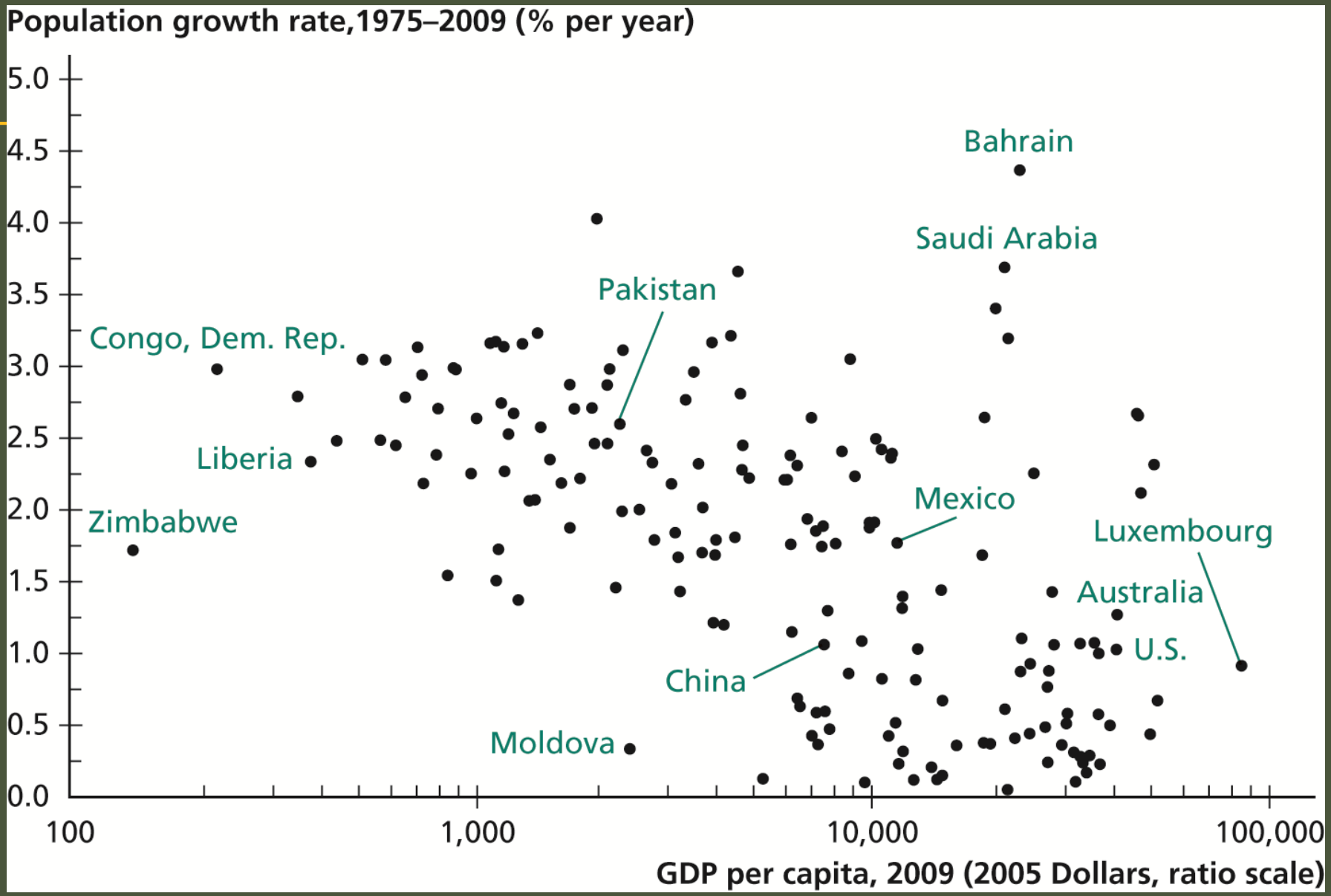
Population growth and capital per capita

- The effect of capital dilution is "effectively" the same as that of depreciation. It is *as if* the depreciation rate had increased.
- A higher population growth rate lowers the steady-state amount of capital per capita.
- This explains why with higher population growth, people tend to be poorer.
- Keep in mind:

The stock of capital per capita is endogenous in the Solow model.

Quantitative analysis

- The previous analysis was *qualitative*.
- It would be nice to put an order of magnitude about the effect of population growth on income per capita.
- Assume a Cobb-Douglas production function…
- Prediction: A 4% difference in population growth can lead to a 34% difference in steady-state per-capita income.
- According to the following graphic, 34% is too small a number:


Population growth rate,1975–2009 (% per year)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Bahrain
Saudi Arabia
Pakistan
Congo, Dem. Rep.
Liberia
Zimbabwe
Mexico
Luxembourg
Australia
U.S.
China
Moldova
100
1,000
10,000
100,000
GDP per capita, 2009 (2005 Dollars, ratio scale)

Quantitative analysis

- Those predictions are quite sensitive to the value of parameter α.
- With human capital, α=2/3 may be more appropriate. This yields:

$$\frac{y_i^{**}}{y_j^{**}} = \left(\frac{0,04+0,05}{0,00+0,05}\right)^2 = 3,24$$

- Income per capita in country i is now 224% higher, instead of just 34%!
- This is a better fit with the data, but still imperfect.

