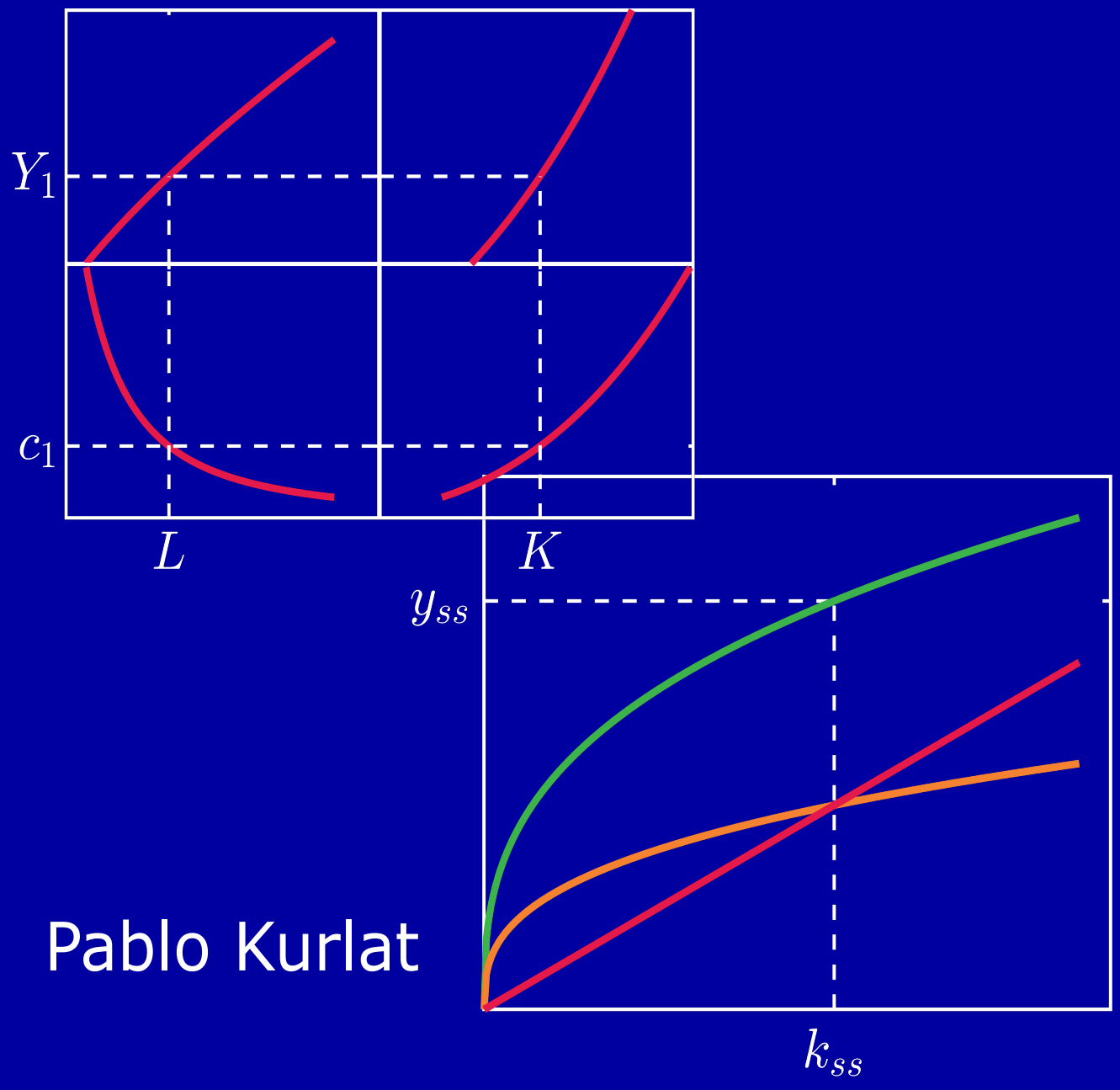
A Course in Modern Macroeconomics



Pablo Kurlat

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Modern Macroeconomics

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For Pam, Felix and Emilia

Introduction

This book started as a collection of my teaching notes for the ECON 52 course that I taught at Stanford University. The objective of that course, and of this book, is to introduce students to the ideas and way of thinking of modern macroeconomics in a unified way that is accessible with a moderate amount of maths. Modern macroeconomics emphasizes explicit microeconomic foundations and general equilibrium analysis, combined with various kinds of constraints and market imperfections. When preparing the class I thought none of the existing textbooks conveyed this in a way that I liked, so I prepared my own notes, which then grew into this book. While mostly self-contained, the book is probably most useful to students who are familiar with the basics of multivariable calculus and have taken a calculus-based microeconomics class.

