Economics of development
M. Vesal
EC3044
2014

Undergraduate study in
Economics, Management,
Finance and the Social Sciences

This is an extract from a subject guide for an undergraduate course offered as part of the University of London International Programmes in Economics, Management, Finance and the Social Sciences. Materials for these programmes are developed by academics at the London School of Economics and Political Science (LSE).

For more information, see: www.londoninternational.ac.uk
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This is one of a series of subject guides published by the University. We regret that due to pressure of work the author is unable to enter into any correspondence relating to, or arising from, the guide. If you have any comments on this subject guide, favourable or unfavourable, please use the form at the back of this guide.

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Chapter 1: Introduction

1.1 Route map to the guide

This subject guide is your study companion for the subject EC3044 Economics of development. The aims of the subject guide are to:

- provide a framework for the study of development economics
- introduce various topics in Economics of development listed in the syllabus
- present the material in a structured format to facilitate learning
- guide you towards various learning activities and exercises
- encourage you to take an active learning approach by reading the essential material, undertaking learning activities and participating in online activities (e.g. discussion) via the VLE.

This guide is divided into 16 chapters, including this introductory chapter. Chapters start with an introduction to the topics covered and provide a theoretical framework to understand the relevant issues. Presentation of the empirical evidence, mostly from journal articles, forms the basis of policy discussions in the rest of each chapter.

Chapters contain a variety of learning activities to facilitate understanding of methods and concepts. It is extremely important that you try all activities in the subject guide before looking up the answers on the VLE. You should also try the exercises at the end of referenced chapters from the course textbook, Development economics (1998).

Although Development economics (1998) is set as the textbook for this course, it does not cover the material in all the chapters. Instead you are expected to read journal articles to fill in the gaps and to get a better understanding of the empirical evidence.

In discussing empirical research we extensively use methods of establishing causality. Various forms of regression analysis, like instrumental variables, fixed effects and difference-in-differences, are used throughout the course.

1.2 Introduction to development economics

Economic development is the process of gradual improvement in the material well-being of individuals. At the macro level, development economics studies why some countries have high standards of living, while others do not. At the micro level, development studies the functioning of markets in low income countries, with the ultimate goal of addressing market failures and lifting individuals out of poverty.

Almost all topics in economics have a counterpart in development economics. A quick look at the syllabus shows the wide range of topics covered in this guide. This, however, is only a selection of topics from an array of development issues. You might be taking courses in international trade or labour economics and you can probably identify intersections of topics covered here with those courses. So, why do developing country issues warrant a separate course of analysis?

The context of developing countries proves to be challenging for conventional economic models due to the prevalence of market failures. Although textbook models of economic behaviour are useful starting
points for thinking about issues in developing countries, the situation often requires a careful investigation of the plausibility of assumptions in a developing context. For example, we will see that poor households are unable to access formal credit from banks and instead rely on alternative, and sometimes more expensive, sources like moneylenders. This is because the degree of information asymmetries and strength of contract enforcement makes formal credit unviable.

### 1.3 Syllabus

The course is divided into three parts. In the first part, we cover macro models of development and focus on explaining cross-country income differences (Chapters 2 to 6). The second part investigates different markets in developing countries with an emphasis on understanding the market failures and potential corrective policies (Chapters 7 to 11). The last part discusses the distinct role of the state in the process of development (Chapters 12 to 16). This course leaves out two important strands of literature: ‘firms and industrial development’ and ‘conflict’. Our treatment of some of the other topics (e.g. trade policy) does not do justice to the vast number of journal articles in the area. The syllabus for this course is broken into three parts:

**Part 1: Cross-country differences and macro models of development**

- Concepts and measurements of economic development and the characteristics of developing countries.
- Models of economic growth and development including endogenous growth theories and multiple equilibria models and their potential in explaining income disparities across countries.
- Role of history and institutions in shaping current economic outcomes and explaining development.

**Part 2: Markets in developing countries**

- Understanding demand for education, role of education infrastructure, and the incentives of education providers in developing countries.
- Demand for health and nutrition in developing countries, provision of public health services and the issue of sex imbalances.
- Importance of agriculture and land reform in shaping the lives of the poor.
- Labour markets in developing countries and understanding the impact of labour relations on poverty.
- Forms of agricultural contracts.
- Forms of credit and insurance markets in developing countries.
- Microfinance and its impacts on the lives of the poor.

**Part 3: State and the process of development**

- Infrastructure and its impact on development, globalisation and the role of trade policy, environment and development.
- Taxation and development, informal economy and tax evasion.
- Development aid and its effectiveness in improving outcomes.
1.4 Aims of the course

The aims of this course are to:

• discuss key issues in the process of economic development
• enhance students’ ability in applying economic models to study development problems
• discuss the relevant empirical literature with an eye toward forming policy recommendations.

1.5 Learning outcomes for the course

At the end of this course, and having completed the Essential readings and activities, you should be able to:

• outline the main theories and concepts in development economics
• select and analyse economic theories relevant for issues in economic development
• summarise and evaluate empirical work in development economics
• compare and contrast empirical work for the purpose of designing policy for a specific context.

1.6 Overview of learning resources

1.6.1 The subject guide

The subject guide is your first point of reference in this course but it is not the only one. Passive reading of the guide and skimming through model answers for questions is **not** a useful strategy. The guide provides ample opportunities for active learning by providing activities that link you to other learning resources.

Each chapter of the guide starts with the aims and learning outcomes. These are listed so you explicitly know what you should learn by the end of the chapter. I recommend that you start by reading the subject guide rather than the Essential readings. You should try to go through activities and questions throughout the chapter. These might include reading some references, looking at data on the web or answering a question. Feedback on activities is provided on the virtual learning environment (VLE).

After reading through the chapter you should go through the essential readings. The subject guide will help you to decide which parts of the readings to focus on. If you find parts of the guide hard to understand, you should particularly try to read the reference on that part (whether it is Essential or Further reading).

At the end of the chapter, you should review the learning outcomes and go through sample questions to make sure you have a solid understanding of that chapter. These questions are very similar to the examination questions and you will have access to suggested solutions both for activities within chapters and questions at the end of the chapter.

1.6.2 Essential reading

Detailed reading references in this subject guide refer to the editions of the set textbooks listed below. New editions of one or more of these textbooks may have been published by the time you study this course. You can use a more recent edition of any of the books; use the detailed chapter and section headings and the index to identify
relevant readings. Also check the VLE regularly for updated guidance on readings.

For most chapters in this guide the following text will be used as Essential reading:


For micro development topics, an indispensable book is:


You should buy copies of both these books.

We rely on Ray (1988) as the theoretical foundation for the topics available in the textbook but for micro evidence and more recent topics we rely on Banerjee and Duflo (2011) and journal articles. This book provides an amazingly informative summary of recent development research that tries to understand the lives of the poor. The book webpage at pooreconomics.com provides data and other useful resources.

Each chapter uses two or three journal articles as Essential readings to complement the textbook. As this might be the first time you read research articles, the subject guide will help you work through the articles by providing questions and learning activities throughout. Reading articles is a skill you need to develop. When reading, it is useful to think about the following questions:

1. What question is the article trying to answer (question)?
2. Why is the question interesting (motivation)?
3. How does the article answer the question (method)?
4. What are the main results (findings)?
5. What are potential problems with the interpretation of results put forward by the authors (limitations)?
6. What potential policy conclusions can you draw from the findings (policy)?

One useful reading strategy is to start with a careful reading of the introduction of the article, then skim through the tables and figures and read the conclusion. After this you should delve into the article and try to understand its main message. This is a useful strategy because most of the articles assigned for this course will have a thorough introduction in which they discuss all six questions mentioned above.

You should note that you are not expected to understand all the technical details of the articles but you should be able to understand and intuitively explain their results and potential limitations. Throughout the guide we will highlight the technical details that are required. You can find the list of Essential readings at the beginning of each chapter but below we provide a full list of all papers used as Essential readings in the course:


Chapter 1: Introduction


Banerjee, A.V. and E. Duflo 'The experimental approach to development economics', Annual Review of Economics 1(1) 2009, pp.151–78. A version of this article is available at http://www.nber.org/papers/w14467


Chen, S. and M. Ravallion 'The developing world is poorer than we thought, but no less successful in the fight against poverty', Quarterly Journal of Economics 125(4) 2010, pp.1577–625.


Easterly, W. 'Can the West Save Africa?', Journal of Economic Literature 47(2) 2009, pp.373–447.


1.6.3 Further reading

Please note that as long as you read the Essential reading you are then free to read around the subject area in any text, article or online resource. You will need to support your learning by reading as widely as possible and by thinking about how these principles apply in the real world. To help you read extensively, you have free access to the VLE and University of London Online Library (see below).

The subject guide also provides a list of Further readings that could guide you in exploring the subject further. Sometimes the results from Further readings are referred to in the subject guide. This material is required and if you have difficulty understanding the interpretations, you should consult the original source. The following is the list of all Further readings in this guide:


### 1.6.4 Online library

In addition to the subject guide and the Essential reading, it is crucial that you take advantage of the study resources that are available online for this course, including the VLE and the Online Library.

You can access the VLE, the Online Library and your University of London email account via the Student Portal at:

http://my.londoninternational.ac.uk

You should have received your login details for the Student Portal with your official offer, which was emailed to the address that you gave on your application form. You have probably already logged in to the Student Portal in order to register. As soon as you registered, you will automatically have been granted access to the VLE, Online Library and your fully functional University of London email account.

If you have forgotten these login details, please click on the ‘Forgotten your password’ link on the login page.
The VLE

The VLE, which complements this subject guide, has been designed to enhance your learning experience, providing additional support and a sense of community. It forms an important part of your study experience with the University of London and you should access it regularly.

The VLE provides a range of resources for EMFSS courses:

• Self-testing activities: doing these allows you to test your own understanding of subject material.

• Electronic study materials: the printed materials that you receive from the University of London are available to download, including updated reading lists and references.

• Past examination papers and Examiners’ commentaries: these provide advice on how each examination question might best be answered.

• A student discussion forum: this is an open space for you to discuss interests and experiences, seek support from your peers, work collaboratively to solve problems and discuss subject material.

• Videos: there are recorded academic introductions to the subject, interviews and debates and, for some courses, audio-visual tutorials and conclusions.

• Recorded lectures: for some courses, where appropriate, the sessions from previous years’ Study Weekends have been recorded and made available.

• Study skills: expert advice on preparing for examinations and developing your digital literacy skills.

• Feedback forms.

Some of these resources are available for certain courses only, but we are expanding our provision all the time and you should check the VLE regularly for updates.

Making use of the Online Library

The Online Library contains a huge array of journal articles and other resources to help you read widely and extensively.

To access the majority of resources via the Online Library you will either need to use your University of London Student Portal login details, or you will be required to register and use an Athens login:
http://tinyurl.com/ollathens

The easiest way to locate relevant content and journal articles in the Online Library is to use the Summon search engine.

If you are having trouble finding an article listed in a reading list, try removing any punctuation from the title, such as single quotation marks, question marks and colons.

For further advice, please see the online help pages:
www.external.shl.lon.ac.uk/summon/about.php

1.7 The examination

Important: the information and advice given here are based on the examination structure used at the time this guide was written. Please note that subject guides may be used for several years. Because of this we strongly advise you to always check both the current Regulations for relevant information about the examination, and the VLE where you
should be advised of any forthcoming changes. You should also carefully check the rubric/instructions on the paper you actually sit and follow those instructions.

**Structure**

The time allowed in the exam is **three hours**. The exam has two sections. In Section A you will have to answer eight true/false questions and provide a justification for your answer. Simply writing true/false will get you no credit. In Section B you will have to answer two long questions from a choice of four. A Sample examination paper and an Examiners’ commentary are provided at the end of this subject guide.

**Advice**

You should follow all the excellent advice to candidates published annually as an introduction to the *Examiners’ commentaries*.

In addition, the following advice is valuable:

1. Prepare thoroughly for the examination by attempting the activities/questions in the textbooks and in this subject guide.