We have just added one additional brick.

Understanding population growth

- We have analyzed the effect of population growth on individual income.
- We assumed that the population growth rate was exogenous.

Can we explain variations in population growth rates?

Comparing the effects of population within two models

- The Malthusian Model:
  - Population size is endogenous
  - Production factor availability is exogenous (except labor)
  - Long-run differences in per-capita income:
    - Due to fertility rate
    - Not due to productivity
- The Solow Model:
  - Population size (or growth) is exogenous
  - Factor availability is endogenous
  - Long-run differences in per-capita income
    - Due to population growth
    - And investment rate

Two big questions remain

1. How can we explain long-run population growth?

2. How can we explain the fertility changes that we observed in the past two hundred years?

Understanding population growth

The Demographic Transition

Understanding population growth

- *Demographic Transition:* Evolution of the demographic characteristics of a country as it develops.
- We are particularly interested in changes in
  1. *The mortality rate*
  2. *The fertility rate*
- We will see in particular that
  - The demographic transition contributes importantly to our understanding of improved standards of living.
  - The demographic transition is not occurring in the same way in today's poor countries as compared to the history of rich countries.

1. The mortality transition

- A remarkable fact of recent history:

The major decline in the mortality rate in the world.

- A common way to measure the mortality rate:

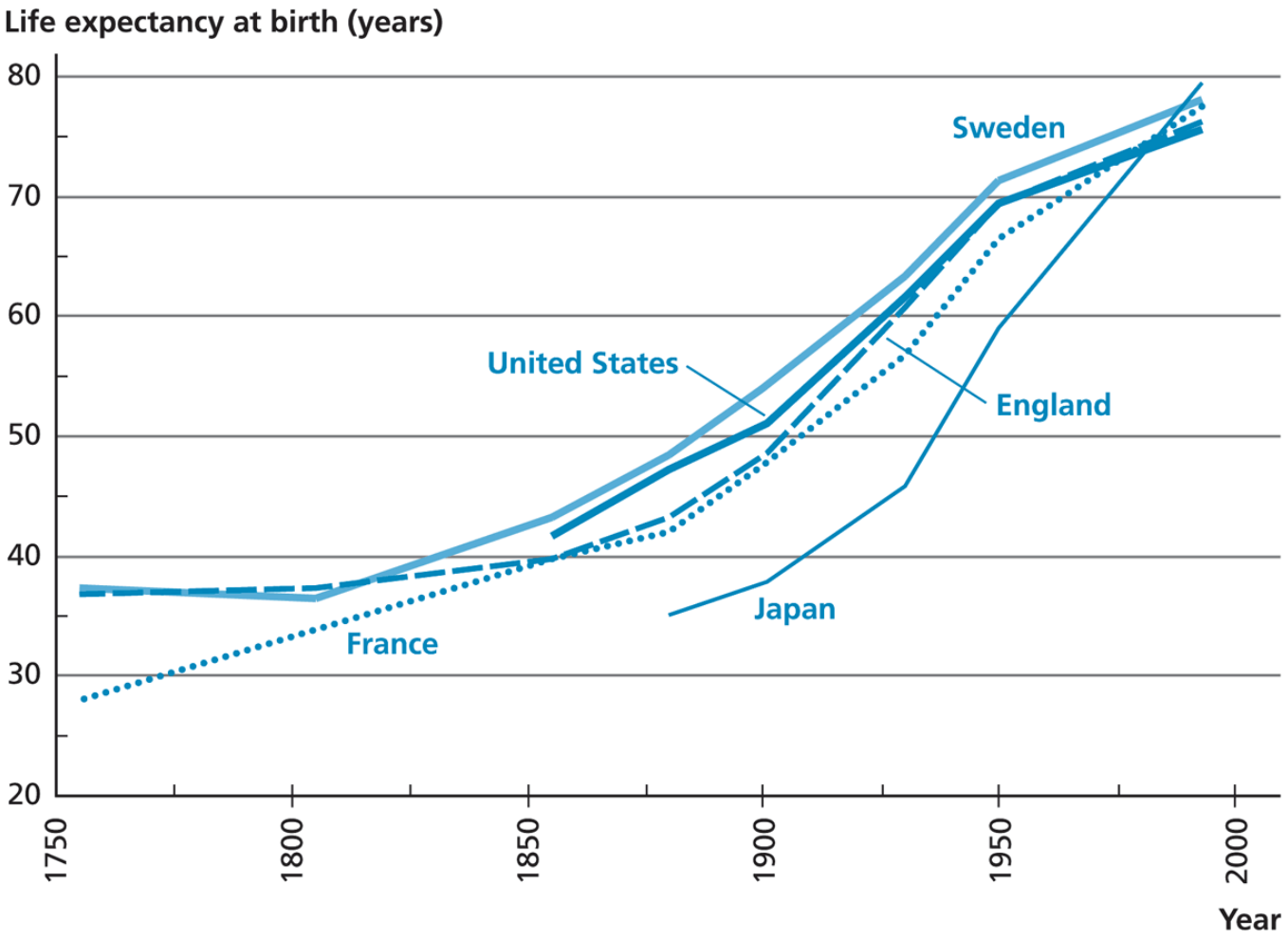
Life Expectancy at Birth

i.e. the number of years that a newborn is expected to live.