The book is meant to be followed approximately in order. Later chapters contain many references to material in earlier chapters. However, not everything from the early chapters is indispensable for what comes next. Chapters 1 and 6-9 are the main core, but even within them everything that has to do with risk, search, adjustment costs, or infinite-horizon problems can be skipped without compromising what comes later.

At the end of each chapter there is a series of exercises. Some are relatively direct applications of the material in the chapter and others are more open-ended or explore topics related to but not directly covered in the chapter. Several of the exercises can serve as the basis for a lecture, a class discussion, or the analysis of a historical episode. The exercises vary in difficulty but are intended to be relatively hard overall.

The list of interesting areas of macroeconomics is vast and growing, and the book does not aim to be comprehensive. Probably the biggest omission is that it mostly deals with closed-economy issues and models, so there is little discussion of exchange rates, capital flows or international trade. Somewhat relatedly, the book is more US-centric than I would like. In many ways the US economy is not like that of a typical country, but it is very well studied, so many of the ideas are discussed in terms of US evidence. The book is also biased towards my own idiosyncratic tastes. For instance, there is more than one might expect on money supply and demand, which is a somewhat old-fashioned topic, and on how to define living standards.

I would like to thank several generations of teaching assistants and students for their input. Alina Arefeva, Juliane Begenau, Daniel Bennett, Ricardo de la O, Adem Dugalic, Guzman Gonzalez-Torres, Pavel Krivenko, Krishna Rao, Yevgeniy Teryoshin, Daniel Layton Wright and Victoria Zuo all contributed to making this book possible. I would also like to thank researchers who allowed me to include their findings in the book, in particular Daron Acemoglu, Daniel Andrei, Regis Barnichon, Robert Barro, Chad Jones, David Lagakos, William Mann, Nathalie Moyen and Valerie Ramey. I also benefited greatly from discussions with people who have taught similar courses, especially Sebastian Di Tella, Pete Klenow, Monika Piazzesi and Alp Simsek.

On my website (https://sites.google.com/view/pkurlat) you can find some complementary materials: data and codes for some of the exercises, clarifications, corrections, downloadable figures, etc. If you have comments, questions, suggestions, criticisms, corrections, or praise (especially praise!), you can reach me at pkurlat@gmail.com.

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PART I

GDP and Living Standards

This part of the book explores the meaning and measurement of living standards.

In Chapter 1 we look at one of the main variables that macroeconomists care about: the Gross Domestic Product, or GDP. We go over its definition, the accounting conventions used to measure it and some of the conceptual issues behind the accounting conventions.

In Chapter 2 we study some of the shortcomings of GDP as a measure of living standards, some alternatives that have been proposed, and how one can use economic theory as a guide to improved measurements.

CHAPTER 1

GDP

1.1 GDP Accounting

One of the basic questions economists are interested in, when analyzing a country, is how much is produced in that country in a given year. The basic measure of this is a country's gross domestic product (GDP). The idea is simple: to record the value of everything that is produced in the country in a year and add it up. GDP accounts can be constructed in three different (but equivalent) ways, based on measuring production, income, or expenditure.

Production	Income	Expenditure
Agriculture & Mining	Employee compensation	Consumption
Construction	Proprietor's income	Investment
Manufacturing	Rental income	Government
Services	Corporate profits	Net exports
Government	Interest income	
	Depreciation[1]	

In each of the three measures we can choose how much detail to go into. For instance, in the production approach we don't need to lump all services together. We can instead separate healthcare, education, entertainment, retail trade, etc., into separate accounts.

The accounting identity from the expenditure approach is sometimes written algebraically as:

$$Y = C + I + G + X - M \tag{1.1.1}$$

where Y stands for GDP, C stands for consumption, I stands for investment, G stands for public goods and services, X stands for exports and M stands for imports. We'll return to this equation many times.