2. If you are unsure of what a question is asking, for example because of doubt about its interpretation, state the assumptions you made to answer the question.

3. Even though a question may not specifically ask for defining key terms, it is a good idea to state the definition of concepts used in the question.

4. The introduction to the *Examiners’ commentaries* mentions the importance of key words. Be prepared for words that tell you what to do – for example: analyse, describe, discuss, outline, examine, assess, suggest, propose – and make sure you follow the instruction. Do not write down all you know about a topic in the hope that some of it is relevant.

5. In many cases, good answers will require diagrammatic or simple algebraic analysis to complement verbal reasoning. The complementary dimension is important: good diagrams can often save much verbal explanation but free-standing diagrams, however well-drawn and labelled, do not communicate sufficient information to the Examiners. Diagrams and algebraic presentations need to be explained in the text of the answer. Symbols and abbreviations, other than those that are widely known and used (for example, ‘Y’ for output; ‘S’ for saving; ‘FDI’ for private foreign investment; ‘IMF’ for International Monetary Fund), should be defined/spelled out when you first use them in the examination.

The examination paper for **EC3044 Economics of development** involves economic analysis. The Examiners expect analytical explanations and/or suggestions for policy based on economic theory and empirical evidence. Thus, even if it is not explicitly mentioned, you need to demonstrate knowledge of theories and empirical evidence in answering questions.

It is also a paper involving economic principles and their application, and therefore the following general guidance is offered. You are not expected to learn and reproduce vast quantities of statistical data. Authors include statistics to introduce, illustrate or highlight particular issues, often prior to presenting possible analytical explanations of the data. To the extent that you wish to refer to statistics in your examination answers, broad orders of
magnitude will suffice. You should, however, be familiar with the results and conclusions of Essential readings.

Remember, it is important to check the VLE for:

• up-to-date information on examination and assessment arrangements for this course

• where available, past examination papers and Examiners’ commentaries for the course which give advice on how each question might best be answered.
Part 1: Cross-country differences and macro models of development
Chapter 2: Overview of development basic facts

2.1 Introduction

2.1.1 Aims of the chapter

The aims of this chapter are to:

• introduce the concept of development
• explain various ways of measuring development
• introduce main methods used in studying development issues.

2.1.2 Learning outcomes

By the end of this chapter, and having completed the Essential reading and activities, you should be able to:

• explain and evaluate various measures of economic development
• recall and state key facts about development such as large income disparities and the staggering number of people who live in poverty
• explain the role of theory and empirics in development and recognise the difference between correlation and causation.

2.1.3 Essential reading

Banerjee and Duflo (2011) Chapters 1 and 2.
Banerjee, A.V. and E. Duflo ‘The experimental approach to development economics’, Annual Review of Economics 1(1) 2009, pp.151–78. A version of this article is available at www.nber.org/papers/w14467

2.1.4 Further reading

2.1.5 Works cited


2.1.6 Overview

In the first section of this chapter we discuss the concept of development. In section 2.3 we look at various ways of measuring development. GDP (gross domestic product) per capita is introduced as a core measure for comparing living standards across countries. We next present facts on large income gaps between developing and developed countries and the heterogeneity of growth performances. We briefly discuss poverty, inequality and other ways of measuring well-being. In section 2.4 we discuss the importance of theory and the role of empirical analysis in development research.

2.2 Concept of development

Development could refer to conditions that identify the quality of material life. It could also refer to the processes of change and improvement that raise living standards. Development is definitely not a pure economic phenomenon but in this course we only focus on the economic aspects of development. This includes a range of issues in health, education, inequality and poverty. You should not confuse the concept of development and the various measures that look at aspects of development (covered in the next section). For a deeper discussion of the concept of development and its roots in economic thinking, you are encouraged to read Sen (1988).

2.3 Measuring development

In order to have an understanding of the relative performance of countries, regions or individuals, we need to measure development. Development is inevitably a multidimensional phenomenon. You can think of many important aspects of material well-being that indicate levels of development. Economists have long focused on income and income growth as measures of economic development. This is, however, no longer the case. Many studies and international organisations widely report other indices of development.

In this section we look at income, poverty, inequality and other measures of well-being used in development.
2.3.1 Income and growth

GDP is the core measure of aggregate income used to measure total production from a country or region over a given period of time (usually a year, sometimes a quarter). You should have a quick catch up with what you have learned from EC2065 Macroeconomics about GDP and be able to distinguish between it and gross national product (GNP).

GDP per capita (divided by population) is, therefore, the primary measure of average individual income in a given country. As income is spent on purchasing goods and services, GDP per capita could be a measure of living standards. Development is concerned about comparisons of living standards over time and across countries. In order to make GDP comparable over time, we need to account for inflation. As prices go up (inflation), the purchasing power of income falls. By choosing a base year and using appropriate price indices, you can convert nominal GDP to real or constant GDP. This will then capture the real change in living standards relative to the base year for a given country.

To compare living standards across countries we need to convert GDP figures into a common currency (e.g. US $). But what is the exchange rate for this conversion? One option is to simply use the average exchange rates from currency markets in a given year. There are certain problems with this method. Most importantly, exchange rates are affected by tradeable goods and services, while GDP includes both tradeable and non-tradeable goods and services. If non-tradeable goods and services are 'cheaper' in developing countries, using an exchange rate conversion GDP would overstate the income gap (i.e. developing countries would appear to be poorer than they actually are).

One way to overcome this problem is to use physical quantities produced in each country and aggregate them using the set of relative prices in a given country (e.g. the USA). In other words, this method calculates how much more material is produced in a country if goods have a relative value similar to the USA. Data on quantities is hard to come by. Therefore this idea is usually implemented by adjusting existing GDP figures using an appropriate price index.

The World Bank started the International Comparison Program (ICP) to collect price data on individual items across a wide range of countries. This price data allows the construction of purchasing power parity (PPP) conversion rates. These conversion rates show the cost of purchasing a given basket of goods in different countries relative to the USA. You can also refer to the World Bank page on ICP for more detailed information: http://siteresources.worldbank.org/ICPEXT/Resources/ICP_2011.html

### Activity 2.1

Here we try to develop a simple example to understand how PPP conversions help make GDP figures more comparable across countries. Consider two countries that only produce haircuts and potatoes. Potatoes are freely traded (without any cost) but haircuts aren’t.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Price (R: Rupee)</th>
<th>Quantity</th>
<th>Price (D: Dollar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>10 ton</td>
<td>100 R/ton</td>
<td>60 ton</td>
</tr>
<tr>
<td>Haircuts</td>
<td>100</td>
<td>10 R/each</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1: Quantities produced and prices in 2013.
a. Calculate the GDP for each country in its own currency. Then use the exchange rate (1 dollar buys 10 rupees) to convert country A's GDP into dollars. What is the ratio of country B's GDP to that of country A?

b. Now use the PPP principle to calculate country A's GDP in dollars. What is the ratio of two countries' GDP using this method?

c. Is it the haircuts or the potatoes that make the two methods different?

2.3.2 How large are the income gaps?

Once you have made GDP figures comparable across time and countries, you can start looking at income gaps between developing and developed countries. You should get a clear idea about the income gap between the rich and the poor countries to appreciate the role of development economics. Ray (1998) Chapter 2 provides some historical figures but for an updated view of the situation, you should try one of the online data sources. Activity 2.2 asks you to look at the staggering income gap between the USA and the poorest country in the world.

Activity 2.2

Use World Development Indicators (WDI: http://data.worldbank.org/data-catalog/world-development-indicators) to find the poorest and richest countries in the sample in 1980. How large is the rich country's income relative to the poor country? Find the poorest country in 1990, 2000, and 2012 and calculate the ratio of US income to the poorest country's income in each year. Is the gap between the USA and the poorest country shrinking or growing? You should use the variable from WDI that measures constant GDP per capita in units of PPP dollars to look at income.

Figure 2.1 shows the evolution of real GDP per capita measured at PPP $ for India, Kenya and the USA. The figure shows the staggering income gaps. While US income was around $42,000 per capita in 2010, Kenyans had an income of just $1,500. In other words, the average income of US citizens was 28 times higher. The graph also shows the growth performance of these countries. While the USA has experienced a continuous increase in income, GDP per capita in the Kenya did not change much over the sample. Average income in India, however, has increased more than threefold over the plotted time.

Figure 2.1: Evolution of GDP per capita in the USA (right axis), India and Kenya (left axis).

Table 2.1 shows the average growth rate of a selected number of countries over 33 years. The USA had a steady growth of around 1.7 per cent and as the last column shows, it takes about 42 years for US income to double if it grows at the average rate (Activity 2.3 asks you to calculate this for China). On the other hand, China and India have experienced rapid growth during the past few decades which led to a reasonable average growth rate of around 8.9 and 4.3 per cent respectively. It seems that at current rates the gap between these countries and the USA is shrinking. The last four countries chosen from Africa show mixed growth performances. Uganda and Ethiopia have grown at reasonable average rates of 2.4 and 1.8 per cent respectively, but Kenya and the Democratic Republic of Congo (formerly Zaire) had poor growth. Average income in Zaire has declined in the past decades while it was stagnant in Kenya, leading to a widening gap between these countries and the USA.

<table>
<thead>
<tr>
<th>Country</th>
<th>Average growth during 1980 – 2012 (per cent)</th>
<th>Years it takes for income to double</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>1.7</td>
<td>42</td>
</tr>
<tr>
<td>China</td>
<td>8.9</td>
<td>8</td>
</tr>
<tr>
<td>India</td>
<td>4.3</td>
<td>16</td>
</tr>
<tr>
<td>Kenya</td>
<td>0.3</td>
<td>204</td>
</tr>
<tr>
<td>Uganda</td>
<td>2.4</td>
<td>29</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>1.8</td>
<td>39</td>
</tr>
<tr>
<td>Zaire</td>
<td>–2.3</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 2.1: Average growth rates for a sample of countries.  

Activity 2.3

China has grown extraordinarily over the past few decades. Assuming China sustains its current growth rate of 9 per cent over a long time, calculate the number of years it takes for China to double its income. WDI reports China had a GDP per capita of $6,819 in 2010 when the equivalent figure in the USA was $42,000. If the US economy continues to grow at 2 per cent and China sustains a growth rate of 9 per cent, calculate the number of years it would take China to catch up with US income.

How reliable are PPP comparisons?

Even with PPP conversions, GDP differences across developed and developing countries could overstate the real gap in living standards. There are two reasons for this. First, home production may account for a larger part of production (and consumption) in developing countries. For example, childcare is a service which the majority of families purchase from a provider in developed countries but in developing countries children stay at home and either siblings or parents look after them. Although in both cases a utility generating service is delivered, in one case it is transacted in the market and hence included in GDP, while in the other it is home production and not included in national accounts.

Activity 2.4

Can you think of other examples of home production that are more common in developing countries? How does the process of development change the nature of home production?
The second reason why PPP-converted GDP ratios might overstate the real gap is the presence of the informal economy or black market. The share of businesses that are not registered with the government to avoid paying taxes and other duties is much larger in developing countries. This means a much larger share of economic transactions are not registered and usually carried in cash. In the presence of an informal economy, the GDP (which relies on formal sources) underestimates actual production. It is however unlikely that these concerns could bridge the large gaps in incomes described above.

► Stop and read

Ray (1998) pp.7–21 on measuring income and growth (sections 2.1 and 2.2).

### 2.3.3 Poverty and inequality

Poverty is a keyword you come across frequently in development literature. In one sense development economics is the study of methods for improving the livelihoods of the poor. But how do we define poverty and how are countries compared on this dimension?

A common definition of poverty is the headcount ratio (HCR). This measure calculates the ratio of the number of individuals living below a level of income relative to the total population. In other words, it shows the percentage of individuals living below a poverty line.

Each country has its own ‘national poverty line’. Higher income countries have higher poverty lines. To make international comparisons, the World Bank adopted a global absolute poverty line of existing on $1 a day. This is close to India’s poverty line and it is hard to imagine how individuals could live on so little. Table 3 in Chen and Ravallion (2010) shows the staggering number of individuals living below the $1 a day poverty line. Over time the situation has improved in many countries, with the exception of Sub-Saharan Africa where 40 per cent of people still live on less than $1 a day.