- Ex 1: All live to 40 years and die.
- Ex 2:
  - Half die immediately.
  - Half die at 80 years old.
- Life expectancy is 40 years for both.

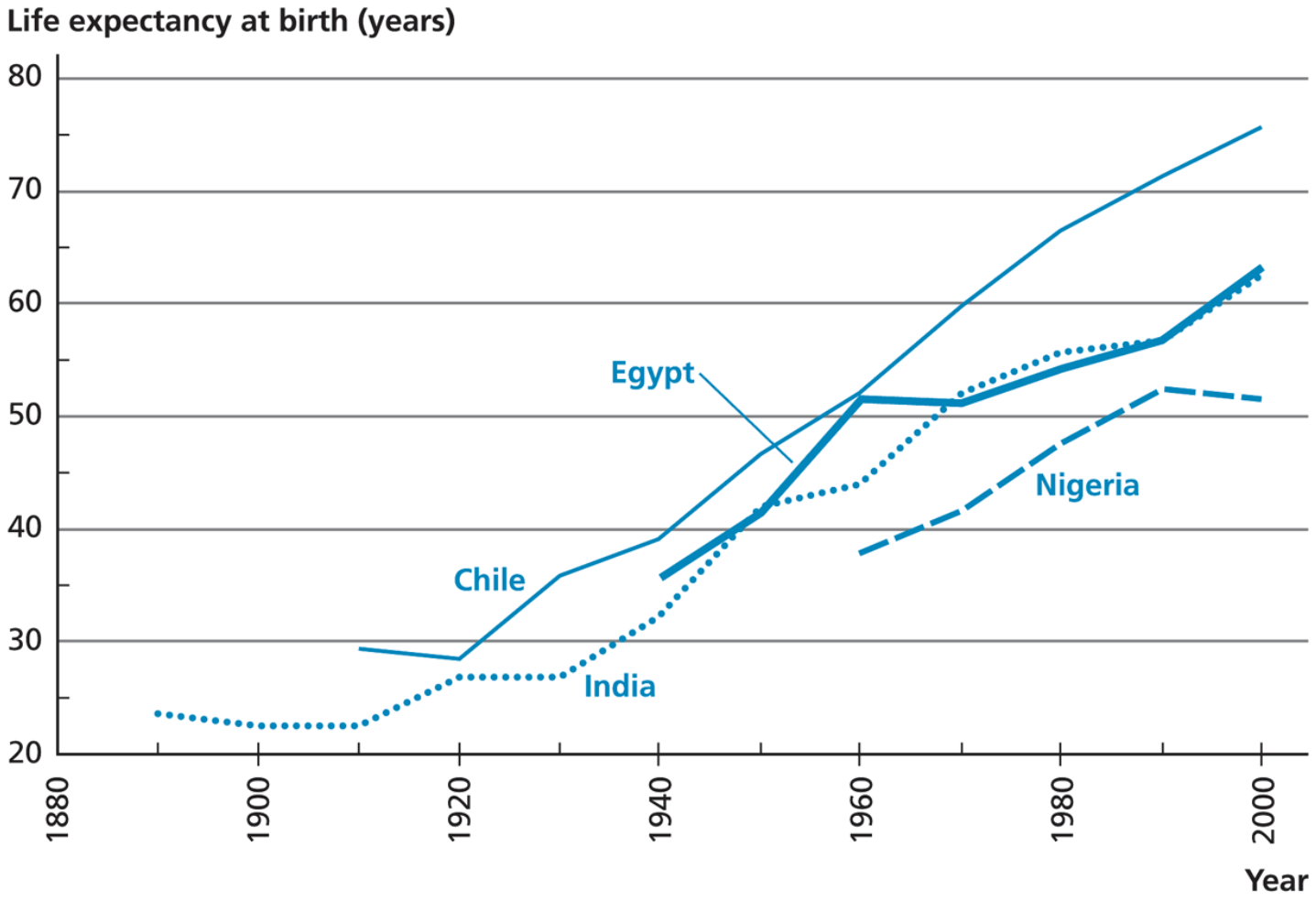
FIGURE 4.8

Life Expectancy in Developed Countries



Source: Livi-Bacci (1997).

FIGURE 4.9
Life Expectancy in Developing Countries



Source: Kalemli-Ozcan (2002).

Important historical differences

- The mortality transition occurred under much lower per-capita income levels in LDCs than happened in the history of today's rich countries.
- India 1980: 55 years with 1239 $US(2000) per capita
- France 1930: 56 years with 4998$US(2000) per capita

This difference has important consequences.

Explaining the mortality transition

Three main factors:

1. Improved standards of living: food, housing, clothes washing, …
2. Public sanitary systems: potable water, non-contaminated food, drainage of mosquito infested marshes, etc.
3. Better health care.