The three measures of GDP are equal to one another. The logic is that whenever goods and services are produced, whatever is spent on them will also constitute someone's income. A good description of how the accounts are constructed can be found at https://www.bea.gov/resources/methodologies/measuring-the-

[1] Including depreciation as a form of income doesn't seem to make much sense, but see below.

economy. Table 1.1 shows measures of GDP for the US for 2017 computed according to each of the three approaches.

Table 1.1: *US GDP in 2017 according to the three methods. Figures in billions of dollars. Source: BEA.*

Production		Income		Expenditure	
Agriculture	169	Employee Comp.	10,421	Consumption	13,321
Mining	269	Corporate Profits	1,807	Investment	3,368
Utilities	308	Proprietor's income	1,501	Govt. spending	3,374
Construction	781	Rental income	730	Exports	2,350
Manufacturing	2,180	Depreciation	3,116	Imports	-2,929
Wholesale + Retail	2,261	Interest Income	768		
Transport	609	Taxes	1,286		
Media	1,051	Statistical discrep.	-143		
Finance + Insurance	1,466				
Real Estate	2,591				
Professional services	2,426				
Educ. + Health	1,700				
Arts + Entertainment	805				
Other services	416				
Government	2,454				
Total	**19,485**	**Total**	**19,485**	**Total**	**19,485**

In this section we will try to understand the logic of GDP accounts through a series of examples.

Example 1.1.
Amy, who is self-employed, produces lettuce in her garden and sells it to Bob for $1. Bob eats it.

Production		Income		Expenditure	
Agriculture	1	Proprietor's income	1	Consumption	1

The production approach measures the value of the lettuce that was produced, which is $1.

The income approach looks at how much income is derived from productive activities. In our example, Amy obtains $1 of income from selling the lettuce. Since Amy is self-employed, we classify her income as proprietor's income (self-employed people are sometimes called "sole proprietors").

The expenditure approach looks at what the production was used for. Here the lettuce was consumed.

Value Added

Production typically takes place in several stages. Someone's output becomes somebody else's input. We want to measure the value at the end of the production process, avoiding double counting.

Example 1.2.
Amy is the shareholder of a corporation that operates a fertilizer plant. The corporation hires Bob to work in the plant and pays him a wage of \$0.50. The corporation sells the fertilizer to Carol, a self-employed farmer, for \$0.80. Carol uses it to produce lettuce, which she sells to Daniel for \$1. Daniel eats the lettuce.

Production		Income		Expenditure	
Manufacturing	0.8	Wages	0.5	Consumption	1
Agriculture	0.2	Profits	0.3		
		Prop. income	0.2		
Total	**1.0**	**Total**	**1.0**	**Total**	**1.0**

Here it would be a mistake to add the value of the fertilizer to the value of the lettuce because the fertilizer was used up in producing the lettuce. The value added in the production of lettuce is just the difference between the value of the lettuce and the value of the fertilizer. Notice that doing things this way makes total GDP consistent across the three methods.

Forms of Investment

Investment can take different forms, with one thing in common: it involves producing something that will be used for production in future periods.

Example 1.3.

1. General Electric builds an X-ray machine, which it sells to Stanford Hospital for \$1,000. The cost of producing it is made up of workers' wages of \$600.

Production		Income		Expenditure	
Manufacturing	1,000	Wages	600	Investment	1,000
		Corporate profits	400		
Total	**1,000**	**Total**	**1,000**	**Total**	**1,000**

2. Zoe builds a house with her bare hands and sells it to Adam for \$1,000.

Production		Income		Expenditure	
Construction	1,000	Proprietor's income	1,000	Investment	1,000

3. Dunder Mifflin produces 500 tons of white paper worth \$40,000 and stores them in its warehouse while it waits for customers to buy them. The cost of producing them is made up of workers' wages of \$50,000.

Production		Income		Expenditure	
Manufacturing	40,000	Wages	50,000	Investment	40,000
		Corporate profits	-10,000		
Total	**40,000**	**Total**	**40,000**	**Total**	**40,000**

In part 1, the X-ray machine will be used to "produce" X-ray scans in the future. In part 2, the house will be used to produce shelter ("housing services") in future periods. "Equipment" (as in part 1) and "structures" (as in part 2) are the largest components of investment.