► Stop and read

Banerjee and Duflo (2011) Chapters 1 and 2 provide an excellent summary of the choices poor individuals face in their everyday life. Chen and Ravallion (2010) estimate the number of the poor below an internationally comparable poverty line.

There is a close relationship between poverty and growth. If the fruits of income growth are distributed evenly among the population, we would expect growth to eradicate poverty. Indeed, from the discussion above you can see that countries/regions that experienced good growth in the past decades also reduced the percentage of their population living in absolute poverty, while countries in Sub-Saharan Africa with a poor growth performance also maintained 1980 poverty levels.

Growth, however, does not necessarily translate into poverty reduction. Growth could be compatible with maintaining or even deteriorating poverty levels when inequality worsens. Inequality is also of intrinsic interest as a direct measure of development. We discuss various measure of inequality and the interplay of inequality and development in Chapter 5 of this guide.

► Stop and read

2.3.4 Measuring well-being

The ultimate goal of development is to increase material well-being and life satisfaction but so far we have focused on income. The central question is whether income is a good measure of human well-being and living standards. In other words, does an increase in income lead to an improvement in various aspects of well-being?

It is useful if we distinguish between subjective and objective well-being. When you ask individuals whether they are satisfied with their lives, you are measuring subjective well-being. On the other hand, when you measure things like life expectancy, infant mortality or years of education, you are choosing a set of objective variables and hence looking at objective well-being.

In an effort to quantify societal objective well-being, in 1990 the United Nations Development Programme (UNDP) started to report a composite index known as HDI (Human Development Index). This Index combines the three elements of life expectancy, education and income and comes up with an objective measure of societal well-being across countries of the world.

Activity 2.5

UNDP has a useful website (http://hdr.undp.org/en/data) that allows visualisation of HDI data. Use the HDI data to create a graph that shows HDI versus GNI per capita (or log of GNI per capita) for countries of the world in 2012.

a. What does this graph tell you about the appropriateness of GDP as a measure of well-being?

b. Thinking about how HDI is constructed, do you think HDI is a good measure of well-being?

Measuring subjective well-being is much more difficult, but the general pattern is that people in developed countries are generally more satisfied with their lives. This however varies greatly with age. Read Deaton (2008) if you are interested in knowing more about subjective well-being and how it changes with the levels of income and age of people.

HDI and several other measures of well-being are strongly correlated with incomes across the countries of the world. Therefore it seems reasonable to focus on income in cross-country comparisons of development. But, as you will see during this course, the story of development is not that simple. In order to understand the causes of development we need to delve into each dimension of development separately and discuss why outcomes are hugely different across countries and how we can improve them.

► Stop and read


2.4 Methods

In this section we provide an overview of the methods used in studying development economics. We offer a discussion of why theory is important and explain how empirical studies inform our thinking about development issues.

2.4.1 Role of theory

In studying development issues it is important to start with a theory. Theory is not necessarily a mathematical model but is a careful articulation of mechanisms that link factors to outcomes. There are four roles that theory could play in development:
1. It maps the relevant factors and their interactions with each other and with outcomes.

2. It clarifies the assumptions under which government intervention is needed. In other words, it helps identify the market failures that justify policy making.

3. Theory provides quantitative implications that could be tested using data.

4. Theory provides a framework for understanding empirical work. If you are interested in the role of theory you should read Acemoglu (2010).

2.4.2 Empirical methods

Once you have a theoretical understanding of issues you need to test whether the predictions are held in the data. Furthermore, theory could outline potential policies for improving outcomes. In order to assess the effectiveness of such policies you need to engage in empirical evaluation using data. Econometrics is a powerful tool in testing predictions and evaluating alternative policies. It is, however, very important to understand the pitfalls and limitations of econometric analysis.

This course will draw heavily on empirical journal articles that use various econometric techniques. Our emphasis is on intuitive understanding of what could go wrong with econometric methods and the assumptions required for causal interpretation of the results. However, you need to have good understanding of basic regression analysis, which we refer to as ordinary least squares (OLS).

► Stop and read

For basics of statistical analysis and simple regression you should read Ray (1998) Appendix 2. If you find the concepts here difficult, you should consult an econometrics textbook. We recommend Stock and Watson (2012), Wooldridge (2012), or Dunning (2012). You should read the first few chapters on the basics of multivariate regression analysis.

Often in development economics, we are interested in knowing the relationship between two variables. For example, we want to know whether building schools increases educational attainment or whether getting a loan helps with entrepreneurial activities. Regression analysis is the natural tool for dealing with these questions. Let us consider a simple regression of $y$ on $x$. The following equation is called a regression specification and shows the dependent variable $y$ is regressed on a constant and another variable $x$. The final term shows the error term in the regression.

$$y_i = \alpha + \beta x_i + \epsilon_i$$

The coefficient $\beta$ shows the increase in $y$ if $x$ is increased by 1 unit. In reality we do not know the true relationship between the variables and we need to estimate $\beta$. The estimated coefficient is usually indicated by a hat above the parameter (e.g. $\hat{\beta}$). The subscript $i$ identifies the unit of analysis (i.e. the level for which we have collected data on $y$ and $x$). We might have country level data, district level data or individual level data. Furthermore, we might have several observations for one unit of analysis. For example, we might observe countries over time. This is usually represented by multiple subscripts.

The key question we have to deal with is how the estimated coefficient is related to the true (unobserved) parameter of interest. Econometric methods like regression rely on observed correlations in the data. In this simple regression, an estimated coefficient is the ratio of the covariance of
\( y \) and \( x \) to the variance of \( x \).

\[
\hat{\beta} = \frac{\text{cov}(y, x)}{\text{var}(x)}
\]

If, for any reason, the two variables show positive covariance in the data, the estimated \( \hat{\beta} \) will be positive. But whether this implies that the true effect of interest is positive or not is a step that requires further assumptions. In principle we would like to have an unbiased estimator of the true parameter. This means drawing several samples from the population under investigation and calculating \( \hat{\beta} \) should, on average, give the true parameter \( \beta \), i.e. \( \text{E}[\hat{\beta}] = \beta \). To give some insight into when and why this desirable property might be satisfied, we start by making the problem more specific.

### 2.4.3 Programme evaluation problem

Let us focus on a policy intervention that tries to improve children’s education by giving cash to poor households. Households above the national poverty line are ineligible for the programme. Our goal is to estimate the effect of cash transfer on children’s test scores. Let us denote \( Y^T_i \) to be child \( i \)’s test score if the household has received the treatment (cash). Similarly denote \( Y^C_i \) to be child \( i \)’s test score when the child’s household did not receive the treatment (no cash). We would like to estimate the treatment effect (i.e. \( Y^T_i - Y^C_i \)), but we never observe the same household, at the same time, both treated and not treated. Therefore, one of the values in the treatment effect is unobserved. This shows the impossibility of estimating individual treatment effects. But is there a way in which we can estimate the average treatment effect? In other words, can we estimate \( E[Y^T_i - Y^C_i] \) using a sample of households in treatment and control groups?

A natural estimate for the average treatment effect is to compare average test scores for households receiving the cash to those not receiving it. This is shown below:

\[
D = E[Y^T_i \mid \text{cash}] - E[Y^C_i \mid \text{no cash}] = E[Y^T_i \mid T] - E[Y^C_i \mid C] \quad (1)
\]

The term \( E[Y^T_i \mid T] \) shows the average test score for households in the treatment group who received the treatment. Similarly \( E[Y^C_i \mid C] \) shows the average test scores for households in the control group that did not receive the treatment. Both of these objects are observable in the data we collected, therefore we can calculate \( D \). In order to see the relation between \( D \) and the average treatment effect, let us add and subtract \( E[Y^C_i \mid T] \) in (1) to get

\[
D = E[Y^T_i \mid T] - E[Y^C_i \mid T] + E[Y^C_i \mid T] - E[Y^C_i \mid C] = E[Y^T_i - Y^C_i \mid T] + E[Y^C_i \mid T] - E[Y^C_i \mid C] \quad (2)
\]

The first term on the right-hand side of (2) shows the average treatment effect for the population of households who are treated. The rest of the expression shows selection bias, that is, the difference between average test scores for households in the treatment group that are not given cash transfers (\( E[Y^C_i \mid T] \)) and average test scores for control households that are not given cash (\( E[Y^C_i \mid C] \)). Selection bias captures the difference between average outcomes in the absence of any treatment (and hence due to other factors). \( D \) captures the average treatment effect only when the selection bias is zero.

The estimator is equivalent to running a regression as follows:

\[
y_i = \alpha + DT_i + \epsilon_i
\]
where $Y_i$ is test scores for household $i$, and $T$ is a dummy variable that is equal to 1 if the household has received cash and zero otherwise. Ignoring selection bias would result in a biased estimate of the treatment effect. In the current example, being poor was used to allocate cash grants. In the absence of treatment we expect poor children to have lower test scores, therefore we expect the selection effect to be negative and we therefore underestimate the effect of cash grants on test scores.

**Activity 2.6**

A rural bank offers low interest loans to poor households in a village. After one year the bank runs a local survey and finds poor households which borrowed money have on average $100 more income compared to poor households that did not borrow from the bank. It concludes that loans improve the income of the poor and therefore the government should subsidise credit to the poor.

1. The data clearly indicate that higher income is positively correlated with borrowing from the bank, but does it imply that the causal effect of borrowing is higher income?
2. Why is it problematic to compare the income of borrowers to non-borrowers? Which households are more likely to borrow from the bank? How does this affect the reliability of the estimates obtained above?

► Stop and read
Ravallion (2001) for a discussion of issues in programme evaluation.

**2.4.4 Randomised controlled trials (RCTs)**

‘Observational data’ usually involves confounding factors that are hard to control for. Issues like selection could render the results of empirical studies useless for making policy recommendations. In response to concerns about causality, the development literature has moved from cross-country empirical studies and survey-based micro work to within-country randomised controlled trials (RCTs) in recent years.

In RCTs researchers and policy makers work together to see which policies work and why. Since RCTs randomly assign individuals to treatment and control groups, there is no a priori reason to believe the treatment and control should have different outcomes except because of the treatment (policy). Therefore by designing careful experiments, researchers could identify the causal effect of policies. In other words, the selection effect in equation (2) will be zero because, in the absence of the treatment, we expect the average outcomes for control and treatment group to be the same: $E[Y_i^c | T] = E[Y_i^c | C]$. Therefore, $D$ above will give a valid estimate of average treatment effect.

There are certain difficulties with running RCTs:

1. RCTs are very expensive and, therefore, are usually implemented at a small scale (a few hundred villages).
2. Randomisation may not be feasible in some contexts due to ethical considerations.
3. Implementation of RCTs is not straightforward and failed RCTs might be even worse than observational data for getting useful insights. Failure could arise from several issues. For example, there might be mix-up between treatment and control group due to migration.
4. Behaviour of subjects might be different simply because they know that they are being observed (Hawthorne and John Henry effects).
5. Since experiments are often small, it might be difficult to generalise the results to populations outside the study area.

6. Experiments might not be able to capture general equilibrium effects because of their size and local focus.

7. Short-run responses to a treatment might differ from long-run effects. Experiments often capture the former while from a policy perspective the long-run effect might be more important.

Early RCTs focused on programme evaluation and were, therefore, subject to most of the criticisms. However, recent experiments start with a theoretical framework and try to disentangle the theoretical effects of interest. If successful in identifying mechanisms for the working of programme effects, RCTs could hold useful lessons for contexts beyond the one studied.

Stop and read
Banerjee and Duflo (2009) and Duflo et al. (2007) for a discussion about randomised experiments, their merits and potential issues. To learn more about other criticisms of RCTs, see Deaton (2008, 2010).