Adoption sequence in today's rich countries

In today's rich countries, the three types of improvements arrived mostly in sequence.

1. England and France 1775-1875: Lower mortality attributed mostly to nutrition improvements.
2. 1850-1900: Creation of sewage systems and potable water reduces mortality significantly thru effect on diseases such as cholera and typhoid fever.
3. Only since 1900 did medical treatment contribute significantly to lower mortality.

Adoption sequence in today's LDCs

In today's Developing Countries, all three improvement types are arriving almost simultaneously.

- This explains the swiftness of transition and why it occurred at lower income levels.
- It is suspected to explain part of the present problems in poor countries. But before we turn to the details, let us look at the fertility transition.

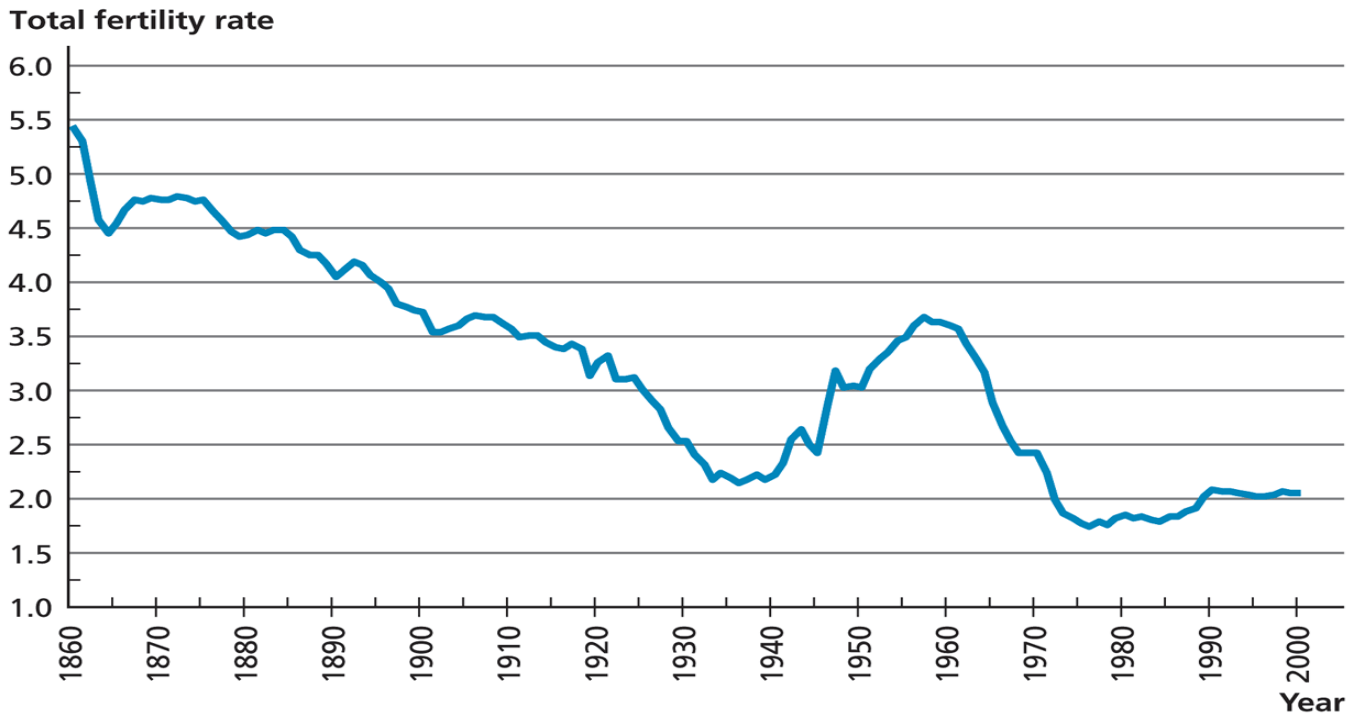
The fertility transition
A definition

- *Total Fertility Rate* (TFR): Total number of children that a woman would have if she lived past the age of fertility and had the average number of children.
- Ex: Suppose that between 20 and 39 years of age, women have 0.2 child per year on average and none after or before:

TFR=0.2child/yr*20yrs=4 children

The fertility transition in the USA

FIGURE 4.10
Total Fertility Rate in the United States, 1860–2000



Source: Coale and Zelnik (1963), Wade (1989).

Fertility transition in LDCs

- Also occurs much faster than with today's rich countries.
- Drop of TFR from 5 to 3:
  - 63 years in USA (1862-1925)
  - 15 years in Indonesia (1975-1990)