Part 3 is a little bit more subtle. The paper was produced to be sold and used, not in order to be left lying around in the warehouse. However, sometimes production and use are not synchronized. The goods that are held in order to be used later are called "inventories" and include finished goods but also inputs and half-finished products that will be part of a further productive process. Since inventories are something that will be useful in the future, an increase in inventories is also a form of investment. In the example, we make the interpretation that Dunder Mifflin has invested in having paper available for when it manages to make sales. When the paper is finally sold and inventories go back to zero we will record that as negative investment.

Example 1.4.
Warren invests $100,000 in shares of General Motors.

Production	Income	Expenditure
0	0	0

This example is a bit tricky because the word "investment" is used somewhat differently in macroeconomics than in other contexts. In the example above there is no investment in the macroeconomic sense. There is a change in ownership but no new productive assets are created.

Durables

The distinction between consumption and investment is not always so clear. Above we saw that residential construction is an investment because it will produce "housing services" in the future. By that logic, many things could be considered investments. A refrigerator produces "refrigeration services" for a long time after it's produced. Similarly for cars, electronics, clothes, etc. How does GDP accounting treat these?

Example 1.5.

1. Panasonic builds a TV (at zero cost) and sells it to Bob for $500.

Production		Income		Expenditure	
Manufacturing	500	Corporate profits	500	Consumption of Durables	500

2. Bob watches the TV he bought last year.

Production		Income		Expenditure	
Production	0	Income	0	Expenditure	0

3. A property developer builds a house (at zero cost) and sells is to Claire for $100,000.

Production		Income		Expenditure	
Construction	100,000	Corporate profits	100,000	(Residential) Investment	100,000

4. Claire lives in the house she bought last year. In the rental market, a similar house would cost $7,000 a year.

Production		Income		Expenditure	
Housing services	7,000	Imputed owner-occupier income	7,000	Consumption	7,000

Conceptually, what's going on with the TV and with the house is very similar. They are produced one year but are enjoyed for a long time thereafter. However, GDP accounting conventions treat them differently. For most durable goods, we just treat them as being consumed at the moment of purchase, though sometimes we classify consumption of durables separately from consumption of nondurables (e.g., food and entertainment) just to emphasize that they are not quite the same. For housing, since it's such a large category and it's very long-lived, we treat the initial construction as an investment and try to measure the flow of housing services even when an homeowner is buying those housing services from herself.

Foreign Countries

GDP includes everything produced within the country, whether it's eventually used by residents or non-residents. Conversely, goods produced abroad are not included in GDP even if they are consumed in the country.

Example 1.6.
A car manufacturer buys components from Japan for $10 and uses half of those components in the production of a car, which it sells to Andy for $20. There are no other production costs. It stores the rest of the components. Amy, who is self-employed, produces lettuce in her garden and sells it to Franz (a foreigner) for $2.

Production		Income		Expenditure	
Car Manufacturing	15	Corporate profits	15	Consumption	20
Agriculture	2	Proprietor's income	2	Investment	5
				Exports	2
				Imports	-10
Total	**17**	**Total**	**17**	**Total**	**17**

The Government

The government is a major producer of goods and services. Many of those services are provided directly, so there is no real price for them. In order to add them to GDP accounts, they are valued at whatever it cost to produce them.

Example 1.7.

1. Ms. Jody teaches Kindergarten in Lucille Nixon Elementary School in Palo Alto for the entire year and earns $85,000.

Production		Income		Expenditure	
Public Education	85,000	Wages	85,000	Government	85,000

2. The City of Palo Alto hires the Los Angeles Philharmonic to play a free concert in Stanford Stadium. The musicians are paid $65,000 and renting the stadium costs $20,000. Four people show up.

Production		Income		Expenditure	
Public Concert	85,000	Wages	65,000	Government	85,000
		Rental income	20,000		
Total	**85,000**	**Total**	**85,000**	**Total**	**85,000**

Notice that GDP is the same in both examples, even though in one case the publicly provided service is something people actually value a lot and in the other case it's not.