2.4.5 Methods using observational data

Before RCTs became popular in development literature, most of the studies relied on observational data. In order to overcome the problem of selection bias, observational studies need to justify their identification strategies. There are several ways that selection bias could be reduced. The first method is to rely on simple regression (OLS) and include sufficient controls so selection is fully taken care of. With controls we would not need to assume \( E[Y_{iC}|T] = E[Y_{iC}|C] \). Instead we assume average outcomes would have been the same in the absence of the treatment conditional on the controls in the regression \( E[Y_{iC}|T, W_i] = E[Y_{iC}|C, W_i] \). In our example, we include parental education, initial household income and other relevant variables. This modified assumption might be easier to satisfy.

A variant of including additional controls is to use fixed effects. Fixed effects are dummy variables that are included as controls in the simple regression. For example, in the cash transfer programme outlined above, we might worry that certain provinces have better test scores because of other characteristics (e.g. more schools per student). To correct for this we can include province fixed effects (i.e. one dummy for each province that is equal to one for the given province and zero otherwise). Province fixed effects control for observable and unobservable province characteristics that affect all individuals similarly in a given province and do not change over time.

A second method is to rely on natural experiments. A natural experiment is a situation where a variable of interest is changing in a seemingly exogenous manner due to a policy reform, a threshold rule or similar sharp changes. Natural experiments create plausibly exogenous variations that might be useful in identifying causal effects. We provide more discussion of specific empirical methods for identifying causal effects using observational data in the following chapters: instrumental variables approach in Chapter 6 (section 6.3.1) and difference-in-differences estimation in Chapter 7 (section 7.4.1)

Stop and read
Angrist and Pischke (2010) and Rosenzweig and Wolpin (2000) for a discussion of how natural experiments could be used in identifying causal effects.
2.5 Overview of the chapter

In this chapter we introduced you to the concept of development and discussed various ways of measuring development. GDP per capita is the key measure of living standards used in cross-country comparisons. We discussed the staggering income disparities between countries of the world and the potential to improve the lives of millions of people.

You should now watch the following TED talks:

1. Hans Rosling shows the evolution of countries of the world in terms of global health indicators and income. This provides an excellent overview of development over the past decades. See: www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html

2. Esther Duflo, a leading scholar in development RCTs, talks about poverty and the role of RCTs in informing policy at: www.ted.com/talks/esther_duflo_social_experiments_to_fight_poverty.html

2.6 Reminder of learning outcomes

Having completed this chapter, and the Essential reading and activities, you should be able to:

• explain and evaluate various measures of economic development
• recall and state key facts about development such as large income disparities and the staggering number of people who live in poverty
• explain the role of theory and empirics in development and recognise the difference between correlation and causation.

2.7 Test your knowledge and understanding

1. A rural bank offers low-interest loans to poor households in village A. One year later it starts the same programme in village B. To assess the effectiveness of lending as a policy for fighting poverty, the bank runs a survey of households in both villages at the start of the second year of operation. The sample includes individuals from village A who borrowed money in the past year and those who did not. It also includes the individuals from village B who have applied for a loan but not yet received it. It also includes households from village B that haven’t applied for a loan. The following table shows the average income of borrowers and non-borrowers in villages A and B at the time of the survey.

<table>
<thead>
<tr>
<th>Average income ($)</th>
<th>Village A</th>
<th>Village B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borrowers</td>
<td>1,000</td>
<td>1,200</td>
</tr>
<tr>
<td>Non-borrowers</td>
<td>900</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Discuss whether it is possible to estimate the causal effect of borrowing on income from this survey. From the variety of estimates you can get from the table, which one is more reliable? Which group do you think would form a more valid control group for the borrowers in village A? Be clear about the assumptions you need to put a causal interpretation on the estimates.

Reminder: Feedback to activities in this chapter are available on the VLE.
Chapter 3: Factor accumulation

3.1 Introduction

3.1.1 Aims of the chapter

The aims of this chapter are to:

- present the Solow model of economic growth in order to understand the role of factor accumulation in development
- discuss empirical evaluation of the Solow model and the relevance of factors of production in explaining income gaps
- introduce development accounting and explain its difference from growth regressions.

3.1.2 Learning outcomes

By the end of this chapter, and having completed the Essential reading and activities, you should be able to:

- analyse and solve for the steady state of the Solow model
- recognise and describe key predictions of the Solow model
- critically evaluate empirical tests of the Solow model
- define development accounting and state key conclusions on the role of factors in explaining income gaps.

3.1.3 Essential reading


3.1.4 Further reading


3.1.5 Works cited

3.1.6 Overview

In Chapter 2 we saw that the income gap between rich and poor countries is staggering and does not seem to be closing. In this chapter we begin our quest for understanding why some countries are able to produce so much output while others struggle to feed themselves.

Firms combine inputs to produce goods and services using a production function. Adding up all production taking place in the economy yields aggregate output (e.g. GDP). It might be that poor countries are poor because of lower levels of production inputs. This story suggests the way to develop is to encourage accumulation of production factors. Poor countries should save more and invest more in their capital stock in order to develop.

In this chapter we consider the Solow model, a theoretical foundation for assessing the relevance of the factor accumulation view of underdevelopment (section 3.2). The theoretical analysis lays the foundation for an empirical assessment of the importance of factor endowments in explaining observed income gaps between the rich and the poor countries (section 3.3). Finally, we introduce development accounting as an alternative approach for looking at the explanatory power of factor endowments (section 3.4).

3.2 The Solow model

In its original form, the Solow model is a model of capital accumulation. The model helps us to understand conditions for continuous growth of economies through the accumulation process. It also shows the limits of contributions of capital accumulation to the growth process. Although most of our discussion is concerned with accumulation of capital, the model is easily extended to incorporate any accumulative factor of production. This, however, does not change the key insights of the model.

Let us start by thinking more carefully about the production process. Production takes place by combining inputs in a special way. To produce vegetables, farmers use land, water, seeds, fertiliser, pesticides, labour, tractors, etc. Each farmer might use a different technology and combine inputs in a different way, leading to different levels of production. In economics the production function models this process. We usually focus on a few factors of production and make them explicit in the production function and keep other factors implicit in the form of a productivity parameter or residual. For example, a production function for vegetable farming could be as follows:

\[ y_i = f_i(k_i, l_i) \]

where \( y_i \) is the quantity of produce by farmer \( i \), \( k_i \) is the capital (machinery) used, and \( l_i \) is labour employed in the production process. All other factors mentioned above are left implicit in the production function \( f_i \). If farmer \( j \) uses fertilisers and farmer \( i \) does not, then they will have different production functions \( f_j \neq f_i \). This means that, using the same level of capital and labour, farmer \( j \) will have a different level of production from farmer \( i \).

Economic growth is concerned about aggregate (total) production in a given country. Therefore we need to sum up the monetary value of all production to arrive at aggregate output. Similar to the farming production function, we can use an aggregate production function to show the link between aggregate output and aggregate levels of input use (factors). For example:
Chapter 3: Factor accumulation

\( Y = F(K, L) \)

shows the relationship between aggregate output \( Y \) and total capital, \( K \),
and total labour, \( L \) as two factors of production. We will naturally assume
that expansion of inputs leads to expansion of output. There are many
other factors of production that are not explicitly listed but influence
aggregate output by changing the shape of the production function \( F \). One
country might have a more efficient judiciary and hence higher security of
investment leading to more production given similar capital and labour in
another country.

**Technical note**

The assumption required for existence of the aggregate production function is existence
of perfect capital and labour markets. These assumptions might not hold, especially in
developing country context. If you are interested you should read Banerjee and Duflo
(2005).

**Activity 3.1**

The Cobb–Douglas function is a commonly used production function. A general Cobb–
Douglas production function takes the form of \( Y = AK^\alpha L^\beta \). Let us assume \( \beta = 1 - \alpha \) and
think about a situation where all countries have access to this aggregate production
function. In this activity we want to see how large the gap in capital endowments should
be to explain an income per capita gap of 10 folds (assume the labour force is equal to
the size of the population).

a. Derive the per capita output as a function of per capita capital stock.

b. Assume \( \alpha = 0.5 \). How large should the gap in capital per capita stock be to explain a
tenfold gap in output per capita?

Economic growth is the expansion of output over time. This could happen
through the expansion of factors of production (factor accumulation) or
through enhancement of the production function (e.g. technical progress).
The Solow model focuses on the process of capital accumulation and
its contribution to economic growth. In each period a constant fraction
of aggregate income is saved and the rest is consumed. Assuming the
economy is closed (no trade or external capital), saving is equal to
investment. On the other hand, capital depreciates over time (wear and
tear of machinery). Therefore the change in the capital stock can be
modelled as follows:

\[
\dot{K} = sY - \delta K
\]

(1)

\( \dot{K} \) shows the time derivative of the capital stock (i.e. change of capital
stock), which is equal to savings minus depreciation of existing capital.
Here \( s \) is the saving rate and \( \delta \) is the depreciation rate.

Since per capita output (income) is the key determinant of individuals’
material wellbeing, we need to rewrite the model in terms of per capita
variables. For the moment let us assume everyone in the economy is
working (i.e. the whole population is the labour force) and that the labour
force is growing at a constant rate of \( n \). Furthermore, assume that the
production function remains constant over time (i.e. we do not have any
technical progress). In what follows the lower case variables show per
worker versions of the original variables. Dividing (1) by \( L \) and using the
fact that \( \dot{K}/L = k + (L/L)\dot{k} = k + nk \), we can derive the per worker version of
(1):

\[
\dot{k} = sy - (\delta + n)k
\]

(2)
This says that the change in capital per worker is equal to savings per worker ($s$) minus depreciation of capital per worker (($\delta + n)k$). In addition to the physical depreciation of capital, the addition of new labourers reduces capital per worker and hence works in a similar way to physical depreciation. When savings per worker is larger than depreciation of capital per worker, we have capital per worker accumulation ($k > 0$) leading to growth of output per worker ($y > 0$). If the two terms on the right-hand side of (2) are equal, capital and output per worker remain constant ($k = y = 0$). This situation defines the steady state of the economy.

To move forward with the analysis, we need to impose two further assumptions on the production function. First, we assume the production function exhibits constant returns to scale (CRTS). This assumption states that scaling-up factors of production would increase output by the same scaling factor. Technically it allows us to write output per worker only as a function of capital per worker as illustrated below.

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

Using this in equation (2) gives equation (3) that determines changes in capital per worker as a function of capital per worker. This is known as the Solow equation.

$$k = sf(k) - (\delta + n)k$$  \hspace{1cm} (3)

**Activity 3.2**

Why is it that no change in capital per worker results in no change in output per worker? Does the same conclusion go through if the production function improves over time? (Hint: use the production function.)

**Activity 3.3**

Does the constant returns to scale assumption make sense at the firm level? To answer this, think about a factory adding more machines and labour (scaling up). Does it make sense to assume that output increases proportionately? Why might the CRTS assumption be more plausible at the aggregate level?

Second, we assume the production function exhibits diminishing returns to capital and labour. This assumption states that fixing labour, the marginal product of capital is decreasing in capital. In other words, the additional output produced from an increase in capital diminishes as the capital stock increases, while other factors remain constant. This assumption implies the production function, $F(K, L)$, is concave with respect to capital and labour. Furthermore, with a little bit of algebra you can see that $f(k)$ is going to be concave in capital per worker too.

**Activity 3.4**

Show that the Cobb-Douglas production function, $Y = AK^{\alpha}L^{1-\alpha}$, exhibits diminishing returns to labour and capital. Does the per worker production function derived from this also show diminishing returns to capital per worker? (Assume $\alpha \in (0, 1)$.)

### 3.2.1 Steady state

The steady state of Solow model is when capital per worker does not change over time. A graphical representation of Solow equation – (3) – is particularly useful here. In Figure 3.1 the straight line is the depreciation line and corresponds to the second term in equation (3). The figure also
shows the per worker production function, \(y\), and the saving line, \(sy\). Both of these curves are concave, reflecting diminishing returns assumption. The change in capital per worker is equal to the difference of savings and depreciation lines. Point \(A\) is the steady state where the two curves intersect and capital per worker remains unchanged at \(k'\). Starting from an initial capital per worker equal to \(k_0\), investment (saving) is less than depreciation and capital per worker declines until we return to \(k'\). Starting from an initial capital per worker equal to \(k_0\), investment is larger than depreciation leading to an increase in capital per worker until we reach \(k'\).