Fertility transition in LDCs

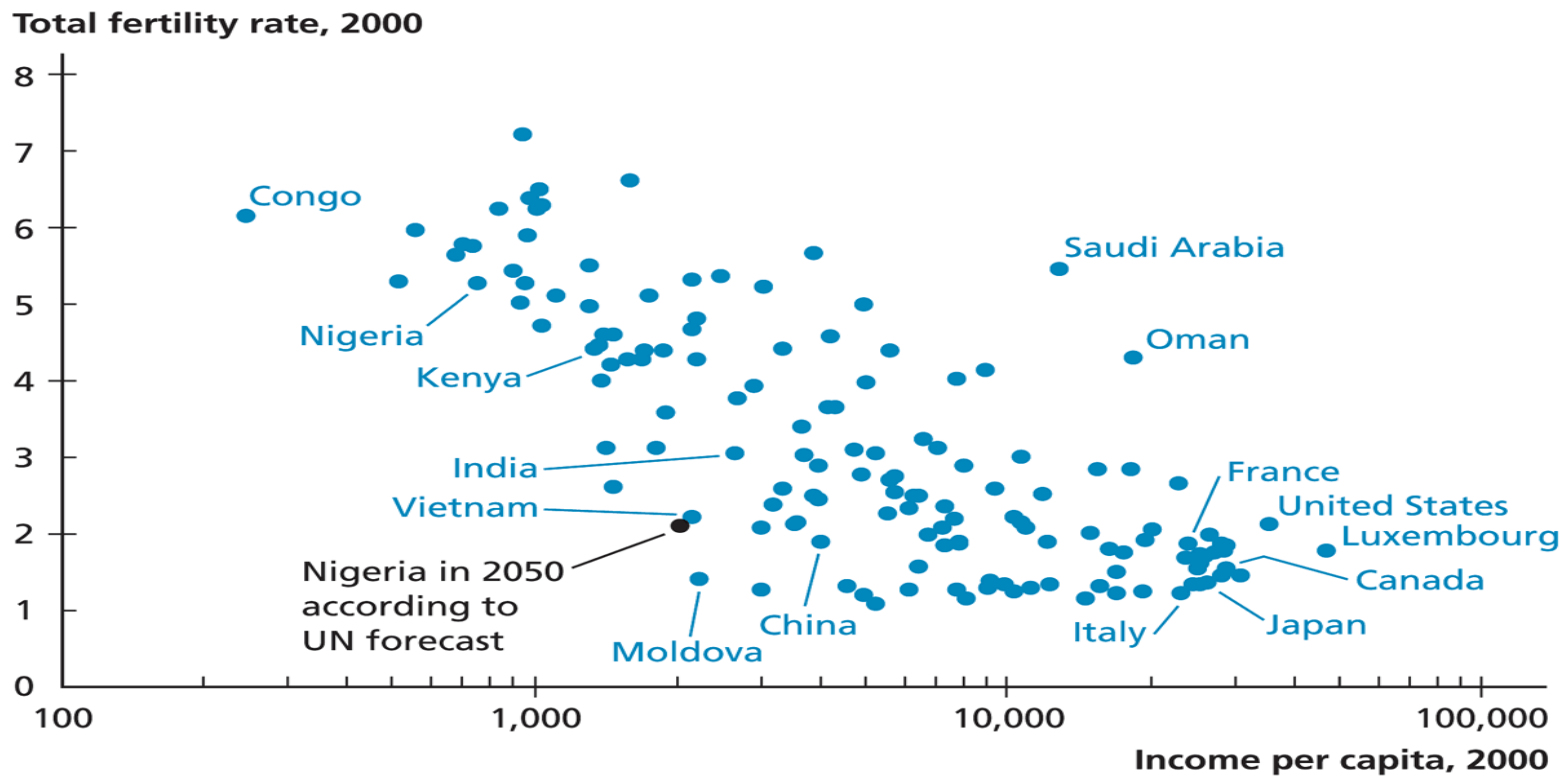
TABLE 5.1
Fertility in the Developing World

	2001 Population (Millions)	Total Fertility Rate, 1970–1975	Total Fertility Rate, 2000–2005
All Developing	**4,864**	**5.4**	**2.9**
Sub-Saharan Africa	626	6.8	5.4
Arab States	290	6.7	3.8
East Asia Excluding China	615	5.2	2.4
China	1,285	4.9	1.8
South Asia Excluding India	422	6.2	4.0
India	1,033	5.4	3.0
Latin America and Caribbean	523	5.1	2.5

Source: United Nations Development Program (2003).

Fertility transition in LDCs

FIGURE 5.4
Income Per Capita Versus Total Fertility Rate



Source: Heston et al. (2003), World Bank (2003).

Question

Today's rich countries had, in the past, TFR similar to those of the LDCs today.

How can we explain that the population growth of rich countries then was not as high as that of LDCs today?

Fertility, mortality, and population growth

- Recall: The TFR represents the number of children that a woman would have if she lived passed the age of fertility.
- For today's rich countries, many women used to die before that age in the past.
- It is thus important to consider the interactions between fertility and mortality.

Explaining population growth
A definition

- *Net Reproduction Rate* (NRR): The number of daughters that a girl is expected to have taking into account both the mortality and fertility rates.
- Measures the per generation growth rate of girls.

Fertility, mortality, and population growth
A fictitious example

An example:

- Half of the girls die during infancy.
- The other half lives to at least 40 yr.
- Average of 4 children/woman of 40 or more.
- Half of the children are girls.

Consequences:

- NRR=1/2*4*1/2=1 girl
- The expected number of daughters per girl is 1, i.e. constant population size.
- If NRR=2, population size doubles every generation.