Example 1.8.
Jack collects his $20,000 pension from Social Security.

Production	Income	Expenditure
0	0	0

Here the government is "spending" $20,000 but it's not in order to produce public goods and services. In terms of GDP accounting, this is just a transfer, which has no impact on any of the accounts.

Example 1.9.
The state of California builds a high-speed train from Merced to Bakersfield. It pays workers a billion dollars to build it with their bare hands.

Production		Income		Expenditure	
Railway construction	1 billion	Wages	1 billion	Government Investment	1 billion

This is an example of public investment: something the public sector does that will be useful in the future. In the expenditure approach, do we classify it as "Government Spending" or as "Investment"? In

equation (1.1.1), it's included within G, but more detailed GDP accounts include a further breakdown of G into government investment and government consumption. The previous examples were all government consumption. This example is government investment.

Depreciation

Machines and buildings usually deteriorate over time, a phenomenon we call "depreciation." GDP is *gross* domestic product because it is measured before taking into account of depreciation.

Example 1.10.
Zak's Transport Co. owns a fleet of taxis. They are all new at the beginning of the year, worth a total of \$1,000. A taxi depreciates completely in 5 years. During the course of the year the company pays its workers \$200 in wages, has no other costs, and collects \$500 in fares.

Production		Income		Expenditure	
Transp. Services	500	Corporate Profits		Consumption	500
		Revenue	500		
		Wages	-200		
		Depreciation	-200		
		Total Profit	100		
		Wages	200		
		Depreciation	200		
Total	**500**	**Total**	**500**	**Total**	**500**

Since the taxis depreciate over 5 years, an estimate of the amount of depreciation is $\frac{1000}{5} = 200$. When the company computes its profits, it understands that its fleet of vehicles has lost value over the course of the year, so it subtracts the amount of depreciation. In order to compute GDP we want to get back to a before-depreciation measure, so we add back depreciation. This makes the income-based measure of GDP consistent with the production-based measure and the expenditure-based measure.

Depreciation plays an important role in the theory of economic growth that we'll study in Chapter 4.

Non-Market Activities

A lot of economic activity does not involve market transactions and is usually not included in GDP calculations. We already saw an exception to this: we impute the production of housing services even for people who live in their own home without conducting a market transaction. This particular exception is made so that GDP does not vary when housing shifts between tenant occupancy and owner occupancy. (Note that the imputed rent of owner-occupied housing accounted is almost 8% of US GDP.) Most of the time, however, we compute the value of an activity only if it is sold in the market.

Example 1.11.

1. Mary mows Andy's lawn for $25. Andy takes care of Mary's kids for $25.

Production		Income		Expenditure	
Gardening services	25	Self-employment	50	Consumption	50
Babysitting	25				
Total	**50**	**Total**	**50**	**Total**	**50**

2. Andy mows his own lawn. Mary takes care of her own kids.

Production		Income		Expenditure	
Production	0	Income	0	Expenditure	0

These two examples show that, even though the economic activity is basically the same in both cases, national accounts treat them very differently.

1.2 Making Comparisons

One of the things we often want to do is compare GDP, either across countries or within a country across time. To do this we have to be a bit careful with the units of measurement. When we compute GDP, we just add the value of everything produced in the country. If it's for the US, it will be in dollars. The problem with this measure is that the amount of goods and services you can get for one dollar is not the same in every country or in every time period, because the prices of goods and services are different.

For this reason we make a distinction between "nominal" and "real" GDP:

- Nominal GDP: the total value of goods and services produced, valued at whatever price they had at the time they were produced.
- Real GDP: the total value of goods and services produced, valued in units such that the values are comparable across time.

Real GDP

Example 1.12.
The country of Kemalchistan uses the dinar as its currency. GDP in the years 2017 and 2018, measured by the production method, was as follows:

2017		2018	
Manufact. (50 balls, 10 dinar each)	500	Manufact. (50 balls, 20 dinar each)	1,000
Educ. (10 teachers, 100 dinar each)	1,000	Educ. (10 teachers, 200 dinar each)	2,000
Total	**1,500**	**Total**	**3,000**

GDP, measured in dinar, doubled between 2017 and 2018 but the amount of goods and services was the same in both years. The reason GDP increased is because all prices increased. Often we are interested in a measure that tracks the changes in the total amount of stuff that is produced and doesn't rise just because prices have changed.