![Solow equation and the steady state level of capital per worker.](image)

At the steady state, capital per worker is constant and therefore from the production function, output per worker remains constant at \(y^* = f(k^*)\). This result says that in the absence of technical progress (i.e. the time-invariant production function) the long-run growth rate of output per worker is zero. This result critically relies on the diminishing marginal return assumption. Adding to the capital stock increases output, but at a decreasing rate. Eventually the addition to capital per worker is just enough to compensate for depreciation and therefore growth falls to zero. Zero long-run growth is, however, not consistent with the observed growth rates for several developed countries. For example, the USA has been growing at an average rate of 2 per cent in the last century. Later we present an extension of Solow model that features positive long-run growth.

**Activity 3.5**

Let us assume the aggregate production function takes the Cobb-Douglas form

\[ Y = AK^\alpha L^{1-\alpha} \]

where \(A\) is total factor productivity (TFP) and captures the aggregate efficiency of combining capital and labour in the economy.

Find the steady state level of capital per worker and output per worker in the Solow model with this production function.

### 3.2.2. Comparative statics

Our initial goal was to understand whether factor endowments could explain the observed income gaps. We learned so far that in the steady state of the Solow model, output per worker does not grow. To explain income gaps we consider two possibilities. First, it might be that countries are away from their steady states and are in transition to reach their corresponding equilibria. We deal with this possibility later under the convergence hypothesis. The second possibility is that countries are at their steady states and observed income gaps are due to steady state
In this section we explore this possibility and try to answer the following question: what parameters could potentially explain large income gaps?

The Solow diagram (Figure 3.1) could be used to study the impact of the model parameters on the steady state. Figure 3.2 shows how we can analyse a rise in the savings rate. An increase in the savings rate from \( s \) to \( s' \) shifts up the saving curve to \( s' y \). Starting from the old steady state at point A, savings now exceed depreciation. Therefore capital per worker increases until we reach point B at the intersection of the new saving curve and depreciation line. At the new steady state, output per worker is unambiguously higher because it is increasing in capital per worker and \( k' > k' \).

**Activity 3.6**

Do individuals care about output per se? If we think individuals care about consumption, could you say whether consumption per worker has increased when the savings rate increased based on Figure 3.2? What is the savings rate that gives maximum consumption per worker?

![Figure 3.2: Impact of a rise in saving rate on steady state output per worker](image)

As another example, consider an increase in the population growth rate. This makes the depreciation line steeper because now capital per worker is reduced at a faster rate because it is spread over a faster growing labour force. At the original steady state, investment is now lower than depreciation of capital per worker. Therefore the capital per worker shrinks until we reach the new steady state with smaller capital and output per worker.

**Activity 3.7**

Draw the Solow diagram for the increase in population growth rate.

Changes in both savings rate and population growth have level effects. They change the steady state level of capital and output per worker. They do not, however, impact on the long-run growth rate of these variables. Regardless of the parameter values, the long-run growth rate is zero in the Solow model. Total output, however, grows at the same rate as the population to keep output per worker constant. Question 2 in **Test your knowledge and understanding** at the end of the chapter asks you to explain changes in response to alterations in the the depreciation rate. You can try this question before moving on.
Chapter 3: Factor accumulation

The comparative static analyses suggest that steady state income gaps across countries could be due to the parameters of the Solow model. Poor countries are poor because they have lower saving rates, higher depreciation, higher population growth, and worse production functions. We will see below if this is a realistic description of the empirical evidence but it does not seem that this is a useful conclusion. If low saving rates, high depreciation and population growth are responsible for low incomes, then how should developing countries change these? These are the parameters in the model and are taken to be exogenous. Therefore we cannot make recommendations about them based on the model.

Activity 3.8

In Activity 3.1 we ignored the fact that economies might be at a steady state determined by Solow parameters. This activity asks you to revisit conclusions derived there under steady state conditions. Again assume a Cobb-Douglas production function. In Activity 3.5 you derived the steady state level of capital and output per worker under this assumption. Now assume that two countries have the same TFP, capital share, depreciation and population growth rates ($A$, $\alpha$, $\delta$, $n$ are equal). What ratio of saving rates could explain a 10–fold gap in steady state output per worker across the two countries? What is the implied gap in capital per worker across the two countries? Is this reasonable? (Assume $\alpha = 0.5$ if needed.)

► Stop and read


3.2.3. Technical progress

The result that, in the absence of technical progress, long-run growth rate of output per worker is zero, is in contrast to the experience of many developed countries. For example, US output per capita on average has grown by 2 per cent each year over the past century. The zero long-run growth rate could be changed in two ways. First, we can replace the diminishing marginal returns assumption with a constant returns assumption. This implies adding more capital always results in the same proportional increase in output and there is no reason for growth to die out. In other words, the savings curve is a straight line in this case and if savings initially exceed depreciation, it will always be higher than depreciation and growth continues forever. This is what you see in Harrod-Domar model. Many of the endogenous growth theories also feature some sort of constant marginal returns to sustain non-zero, long-run growth rates (we will see these models in Chapter 4).

The second method is to consider a variant of the Solow model where the production function exogenously expands over time. In other words, the technology used to produce output from capital and labour improves. The steps taken to solve the model in the presence of technical progress are similar to what we did for the original model. At the steady state, output per worker will grow at the exogenously given rate of technical progress. This solves the empirically implausible conclusion of zero steady state growth, but the revised model is silent about how countries could influence the rate of technical progress, thus limiting its usefulness in articulating policy.

► Stop and read

### 3.2.4. Unconditional vs. conditional convergence

What are the predictions of the Solow model if countries are not at their steady states? Let us start by looking at the Solow diagram in Figure 3.1 and consider two countries with exactly the same parameter values and therefore the same steady states. Now consider a case where country 1 starts from an initial capital per worker equal to \( k_0 \) and country 2 has a higher initial capital per worker at \( k'_0 \). Although country 1 is poorer in this example (smaller output per worker), it has a higher growth rate. This is because at \( k_0 \) the gap between the savings curve and the depreciation line is larger than the gap at \( k'_0 \) and therefore the change in capital per worker is larger. Therefore, country 1 will have a faster growth rate compared to country 2 and eventually it catches up with country 2. Both countries will converge to the common steady state at point \( A \). This is unconditional convergence. It states that countries converge to the same steady state regardless of their initial level of development. Furthermore, poorer countries grow faster than rich ones, until they catch up.

In the absence of any estimates for the parameter values it is logical to start from a baseline of equal parameters, but some empirical regularities go against the unconditional convergence hypothesis. For example, we have seen in Chapter 2 that some very poor countries remain poor and have lower growth than the rich countries in the sample.

We now explore the case where different countries might have different parameter values. Figure 3.3 shows a situation where two countries are the same except for their saving rates. Country 1 starts from a lower level of capital per worker at \( k_0 \) while country 2 starts from \( k'_0 \) which is higher than country 1’s initial capital per worker. In contrast to unconditional convergence, here country 2 has a higher growth rate because the gap between the savings curve and the depreciation line is larger for country 2. What matters for the transitional growth rate is the distance of countries to their own steady states. A poor country with a low steady state might have slower growth than a rich country which is still far from its steady state. As the two countries converge to their own steady states, output per capita growth rate falls to the rate of technical progress. This implies no convergence in levels of output per worker but convergence in growth rates.

![Figure 3.3: Conditional convergence.](image)

In summary, unconditional (absolute) convergence states that, regardless of the initial level of output per worker, countries converge to the same steady state level of output per worker. Conditional convergence,
in contrast, states that countries converge to their own steady states depending on their rates of savings, depreciation, population growth and technological progress. Countries further from their own steady state grow faster and in the steady state, countries could have different levels of output per worker. Assuming a similar rate of technical progress would result in convergence in long-run growth rates.

3.3 Testing the Solow model

How much of the observed income gaps across countries could be explained by the accumulation story offered above? Mankiw et al. (1992) provided the first empirical test of Solow’s predictions. In this section we review their results.

\[
\dot{k} = sk^{\alpha} - (\delta + n + g)k
\]

(4)

Before facing the model with the data we need to derive an empirical specification from the model. Let us start with equation (3) and assume a Cobb-Douglas production function with labour augmenting technological progress \( Y = K^{\alpha} (AL)^{1-\alpha} \). This is called labour augmenting because technology seems to expand the effective units of labour (or its productivity). The Solow equation for this model could be written as follows:

where \( \dot{k} \) is capital per efficiency units of labour \((K / AL)\) and technology grows at a constant rate of \( g \). Assuming countries are at their steady states we can derive an expression for output per worker in terms of the model parameters. First we find the steady state level of capital per efficiency unit of labour by setting \( \dot{k} = 0 \) in equation (4):

\[
\bar{k}^* = \left( \frac{s}{\delta + n + g} \right)^{\frac{1}{\alpha}}
\]

(5)

Taking logs of the original production function and using (5) in that we can see the steady state level of output per worker is:

\[
\log \frac{Y}{L} = a_0 + \frac{\alpha}{1-\alpha} \log s - \frac{\alpha}{1-\alpha} \log (n + \delta + g)
\]

(6)

Equation (6) can be written as an empirical specification for the determinants of output per worker across countries as follows:

\[
\log \left( \frac{Y}{L} \right)_i = a_0 + \frac{\alpha}{1-\alpha} \log s_i - \frac{\alpha}{1-\alpha} \log (n + \delta + g) + \epsilon_i
\]

(7)

where \( i \) shows we are looking at country \( i \), \( a_0 \) is the regression constant derived from the average level of technology, and \( \epsilon_i \) is an error term that reflects random technological differences (not captured by \( a_0 \)). Under the assumptions of the Solow model, and if countries are at their steady states, equation (7) suggests output per worker is positively related to the savings
rate and negatively related to rates of population growth and depreciation. Furthermore, the coefficient estimates of the second term and the third term in equation (7) should be of similar magnitude and opposite sign.

Using early versions of Penn World Tables (PWT), Mankiw et al. (1992) regress log of GDP per worker in 1985 on log of average investment to GDP ratio as a proxy for saving rate \(s\) and log of average population growth \(n\) plus 0.05 (they assumed \(\delta + g\) is constant across countries and equal to 0.05). Interestingly, the final coefficient estimates of the saving and depreciation terms are almost equal in magnitude and opposite in sign (as predicted theoretically). But the implied capital share, \(\alpha\), from the estimated coefficients is not close to the reasonable estimate of 0.33 except for the OECD sample.

**Activity 3.10**

To get causal coefficients on covariates in equation (7), the saving rate and depreciation term must be exogenous with respect to the error term. Do you think the assumption of an exogenous saving rate is plausible? What factors could influence the saving rate? Would these factors also affect GDP per worker? Given these, could you still argue coefficient estimates in Mankiw et al. (1992) reflect the causal effect of variables on GDP per worker?

**Activity 3.11**

An important factor absent in equation (7) is human capital. Does ignoring human capital in the empirical estimation of the Solow model imply an under- or overestimate of the influence of savings rate on growth rates?

Mankiw et al. (1992) show that 59 per cent of the cross-country income differences is explained by the two variables included in the regression. Although this shows theSolow model has good explanatory powers, it is not clear what we can learn from this exercise. For example, this analysis says poor countries are poor partly because they do not have enough investment. But the critical question is how they could encourage more investment.

Many factors that are omitted from the analysis above could affect the saving rate and output per worker. For example, financial development affects the ease of getting business and consumption credit, which in turn improves the investment environment and could result in higher saving and investment. At the same time, better access to credit could enhance consumption smoothing and hence better occupational decisions by households that could improve national income. The positive correlation between the omitted financial development factor, investment rate and output biases the estimated coefficient of investment rate upward. Therefore the results of Mankiw et al. (1992) should be seen as simple correlations without any causality implications, leaving the question of growth mechanisms unanswered (see Caselli et al. (1996) for a discussion of omitted variable bias and endogeneity in growth regressions).