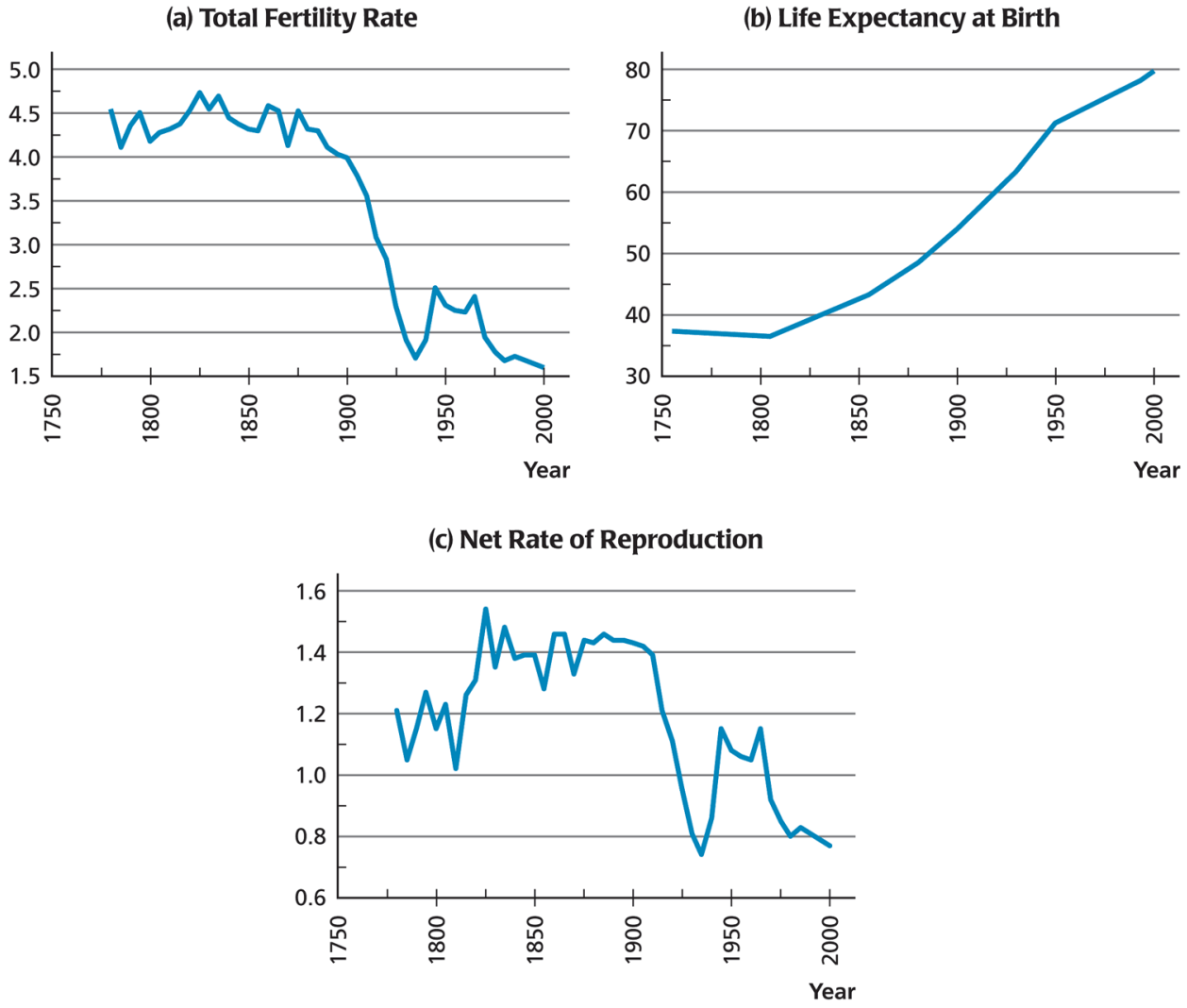
The net reproduction rate

- In our (OECD) pre-industrial societies, roughly half the girls used to die before reaching age of procreation.
- Imagine now that all live passed 40 yr.

The NRR doubles!

- The population would double its size every generation without any change in the fertility rate.

FIGURE 4.11
Fertility, Mortality, and the Net Rate of Reproduction in Sweden



Sources: Keyfitz and Flieger (1968, 1990), Livi-Bacci (1997).

The Swedish Case

The NRR are equal in 1780, 1915 and 1965, but for different reasons:

- 1780: TFR= 4.54; life expectancy = 36.9
- 1915: TFR= 3.08; life expectancy = 58.6
- 1965: TFR= 2.41; life expectancy = 73.7

It is the timing differential between the drops in mortality and fertility rates that explains the large population growth rates in the 19th C.

- Life expectancy begins to increase much before the drop in fertility.

NRR and LDCs

- Even if the decline in both rates were faster in LDCs, the decline in the mortality rate was more important than that of fertility.
- This explains the even faster population growth than that of today's rich countries in the 19th c.
- In many LDCs, the fertility transition is not finished.
- Two interesting cases: India and Nigeria.