In the example above, it's clear that real GDP is the same in both years and we can express it as either "1,500 dinars in 2017 prices" or "3,000 dinars in 2018 prices." Either way, GDP did not grow between the two years. But the example is special in two ways:

1. The relative quantities of the different goods produced don't change between the two years.

2. All the prices change by the same amount.

When these conditions fail, the way to measure real GDP in a way that's comparable across years is less obvious.

Example 1.13.
The country of Expandia uses the dollar. GDP in the years 2017 and 2018, measured by the production method, was as follows:

2017		2018	
Agric.(10 tons of wheat, \$50 each)	500	Agric. (11 tons of wheat, \$60 each)	660
Manufact. (1 computer, \$1,000)	1,000	Manufact. (2 computers, \$600 each)	1,200
Total	**1,500**	**Total**	**1,860**

How much has the real output of the economy of Expandia grown? We know that agricultural output has expanded 10% (from 10 to 11) and manufacturing output has grown 100% (from 1 to 2). How should we compute the total growth? There is more than one way to do it.

Alternative 1: base year prices

One approach is to choose a "base year" and measure the value of all goods at the prices they used to have in the base year. In the example above, if we chose 2017 as the base year, we'd have the following figures for real GDP for the year 2018:

2018, at 2017 prices	
Agriculture (11 tons of wheat, \$50 each)	550
Manufacturing (2 computers, \$1,000 each)	2,000
Total	**2,550**

We'd say that "real GDP in 2018 was \$2,550 at 2017 prices." If we want to compute the rate of growth of GDP, we would have

$$\text{growth} = \frac{2,550}{1,500} - 1 = 70\%$$

The general formula for computing real GDP this way is:

$$Y_t = \sum_i p_{i0} q_{it} \tag{1.2.1}$$

where:

- Y_t is real GDP in the year t.
- p_{i0} is the price of a certain good i in the base year (which we call year 0)
- q_{it} is the quantity of good i produced in year t

Alternative 2: final year prices

This is exactly the same, except that the base year is the last one we look at rather than the first one. In the example above, this means recomputing GDP in the year 2017 at the prices of 2018:

2017, at 2018 prices	
Agriculture (10 tons of wheat at \$60 each)	600
Manufacturing (1 computers at \$600 each)	600
Total	**1,200**

The general formula (1.2.1) still applies, it's just that we have changed what year we call year 0. With 2018 as the base year, we'd say that "real GDP in 2017 was \$1,200 at 2018 prices," and the rate of growth of GDP is

$$\text{growth} = \frac{1,860}{1,200} - 1 = 55\%$$

Notice that the two formulas give us a different answer to the question "how much did the economy grow overall between 2017 and 2018?" This is often the case. Using an earlier year as the base year gives a higher rate of growth if the sectors that are expanding most (in the example, manufacturing) are those whose relative price is falling, and vice versa.

Alternative 3: chained prices

Neither of the above alternatives is obviously preferred, so another option is to do something in between. The idea is to:

1. Start from some base year 0
2. Compute real growth between year 0 and year 1 in two ways: at year 0 and year 1 prices
3. Average the two growth rates in some way

4. Compute real GDP in year 1 by adding the "average" growth rate to year-0 GDP
5. Repeat for years 2, 3, 4, etc.

The term "chained" comes from the fact that the estimate of real GDP in any given year will be the result of a chain of calculations linking that year to the base year. In general formulas:

$$g_t^I = \frac{\sum_i p_{it-1} q_{it}}{\sum_i p_{it-1} q_{it-1}} - 1 \qquad \text{growth based on initial year prices}$$

$$g_t^F = \frac{\sum_i p_{it} q_{it}}{\sum_i p_{it} q_{it-1}} - 1 \qquad \text{growth based on final year prices}$$

$$g_t = \left(1 + g_t^I\right)^{0.5} \left(1 + g_t^F\right)^{0.5} - 1 \qquad \text{average growth; this is a geometric average}$$

$$Y_t = Y_{t-1}(1 + g_t) \qquad \text{real GDP one year ahead}$$

This will result in a measure of GDP in "chained" prices of the base year.