In Activity 3.9 you worked with data and looked at convergence. In order to study convergence in a more systematic way we need to model the dynamics of output per worker rather than just the steady state relationships as in equation (6). Furthermore, we need to control for each country’s steady state. We have seen in equation (6) that the steady state is a function of rates of saving, depreciation, population growth and technical progress. Once we control for the steady state, countries further from the steady state should have higher growth rates. This is the intuition for specification (8) used by Mankiw et al. (1992) to test conditional convergence.
Chapter 3: Factor accumulation

3.4 Development accounting

The analysis we have seen in Mankiw et al. (1992) is an example of growth regressions. It uses a regression framework to estimate the contribution of factors of production and other institutional and policy variables on economic growth. The difficulty of overcoming endogeneity concerns (e.g. omitted variables, measurement error and reverse causality) in growth regressions implies these regressions are at best showing correlations in the data. Growth accounting is an alternative approach that, instead of estimating parameters, assumes some reasonable values for parameters and tries to see how much of the growth could be explained by measured expansions in factors of production.

Development accounting is similar to growth accounting in terms of techniques used but focuses on a cross-section of countries, whereas growth accounting considers a single country over time. Development accounting assesses how much of the variation in output per worker across countries could be explained by differences in factors of production. It is an accounting exercise because it is silent about the mechanisms that could shape factor contributions and builds on calibrations of factor shares (e.g. capital share, \( \alpha \)) as opposed to estimation of such variables from cross country data.

To get an idea of what development accounting does, let us start by assuming a Cobb-Douglas production function as follows:

\[ Y = AK^\alpha (LH)^{1-\alpha} \]

where \( K \) is physical capital, \( L \) is labour, \( H \) is human capital and \( A \) is total factor productivity (TFP) and captures the efficiency of inputs’ use. Rewriting the production function in per worker terms and taking logs results in

\[ \log y = \log A + \alpha \log k + (1 - \alpha) \log h \] (9)

as usual lower case variables show per worker versions of original ones.
Once capital share, \( \alpha \), is calibrated (usually it is assumed to be 0.33) we can measure everything except TFP. In other words, TFP is backed out as a residual similar to Solow residual in growth accounting. Caselli (2005) provides a discussion of how you can measure \( k \) and \( h \) using existing data from Penn World Tables (Heston et al., 2012) and educational attainment datasets (e.g. Barro and Lee, 2013).

The evidence from this exercise suggests that at least 50 per cent of differences in per capita income cannot be explained by differences in physical and human capital (Caselli, 2005). In other words, TFP differences explain more than half of the income gaps. The critical question is, of course, why TFP varies so dramatically across countries. Development accounting is silent on this question simply because TFP is the unexplained residual in this framework.

**Activity 3.13**

Explain the difference between development accounting and growth regressions. How could you reconcile the fact that Mankiw et al. (1992) were able to explain 59 per cent of income differences using physical capital only but Caselli (2005) states physical and human capital cannot explain more than 50 per cent of the income gaps in a development accounting exercise?

If we rely on a narrow technological interpretation of TFP it is hard to see how a single measure of aggregate technology could vary so much across countries. Poor countries may not have access to the best available technologies, but many machines are imported and huge gaps in technology seem unreasonable. TFP however, is not all about technology. It includes all other inputs of production, apart from those measured (e.g. human and physical capital for most studies). Quality of management practices, protection of property rights, efficiency of labour markets, regulation of entry, transport infrastructure and openness to trade are only a few variables from the long list of factors exerting an influence on TFP. In the upcoming chapters of the guide we will investigate several of these factors. Here we discuss a recent literature that relies on within-country heterogeneity of firm-level TFP as an explanation for large gaps in cross-country aggregate TFPs.

If capital is allocated efficiently across sectors the marginal product of capital should be equalised. Therefore sectors with higher productivities would absorb more capital and expand, while sectors with lower productivity attract little capital. Market failures could prevent reallocation of capital from low to high productivity sectors. This implies that even if countries have identical best technologies in each sector, they might still have different aggregate productivities due to inefficient allocation of capital. To better understand this concept, let us work through the following activity.

**Activity 3.14**

Consider country 1 that has two sectors, A and B. There is only one firm in each sector that uses capital to produce a homogenous output. The production function in sector \( i \) is \( y_i = A_i k_i^{\alpha_i} \) where \( A_i \) is the sectoral productivity and \( \alpha_i = 1/3 \). Furthermore, share of capital, \( \alpha \), is 1/3.

a. Assume in country 1 there is one unit of capital and 1/9 of it is invested in sector \( A \) and the rest is used in sector \( B \). Find the aggregate productivity parameter in this economy, assuming the aggregate production function is \( y = Ak_1^{\alpha} \) where \( y = y_A + y_B \) and \( k = k_A + k_B \). [hint: find total output by adding each sector’s output using the sectoral production functions, then use the aggregate production function to back out \( A \).]
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b. Consider country 2 with an exactly similar structure to country 1 except for the sectoral distribution of capital. Here 8/9 of the capital is used in sector A and the rest is employed in sector B. Find the productivity parameter for this country.

c. What is the ratio of productivities in the two countries? By how much is country 2 richer?

d. Repeat the analysis in c) assuming \( a_A = 4 \) and \( A_B = 4 \).

Another source of inefficiency is within-sector misallocation. Looking at narrow industries, one would expect more productive firms to expand at the expense of low productivity firms until the marginal product of capital (and other factors) is equalised across firms. Presence of market failures again prevents equalisation of marginal products. For example, Hsieh and Klenow (2009) show that reducing within-industry productivity dispersion in China and India to the level observed in the USA would increase aggregate TFP in the respective countries by 30 and 59 per cent.

Stop and read


3.5 Summary

In this chapter we reviewed the Solow model to assess the role of factor accumulation in explaining large income gaps between developing and developed countries. With diminishing marginal returns to capital, steady state growth would converge to zero unless we have TFP improvements. The Solow model is, however, silent about factors impacting on TFP.

Growth regressions confirm most of the theoretical predictions of the Solow model, but endogeneity and omitted variable issues prevent us from putting a causal interpretation on these results. Development accounting literature suggests a big part of income differences cannot be explained by differences in factors of production (physical and human capital). Furthermore, TFP itself matters for factor accumulation decisions. A higher TFP increases the returns to physical and human capital accumulation. Therefore, TFP not only has a direct effect on income gaps but also indirectly affects the income gap by changing incentives for factor accumulation. Notice that the development accounting exercise assigns the indirect role of TFP to factor endowments.

3.6 Reminder of learning outcomes

Having completed this chapter, and the Essential reading and activities, you should be able to:

• analyse and solve for the steady state of the Solow model
• recognise and describe key predictions of the Solow model
• critically evaluate empirical tests of the Solow model
• define development accounting and state key conclusions on the role of factors in explaining income gaps.

3.7 Test your knowledge and understanding

1. What are the implications of the Solow model for international aid? Suppose the economy is in steady state, what is the impact of providing cash aid? What if the economy is away from the steady?
2. What is the effect of an increase in the depreciation rate on steady state capital per worker and output per worker in the Solow model? How does it impact on total output? Does this change affect the long-run output per worker growth rate? What about growth rate of total output?

**Reminder:** Feedback to activities in this chapter are available on the VLE.
Chapter 4: Endogenous growth and poverty traps

4.1 Introduction

4.1.1 Aims of the chapter

The aims of this chapter are to:

- present an introduction to endogenous growth theories
- discuss complementarities and increasing returns as two fundamental issues in endogenous growth theory and poverty trap models
- introduce models of poverty traps and discuss empirical evidence on existence of such phenomenon in developing countries
- discuss the relevance of historical events in shaping current outcomes.

4.1.2 Learning outcomes

By the end of this chapter, and having completed the Essential reading and activities, you should be able to:

- outline core differences between endogenous growth theories and the Solow model
- define complementarities and relate them to real economic examples
- analyse models of poverty traps and explain the role of different assumptions in shaping conclusions
- outline the role of history in development.

4.1.3 Essential reading

Ray (1998), Chapter 4 and 5.

4.1.4 Further reading


4.1.5 Overview

The unfortunate prediction of the Solow model was that growth fades away as the economy approaches a steady state. Incorporating technical progress in the Solow model maintains long-run growth but since the rate
of technical progress is exogenous, the model does not provide insights into factors influencing long-run growth.

In the first section of this chapter, we introduce endogenous growth theories. These models replace the diminishing marginal returns assumption in Solow with constant marginal returns in one way or another in order to deliver non-zero long-run growth. With diminishing returns to capital, additions to the capital stock result in a decreasing contribution to output. As the capital stock grows, eventually the increase in output yields just enough investment to offset depreciation, resulting in no further increase in output. In contrast, in endogenous growth theories the assumption of constant returns to accumulable inputs (factors like physical and human capital) ensures a proportional contribution of such factors to output. Simultaneous accumulation of all such factors would maintain long-run growth, and output growth is always enough to sustain higher than depreciation investments in factors, leading to a balanced growth path in the long run (see section 4.2).

In section 4.3 we introduce the idea of complementarities and argue that their presence could result in endogenous growth and multiple equilibria. Section 4.4 introduces the idea of poverty traps. We present an example of coordination failure and discuss the big push theory, outlining the role of complementarities and market failures in these models. We also present empirical evidence on the existence of poverty traps. Section 4.5 discusses the role of history in shaping economic outcomes.

### 4.2 Endogenous growth theories

Endogenous growth is in contrast to the assumption of exogenous technical improvement in the extended Solow model. Here long-run growth is a result of endogenous factors in the model as opposed to assumed exogenous technical progress. The rate of long-run growth therefore is determined inside the model.

Let us start with the simplest possible endogenous growth model, the AK model. In this model, diminishing returns to capital is replaced by constant returns and capital accumulation results in sustained growth. In the AK model, capital is the only factor of production and increases in capital lead to a proportional increase in output (i.e. capital output ratio is fixed). The production function takes the following form

\[
y = Ak
\]

where \( y \) is output per worker, \( k \) is capital per worker, and \( A \) is the inverse of capital output ratio. A constant fraction of output is saved each period and invested in the capital stock. Natural wear results in depreciation of capital at a constant rate of \( \delta \) and the labour force grows at an exogenous rate of \( n \). Therefore we have the standard accumulation equation as follows:

\[
\dot{k} = sy - (n + \delta)k
\]

This model is very similar to Solow and in fact you can see the only difference is that we have replaced \( \alpha = 1 \) in the Solow model with a Cobb-Douglas production function. The steady state of the AK model is, however, markedly different from the Solow model. To see this, replace (1) in (2) to get

\[
\dot{k} = sAk - (n + \delta)k
\]

\[
\frac{\dot{k}}{k} = sA - (n + \delta)
\]

The right hand side of (4) is composed of constant parameters leading to a fixed growth rate for the capital stock. If \( sA - (n + \delta) > 0 \) capital per worker
grows at this rate. There is no transitional dynamics here and the economy is at its steady state growth rate starting from any initial level of capital stock.

**Activity 4.1**

By taking logs from both sides of the production function, show that the growth rate of output per worker in the AK model is equal to that of capital per worker.

The assumption of constant returns to physical capital is hard to justify in the AK model. There are good reasons to believe that adding capital when there is little existing capital should have high returns but increasing the stock when it is already high should result in a small change in output. Therefore we need to go beyond this simple model to create endogenous growth under more reasonable assumptions.

### 4.2.1 Human capital

So far we have considered labour as a homogenous input that exogenously expands due to population growth. Individuals, however, spend considerable resources on education and health. While there is intrinsic value to health and education, these investments contribute to the productive abilities of individuals. Ignoring the contribution of accumulated skills to production could be the reason for the lack of sustained growth in the Solow model.

Skilled workers have higher productivities because they have better knowledge and ability to carry out production tasks (e.g. working more efficiently in teams and with sophisticated machinery). Skilled workers also increase the marginal product of capital. Therefore additional investments in capital yield higher returns. Simultaneous accumulation of human and physical capital could overcome diminishing returns and maintain non-zero steady state growth.