India

Period	Total Fertility Rate	Life Expectancy at Birth	Net Rate of Reproduction
1955–1960	5.92	42.6	1.75
1965–1970	5.69	48.0	1.87
1975–1980	4.83	52.9	1.73
1985–1990	4.15	57.4	1.61
1995–2000	3.45	62.1	1.43
2000-2005	2.73	64.2	1.17

Source: United Nations Population Division (2010).

NRR and Nigeria

Period	Total Fertility Rate	Life Expectancy at Birth	Net Rate of Reproduction
1955–1960	6.90	38.2	1.97
1965–1970	6.90	42.0	2.12
1975–1980	6.90	46.1	2.28
1985–1990	6.70	50.2	2.38
1995–2000	5.92	52.5	2.20
2000-2005	5.61	50.3	2.00

Source: United Nations Population Division (2010).

Explaining population growth

- We have seen how mortality and fertility rates can explain population growth.
- We now have to explain changes in mortality and fertility rates.

2. Understanding the fertility transition

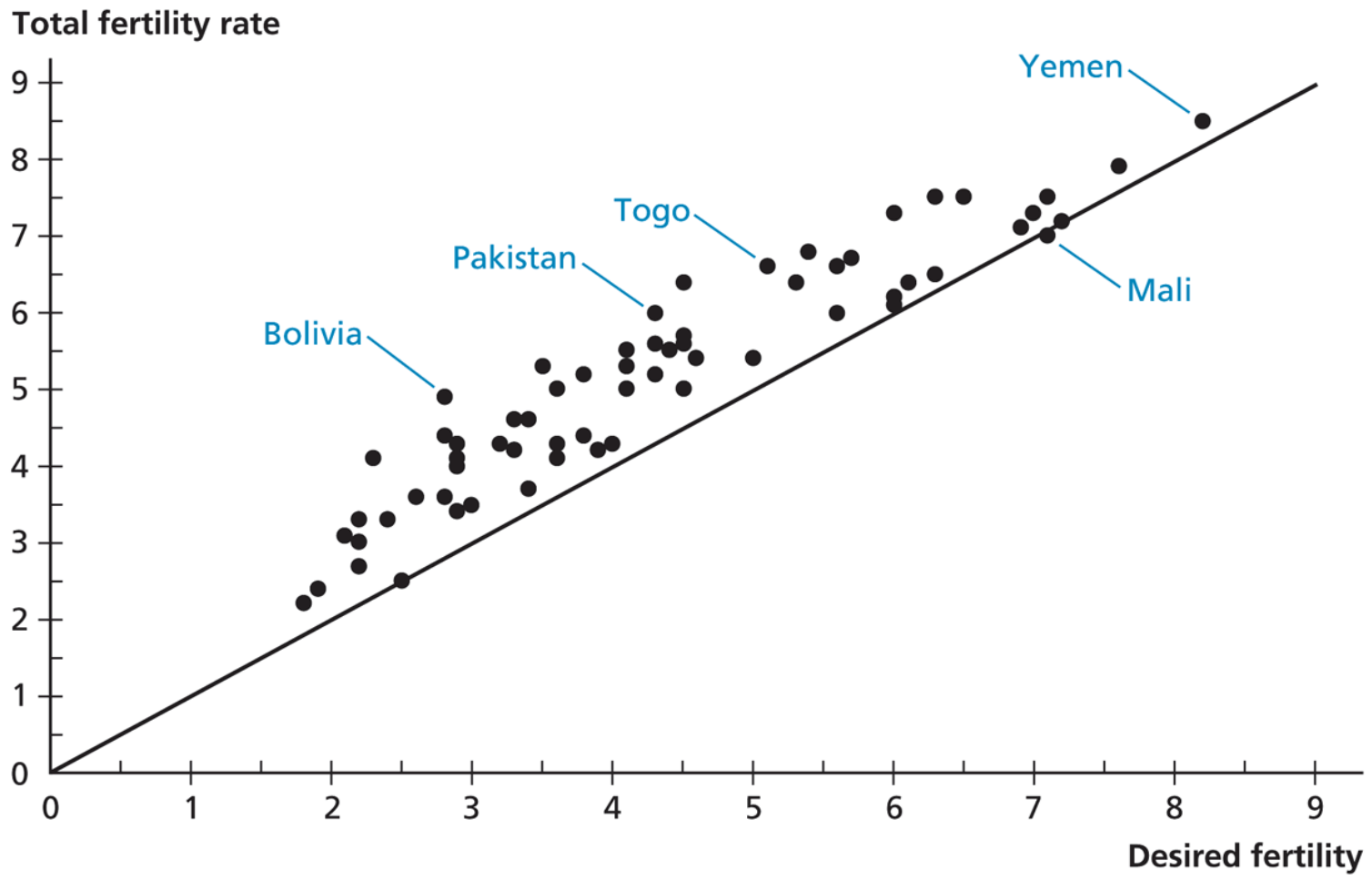
- It is easy to explain the mortality transition.
- But how can we explain the fertility transition?
- How is it that as we become richer, we desire less children while it would be easier to have more? (Opposite of Malthus)

- Important difference to consider:
  1. The number of children that people want to have.
  2. The means of controlling that number.

The Means: Old and New

- Old means:
  - infanticide
  - Late marriage
  - Breast feeding
  - Attitudes, culture, propaganda, …
- New means:
  - Condoms
  - Contraceptive pill, …
- In Europe, the decline in fertility started much before the introduction and use of new means.
- In LDCs, there is a coincidence of both.
- Correlation does not imply causality.
- The new means explain between 10 and 40% of lower fertility in LDCs. The rest is explained by desired fertility.

FIGURE 4.12
Desired Fertility Versus Total Fertility Rate in Developing Countries



Source: Pritchett (1994).

Contraceptive use and fertility

- Results from a direct poll to women in LDCs.
- Women have generally more children that they wish: 0.86 on average.
- In high fertility countries, wanted and actual fertility is quite close.
- Little hope from effectiveness of contraceptive use in reducing fertility.
- In order to understand why couples have less children as their income rises, we need to look more closely at the wanted fertility. (Important public policy implications.)

The drop in desired fertility

Four factors to consider:

a) The effect of lower mortality
b) Income and substitution effects
c) Intergenerational resource flows
d) The "quantity-quality" compromise

a) The effect of lower mortality

- Parents are ultimately concerned about the surviving number of children, not the number of births.
- The number of births is adjusted by taking the risk of death into account.
- Ex:
  a. Suppose parents want at least one adult surviving son.
  b. Suppose proba of survival is ½.
  c. Having two sons implies that one will survive on average, but with proba ¼ that none will. This risk may be too high for some.
  d. Solution: Have three sons to reduce risk to 1/8.
  e. On average: each family has 6 children, 3 survivors including 1.5 boys.
  f. With 3 survivors, NRR=1.5 girls.
- Insurance against risk argument: Over-shooting.

a) The effect of lower mortality

- Suppose proba of survival jumps to 1.
- Couples now have two children on average.
- NRR=1: No more over-shooting.
- General Implications:
  1. Lower mortality causes lower fertility
  2. Due to insurance effect, lower mortality is overcompensated for by lower fertility.
- Problem: It takes time for people to realize that the mortality rate has gone down. The drop in mortality precedes the drop in fertility (Swedish case?).

b) Income and substitution effects

1. *Income effect:* The richer we are, the more children we can raise.
2. *Substitution effect:* When parents' salaries go up, the opportunity cost of having a child goes up.

- One of the most important opportunity cost of having a child is the time we have to devote to her/him.
- As salaries go up, income forgone goes up.

b) Income and substitution effects

Possible large feedback effect from girls' education

- When women are expected to stay home, returns to girl education are low.
- With labor market opening up to women, incentives to invest in girl education increase.
- Once educated, women's salaries go up:
  1. It increases further their education investments through higher anticipated returns.
  2. It increases the opportunity cost of having children.

c) Intergenerational resource flows

- In poor countries, children contribute early to household income:
  - A 1970 study in Bangladesh has estimated that at 12 yrs, a boy contributes enough to compensate for his own costs.
  - Similar estimations for France in 19th C.
- In rich countries, educating the children is long and costly to parents.
- In LDCs, children often support parents during old age.
- In rich countries, well developed financial markets and governments interventions fill up that role. Children's help is much less called for.
- All the above factors lower economic incentives to have children in rich countries.

A note on economic determinants of fertility

- Does our analysis imply that only financial considerations are involved in the decision to have a child?

  NO

- If it were the case, the fertility rate in Canada would be almost zero.
- There are many other explanatory factors.
- We are here concentrating on those that allow us to understand the fertility transition and its link to economic growth. Once we do that, such economic considerations are hard to escape. Empirically, they work well.
- But how can we explain that parents spend so much more on each child today than in the past? After all, parents don't really have to in order to insure their survival.

d) The "quantity-quality" compromise

- Parents value the "condition" of their children:
  - Better health
  - Better education
  - Better career
  - Better welfare
- People "invest" in the condition of their children. True even if their don't expect future financial benefits. They are just happy and proud about it.
- Resources being limited, there is a compromise to be had between number of children and the conditions in which they grow.
- So why would this compromise turn so much in favor of better condition as income rises?

d) The "quantity-condition" compromise

- Mortality effect: Low incentive to invest in a child with a low proba of reaching adult age.
- Growth-Education link: It is believed that economic growth is linked with higher returns to education. Parents prefer less children if it means higher education per child.
- Feedback effect: More growth causes more education; more education causes more growth.

Fertility and Economic Development

1975 United Nations Conference:

Economic development may be the best contraceptive

Population and Growth: A recap

1. Malthusian growth:
   - Endogenous population growth
   - Bleak prediction for long-run
2. The Solow Model
   - Exogenous population growth
   - Capital dilution
3. Understanding population growth
   - Demographic, mortality and fertility transitions
4. Explaining fertility
   - Actual v. desired fertility
   - Economic factors
   - Possible feedback effects
5. Comparing experiences:
   - Transitions happen at a faster rate in LDCs.
   - This causes complications.

To do

- Read all of chapter 4 excluding Appendix.
- NB Chapter 5 will not be covered.