Many models incorporate human capital accumulation to generate endogenous growth. We briefly discuss a simple extension of the model presented in Ray (1998). We consider a model where physical and human capital enter a Cobb-Douglas production function with constant returns to scale

\[
Y = AK^\alpha H^{1-\alpha}
\]

where \(Y\) is output, \(K\) is physical capital, \(H\) is human capital, and \(A\) is time-invariant total factor productivity. We still assume that the labour force grows at an exogenous rate of \(n\). In per worker terms, the production function is as follows (divide by \(L\))

\[
\frac{Y}{L} = \frac{Ak^\alpha h^{1-\alpha}}{L}
\]

where small case variables show per worker versions of the corresponding variables. Physical and human capital accumulation are similar to capital accumulation in Solow as follows:

\[
\dot{k} = s_k y - (n + \delta)k
\]

\[
\dot{h} = s_h y - (n + \delta)h
\]

where \(s_k\) and \(s_h\) are saving rates for physical and human capital, and \(\delta\) is a common depreciation rate. Equation (8) says that the change in human capital is equal to investment minus depreciation. A constant share of output is allocated to human capital investment (\(s_h y\)) while the existing stock of human capital depreciates due to population growth and loss of skills.
Activity 4.2

Derive equation (8) from the aggregate human capital accumulation equation \( H = s_h Y - \delta H \). This is very similar to what we did in the previous chapter to derive (7).

In steady state, output per worker grows at a constant rate. Looking at the production function in equation (6), you should observe that this is only possible if physical and human capital also grow at exactly the same rate. Therefore physical and human capital output ratios must remain constant in steady state. To solve for steady state growth rate, divide equation (7) and (8) by \( k \) and \( h \) respectively and use the production function, equation (6), to get:

\[
\frac{\dot{k}}{k} = s_k \frac{\dot{A}}{A} - (n + \delta) = s_k A \left( \frac{\dot{h}}{h} \right)^{1-\alpha} - (n + \delta) \quad (9)
\]

\[
\frac{\dot{h}}{h} = s_h \frac{\dot{h}}{h} - (n + \delta) = s_h A \left( \frac{\dot{h}}{h} \right)^{\alpha} - (n + \delta) \quad (10)
\]

Given that steady state growth rates for physical and human capital are identical, we can derive the physical to human capital ratio as follows by equating (9) and (10):

\[
\frac{\dot{k}}{k} = \frac{s_k}{s_h} = \frac{\dot{h}}{h} \quad (11)
\]

Replacing (11) into (9) and (10) gives the steady state growth rate of the economy

\[
\frac{\dot{k}}{k} = \frac{\dot{h}}{h} = \frac{s_k}{s_h} A \left( \frac{\dot{h}}{h} \right)^{1-\alpha} - (n + \delta) \quad (12)
\]

Assuming the right hand side is positive, we get endogenous growth that continues forever. Although physical and human capital exhibit diminishing returns on their own, there are constant returns to physical and human capital together in this model. Therefore, a balanced expansion of both forms of capital allows proportional expansion of output. This is why we get endogenous growth here.

Activity 4.3

In the AK model we argued it is not reasonable to assume constant returns to physical capital. Is it plausible to assume constant returns to human and physical capital above? This model shows an interesting feature of endogenous growth models. Changing parameters like saving rates, depreciation and capital share have growth effects. For example, from (12) you can see that increasing the saving rate for physical capital increases steady state growth rate. Furthermore, the convergence result in the Solow model is overthrown and initial income gaps are maintained in steady state. Countries with higher saving rates, lower population growth and lower depreciation continue to grow faster even in the steady state. This should not be surprising because, as we discussed in Chapter 2, the convergence result relies on diminishing return assumption.

The AK model also featured a similar property and, in fact, the two models are more similar than it appears at first sight. The following activity helps you discover this point.

Activity 4.4

Rewrite the production function in (6) as follows

\[
y = A \left( \frac{\dot{h}}{h} \right)^{1-\alpha} k
\]

Now assume we are in the steady state. Why is it that in steady state the production function in (6) is equivalent to the AK production function? How could you redefine the productivity parameter here to have exactly an AK production function?
4.2.2 Technical progress

A large number of articles in the endogenous growth literature deliver sustained long-run growth through purposeful investments in technological advancement. In these models firms invest in enhancing the productivity parameter in the production function. If sufficient resources are spent on technical progress it could compensate for the falling marginal product of capital and result in non-zero long-run growth. In other words, these models again target the diminishing return assumption and replace it with constant returns to technology and capital.

Firms can either invest in developing new blueprints (innovation) or in adopting existing ones (imitation). Depending on the position of a country with respect to the world technology frontier, modelling one or the other might be more relevant. Innovation or imitation could happen along two dimensions. They could increase the number of available goods or improve the quality of existing products. The key in all models of technical progress is that firms choose to spend resources on research and development (R&D) in the hope of discovering a new variety or an improved product.

While innovation is a costly process, copying from existing ideas is relatively cheap. With perfect competition, no firm invests in R&D because once the innovation is available, competitors can easily copy and beat the innovator on price, leading to negative economic profits for the innovator. This necessitates a departure from perfect competition. Innovators need to get positive economic profits from selling their innovations to cover the upfront cost of R&D. Investors weigh net present value of future profits against costs of innovation and choose to invest in developing new ideas until the marginal cost of doing so is equal to the marginal benefit.

Activity 4.5

Explain why under perfect competition and free entry no firm has an incentive to engage in R&D activities.

Microfounded endogenous growth models usually feature many sectors and profit maximisation for heterogenous firms. Therefore we are not going to cover any of them in detail. Once solved, however, they resemble the simpler models as discussed above. The key features in both models is constant returns with respect to accumulable inputs. An exercise at the end of this chapter asks you to solve a model of a product-variety expansion with the following production function:

\[ Y = N^{1-\alpha} k^\alpha. \]

Here \( N \) is the number of available varieties in the economy and \( K \) is capital. Firms divert part of their output to invest in R&D and develop new varieties. This will increase the number of available varieties used in the production. Therefore, capital is spread over more varieties and, although each variety (sector) could exhibit diminishing returns to capital, in aggregate there are constant returns to the combination of the number of varieties and capital.

Stop and read


Stop and read

4.3 Externalities, complementarities and increasing returns to scale

One way to get constant returns is to incorporate externalities in the production function. When someone’s choice affects the payoff of another person, we say that the decision has created an externality. If the payoff is increased, we refer to it as a positive externality and if it is decreased, it is a negative externality. For example, when an entrepreneur introduces a new production technique to an industry, other firms active in the sector will become aware of the technique and receive an information benefit from an entrepreneur’s action. Having more information, they can better plan for adoption of new technologies and hence receive a positive externality. It is called an externality because the entrepreneur himself would not care about potential benefits to others and therefore the benefits are external to him.

Activity 4.6

Think about the process of human capital accumulation. What are potential externalities attached to the decision of investing in one’s education? Are these positive or negative externalities?

4.3.1 Learning by doing

To understand how the presence of externalities could influence the growth process let us focus on a learning by doing externality. There are a number of firms in the economy and each uses the same production technology with diminishing returns

\[ Y_i = AK^\alpha L_i^{1-\alpha} \]  

where \( Y_i \) is output produced, and \( K_i \) and \( L_i \) are the amount of capital and labour employed by firm \( i \). \( A \) is a common productivity parameter that, in this model, we assume to be dependent on aggregate capital in the economy

\[ A = A_0 K^{\eta} \]  

This assumption creates a positive externality for firms’ capital accumulation decisions on everyone’s productivity. One firm investing in its own capital stock delivers a benefit to all existing firms through an increase of productivity parameter. For example, if more farmers use tractors and fertiliser, the remaining farmers get a better knowledge of how to use these inputs (learning from others).

Under perfect competition, it can be shown (see Activity 4.8) that the aggregate production function takes the following form

\[ Y = AK^\alpha L^{1-\alpha} \]  

where \( Y \) is total output, \( K \) is total capital and \( L \) is total labour employed by firms. Using (14) in (15) results in

\[ Y = A_0 K^{\alpha+\eta} L^{1-\alpha} \]  

Although we assumed diminishing returns at the micro level, the aggregate production function exhibits increasing returns to scale. Increasing returns creates the possibility of sustained and even accelerating growth which suggests a divergence between developed and developing countries. Countries with higher capital stock have higher productivity. This compensates for some of the fall in the marginal product of capital due to higher capital stock.
Activity 4.7
Why does the production function in (16) represent increasing returns to scale?

Activity 4.8
In this activity, you will show that the aggregate production function can be derived from the firm level production function.

a. Write down the profit maximisation problem for firm $i$ and derive the first order conditions. You can assume a common real wage of $w$ and a common real capital rental rate of $r$.

b. How does the profit-maximising capital-labour ratio differ across firms?

c. (optional) Now write aggregate output as the sum of all output produced by individual firms, and use the results for capital labour ratios from above to derive a production function in terms of total capital and labour.

(Hint: $Y = \sum_i Y_i$ and you are asked to find $Y$ as a function of $K = \sum_i K_i$ and $L = \sum_i L_i$)

► Stop and read
Ray (1998) Chapter 4, pp.112–19 (subsection 4.4.4 up to end of section 4.4).

4.3.2 Complementarities
The positive externality from capital accumulation in the model above is in fact a complementarity. The capital accumulation decision of each firm affects the accumulation decision of others. If one firm decides to invest, everyone will enjoy a higher marginal product of capital and increase their investments. In other words, capital accumulation by one firm increases the gains from accumulating more capital for others. This is a complementarity because not only is the level of utility (profit) affected but the relative value of alternative options (investment) has also changed. When a firm invests more it increases the value of the investment for other firms and therefore they are inclined to choose this option (relative to the no investment option).

Activity 4.9
Define a complementarity and explain how it differs from an externality.

Complementarities have a ubiquitous presence. Consider the example of the adoption of high yield variety (HYV) seeds. Farmers need to use the right amount of fertiliser and other inputs to get the most benefit of HYVs. Therefore, adopting HYVs involves costly experimentation with inputs. Once farmers learn the right amount of inputs, HYV are much better than traditional seeds. If most of the farmers in an area have already adopted HYVs, neighbouring farmers can see the results of their experimentation and learn from their mistakes. On the other hand, if no one has chosen HYVs, farmers need to carry out several rounds of experimentation to learn the right amount of inputs.

Activity 4.10
Why is the adoption of HYV seeds an example of a complementarity? Try to be specific about the complementary actions.

Now think about the cost of adopting the traditional crops. Since everyone is familiar with these crops, farmers know which seeds are suitable for which plots and they have learned the right level of inputs too. Figure 4.1 shows the cost of adoption of HYVs and traditional seeds as a function of
the number of farmers using them. We have drawn the curves so that the cost of adopting traditional crops is always higher than HYVs crops for a given number of users. Historically, only traditional crops were available so many have already chosen them. Since most of the farmers are using the old varieties, the cost of adopting a traditional crop is lower (point A) than the cost of learning about HYV (point B). A new farmer, deciding on what to cultivate next year, will choose to go with the old varieties. This results in non take-up of HYV (or slow take-up if we change the model to allow for some heterogeneity among farmers).

![Figure 4.1: Cost of adoption in the presence of complementarities.](image)

In effect, the model described here has two equilibria: one in which everyone is doing traditional agriculture with low levels of production and the other where everyone has adopted the HYV with a high level of production. If we start with a situation where there are no traditional farmers, HYVs are the better option because they involve lower adoption costs. But starting from an existing pool of traditional farmers (e.g. at point A), the HYVs are not taken up.

In this framework, history plays a key role in the process of development. We have path dependency and it matters what initial endowment and practices countries have. This is in contrast to Solow where we had convergence, and so the initial level of capital did not matter. The presence of complementarities also provides a justification for government intervention. If the government gives a temporary subsidy for adoption of HYV, then we might move from the old variety equilibrium to the HYV equilibrium as you will see in Activity 4.11.

**Activity 4.11**

How could a temporary subsidy for adoption of HYV change the equilibrium of the economy? First think about the impact of the subsidy on Figure 4.1 curves, then try to argue why a temporary subsidy is enough and we do not need permanent support.

► Stop and read


### 4.3.3 Increasing returns

Increasing returns to scale (IRS) is a situation where scaling up all production inputs results in a more than proportionate increase in output. The presence of IRS results in decreasing marginal and average costs of production. Therefore, firms with higher levels of production have a cost advantage over new entrants and smaller firms. Further expansion
Chapter 4: Endogenous growth and poverty traps

of output and stealing the market from competitors is profitable because it leads to greater utilisation of IRS and reduction of average costs. This characterises the case of a natural monopoly. Other entrants are deterred because they cannot undercut the monopoly's price and still survive.

Activity 4.12

Explain why the presence of IRS in an industry is not compatible with competitive markets.

► Stop and read

Ray (1998) Chapter 5, pp.147–54 (sections 5.3 and 5.4).

4.4 Poverty traps

Poverty traps are an undesirable equilibrium situation. They are traps because they are difficult to escape from. Individuals without any assets or skills could be in a poverty trap because they earn low incomes and this income is insufficient to be invested in the acquisition of productivity enhancing skills. Countries with poor institutions might be in a poverty trap because they cannot produce enough output to fix their institutions. Institutions are, however, a critical determinant of aggregate productivity. Maintaining poor institutions keeps the country's income down.

4.4.1 Coordination failure

Coordination failure could result in poverty traps. Consider an example with two firms using an old technology to produce two goods. Firms can choose a new technology by paying an upfront cost of $F$ (e.g. training workers to operate the new machines). Furthermore, investment in new technology creates a positive externality on the other firm (as in the learning model you saw earlier). Table 4.1 shows the payoff structure for these firms under the two scenarios of investing or not investing in the new technology. When both continue with the old technology and do not invest, they both get zero profits (this is a normalisation). When firm 1 invests, it pays the upfront cost of $F$. If firm 2 does not adopt the technology, firm 1’s payoff is $\sigma - F$ but if firm 2 also invests in new technology, the externality results in an additional gain and increases firm 1’s payoff to $\pi - F$. On the other hand, if firm 1 decides not to invest in new technology, but firm 2 does, firm 1 receives a payoff of 1. We assume $\sigma - F < 0$ and $\pi - F > 1$, so investment is an inferior decision if the business partner does not invest and it is superior if the partner decides to invest.

<table>
<thead>
<tr>
<th>Firm 1</th>
<th>Invest</th>
<th>Do not invest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invest</td>
<td>$\pi - F, \pi - F$</td>
<td>$(\sigma - F, 1)$</td>
</tr>
<tr>
<td>Do not invest</td>
<td>$(1, \sigma - F)$</td>
<td>$(0,0)$</td>
</tr>
</tbody>
</table>

Table 4.1: Payoffs under the two scenarios of investing or not investing.

Activity 4.13

Explain why the externality in Table 4.1 is a complementarity too.

This simple game has two pure strategy Nash equilibria. There is a good equilibrium where both firms invest in the new technology. Conditional on firm 2 investing in the new technology, firm 1 prefers to invest as well, because $\pi - F > 1$. Symmetrically, conditional on firm 1 investing in the new technology, firm 2 prefers to invest too because $\pi - F > 1$. The other
equilibrium is where no one invests in the new technology. When firm 2 does not invest then firm 1 prefers to withdraw from investment because \( \sigma - F < 0 \) and vice versa. Therefore either both firms invest or both withdraw from investment. This shows the classic big push argument, although industrialisation by one firm is not viable \( (\sigma - F < 0) \); when both firms industrialise they can get a higher profit and generate more income (see next subsection).

Expectations play a key role in this classic example of coordination failure. If each firm expects the other to invest in adopting the new technology it will invest itself. But if expectations are for some reason set at non take-up of new technology the economy remains at the low equilibrium.

4.4.2 Big push

The example of the shoe factory from Ray (1998, p.137) is quite telling in motivating the big push idea. An economy that has only one big shoe factory serving the domestic market cannot be viable, because individuals working in the factory purchase everything, not just shoes, with their incomes. There will not be enough demand for all the shoes produced. In contrast, simultaneous expansion of several sectors could be viable, even when they all cater for domestic demand. Some individuals work for the shoe factory, others work to produce garments, etc. and with their incomes they would also purchase the output of these factories.

Activity 4.14

Explain how the parable of the shoe factory fits the coordination failure game represented in Table 4.1.

Murphy, et al. (1989) offer a formal model for the parable of the shoe factory. Consider an economy where firms can use an old cottage production method or an industrialised new technology with increasing returns to scale. Sectors using the cottage production method are competitive. Industrialisation involves fixed costs, paid only if subsequent profits are sufficiently high to cover upfront costs. Once a sector is industrialised, all production is done by the single monopolist using the advanced technology (due to increasing returns discussed earlier). Workers in the industrialised sectors receive a higher wage than the workers in cottage production. Therefore, there is positive externality of industrialisation. Once a sector is industrialised, workers receive higher wage and therefore would increase demand for all products thus increasing the profitability of other sectors. In fact, this is a case of a complementarity, because industrialisation in one sector increases returns to industrialisation in other sectors.

This model features multiple equilibria. An equilibrium where none of the firms decides to industrialise and everyone uses the cottage method leads to low incomes, and a second equilibrium where all sectors industrialise and incomes increase. As Murphy, et al. (1989, p.1004) put it,

> simultaneous industrialization of many sectors can be self-sustaining even if no sector could break even industrialising alone.

There are two features of this model worth emphasising. First, the size of the market matters greatly for the industrialisation decision. In the absence of trade, producers cater for the domestic market, the size of which depends on population and income.
Activity 4.15

Explain how the presence of a large export market could remove the cottage equilibrium in the big push model.

The second feature of the model, which leads to a multiplicity of equilibria, is the presence of market failures in the labour and capital markets. The model assumes wages are higher in the industrialised sector. This suggests the presence of market failure which prevents equalisation of wages potentially due to efficiency wages or skills. In order to have the two equilibria we also need imperfect capital markets. If capital markets are perfect then one firm could borrow enough money to industrialise all sectors at the same time to solve the coordination problem.

Activity 4.16

What are policy implications of the big push theory? How could the government intervene to promote industrialisation?

4.4.3 Empirical evidence on poverty traps

We have studied several ideas that could lead to multiple equilibria and the presence of poverty traps. But, is there any empirical evidence that supports this view of development? Testing for poverty traps is hard, because it is not clear how we can empirically see if a country has moved from a bad equilibrium to a good one. Empirically it is difficult to separate transitional dynamics from a shift in steady states.

Miguel and Roland (2011) compare the heavily bombed districts of Vietnam during the Vietnam War to those that were not destroyed as much. The presence of regional poverty traps could leave the heavily bombed areas in a poverty trap because most of the capital stock was destroyed in these areas. They test for local poverty traps by looking at various outcomes but find no significant difference between local poverty rates, consumption levels, infrastructure, literacy and population density. Therefore, this study points to the absence of local poverty traps and confirms convergence in the long run. The empirical setting, however, does not allow identification of countrywide poverty traps (e.g. if Vietnam as a whole has fallen into a poverty trap due to US bombing).

Activity 4.17

Explain why inter-regional trade in Vietnam could eliminate local poverty traps.

In another study, Davis and Weinstein (2002) find that Allied bombing of Japanese cities during the Second World War did not have a significant impact on long-run population trends. Therefore, they find evidence in support of unique steady states for city size rather than multiple steady states.

Redding et al. (2007) provide evidence in support of multiple equilibria and show the temporary division of Germany resulted in a permanent shift of German's air traffic from Berlin to Frankfurt. Before division, Berlin airport was the primary hub, but after division, Frankfurt adopted this role. The reunification of the Germany did not reverse this change. This suggests strong path dependency where, for historical reasons, the airport hub was moved to another location and remained there.
**Activity 4.18**

Why might the case of Frankfurt airport not be very useful in providing evidence for the existence of multiple equilibria in a cross country setting?

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### 4.5 The role of history

History could influence current economic outcomes through various channels. In the presence of multiple equilibria, historical events could shift the path of development from one equilibrium to the other, resulting in a long-lasting impact on economic outcomes. Alternatively, historical events could change fundamental factors influencing economic growth. For example, historical events could shape local institutions. Institutions, however, are persistent and therefore link historical events to current outcomes. In Chapter 6 we will see examples of studies in this area. Here we touch the surface of a growing empirical literature that looks at the impact of history.

History could shape social norms and expectations. For example, Nunn and Wantchekon (2011) use the Afrobarometer survey of 2005 and link today’s trust levels to historical slave trade in Africa. They show that individuals whose ethnic group was exposed to more slave trade between 1400 and 1900 have less trust in their neighbours, relatives and local government. The level of trust affects the extent of cooperation and teamwork in society and hence could influence development.

Historical levels of knowledge and technology could affect current economic outcomes. For example, if higher levels of technology reduce the cost of adopting new technology, then countries with historically higher levels of technology would be able to grow at a faster rate. Comin et al. (2010) find that technology levels in 1000BC, 0AD, 1500AD and GDP per capita levels are positively correlated.

▶ Stop and read


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### 4.6 Summary

Endogenous growth theories resolve the inability of the Solow model to generate sustained economic growth. The crucial difference between the two paradigms is the assumption of diminishing returns to factors of production. In Solow, consecutive increases in capital stock result in decreasing additions to output. In the steady state, this additional output is just enough to offset depreciation of capital. Therefore, the net addition to capital is zero and the growth process halts. But, in endogenous growth models, there are constant returns to accumulable factors of production. Simultaneous investments in these factors result in additional output that is sufficiently high to continue net increases in factors of production. This virtuous circle yields endogenous growth.

Another paradigm that could explain wide income gaps across countries is based on the existence of multiple equilibria. In presence of market failures, complementarities could result in multiple equilibria. Countries might be trapped in a bad equilibrium due to their inability to coordinate their way out of the situation. Although models of poverty traps are intuitive, empirical evidence is inconclusive on their existence.
4.6 Reminder of learning outcomes
Having completed this chapter, and the Essential reading and activities, you should be able to:

- outline core differences between endogenous growth theories and the Solow model
- define complementarities and relate them to real economic examples
- analyse models of poverty traps and explain the role of different assumptions in shaping conclusions
- outline the role of history in development.

4.7 Test your knowledge and understanding

1. A toy model of product-variety expansion. Consider the following production function

\[ Y = N^{1-\alpha}K^\alpha \]

where output depends on the number of available varieties and the capital stock. \( s_n \) fraction of output is invested in R&D and results in a flow of new varieties proportional to the amount invested. Furthermore, \( \delta \) fraction of existing varieties become obsolete and is not produced. Therefore the change in the number of varieties over time is \( \dot{N} = \mu s_n Y - \delta N \), where \( \mu \) is the yield of R&D investment. Capital accumulation takes the Solow form with a saving rate of \( s_k \) and depreciation rate of \( \delta \). The population is assumed to be constant. Find the steady state growth rate of output, capital and the number of varieties. How is this model different from the human capital investment studied in the chapter?

2. Plot a diagram for the capital accumulation equation in the AK model and show why growth continues forever if \( sA - (n + \delta) > 0 \).

3. Recognising the difficulties of HYV adoption, the government of India decides to show how HYVs outperform traditional varieties by planting them on a set of randomly chosen plots next to traditional varieties. Furthermore, it hires skilled farmers to find out the right amount of fertiliser and other inputs for HYVs. Do you expect this policy to be effective in encouraging farmers to take up HYVs? What are the merits of using model farms as opposed to providing a monetary subsidy for HYV farmers?

4. Explain the idea of the big push. Why might industrialisation by one sector not be viable but simultaneous industrialisation of several sectors prove to be viable?

Reminder: Feedback to activities in this chapter are available on the VLE.