Comparisons Across Countries and PPP

Suppose we want to compare GDP across countries.

Example 1.14.
In 2018, GDP in the US and Mexico were as follows:

	United States	Mexico
GDP	20.5 trillion dollars	23.5 trillion pesos
Population	327 million	127 million
GDP per capita	62,700 dollars per person	185,000 pesos per person

Suppose we wanted to ask: did US residents produce more output per person than Mexican residents in 2018? The figures above don't quite give us the answer because they are in different units: GDP in the US is measured in dollars while GDP in Mexico is measured in pesos. How do we convert everything to the same units?

One approach is to look up the exchange rate between the Mexican peso and the US dollar. On average during 2018, you could trade one dollar for about 19 Mexican pesos in foreign exchange markets; equivalently, you could trade one Mexican peso for 0.053 US dollars. Using this exchange rate, we can restate Mexican GDP in US dollars as:

$$\begin{array}{c}\text{GDP in Foreign Country} \\ \text{(in dollars, at market} \\ \text{exchange rates)}\end{array} = \begin{array}{c}\text{market exchange rate} \\ \text{(dollars per unit of foreign} \\ \text{currency)}\end{array} \times \begin{array}{c}\text{GDP in Foreign Country} \\ \text{(in foreign currency)}\end{array}$$

Using this approach, we'd conclude that Mexico's GDP in 2014 was 1.24 trillion dollars, or 9,700 dollars per person.

One drawback of this approach is that it doesn't take into account that, even after converting currencies, prices are different in different countries. In other words, if you take one dollar, use it to buy Mexican pesos, go to Mexico and go shopping, the amount of stuff you'd be able to afford need not be equal to the amount of stuff you'd be able to afford if you had just stayed in the US. When we see that a country has low GDP when converted at market exchange rates, it could mean that their output is low or that prices, converted to dollars, are low. How do we distinguish between these possibilities?

One way to do it is to change the way we assign dollar values to goods produced in foreign countries. Instead of measuring their value in local currency and converting to dollars at the market exchange rate, we look up an equivalent good in the US, see its US price and value the foreign goods at their US price. In formulas:

$$\begin{array}{c}\text{GDP in Foreign Country} \\ \text{(in dollars, at PPP)}\end{array} = \sum_{i=1}^{N} p_i^{US} \times q_i$$

where N is the number of different goods that we are adding up, p_i^{US} is the market price of good i in the US and q_i is the quantity of good i produced in the foreign country. This is known as the "Purchasing Power Parity" or PPP approach because it aims to adjust for the fact that the purchasing power of a dollar is different in different countries. In practice, PPP calculations are harder to do than converting GDP at market exchange rates: one needs to figure out what US good is the correct equivalent to each foreign good, which is not so easy because the goods available in each country are different. For Mexico, most estimates of PPP put its per capita GDP at around 18,000 dollars, almost twice as high as using market exchange rates, reflecting the fact that goods tend to be cheaper than in the US.

A byproduct of computing GDP at PPP is to define a "PPP exchange rate." This is an answer to the following question: "what would market exchange rates need to be for GDP at market exchange rates and GDP at PPP to coincide?" In formulas:

$$\begin{array}{c}\text{GDP in Foreign Country} \\ \text{(in dollars, at PPP)}\end{array} \equiv \begin{array}{c}\text{PPP exchange rate} \\ \text{(dollars per unit of foreign currency)}\end{array} \times \begin{array}{c}\text{GDP in Foreign Country} \\ \text{(in foreign currency)}\end{array}$$

or

$$\text{PPP exchange rate} \equiv \frac{\text{GDP in dollars at PPP}}{\text{GDP in foreign currency}}$$

If PPP exchange rates and market exchange coincide it means that on average goods cost as much in the foreign country as in the US. For many years, *The Economist* magazine has computed a simple indicator of PPP exchange rates: instead of looking for the exchange rate that would make goods overall cost the same in the US and in foreign countries, they focus on a single good: the Big Mac. This has the advantage of being highly standardized across countries.[2] The Big Mac index is simply

$$\text{Big Mac exchange rate} = \frac{\text{Big Mac price in US (dollars)}}{\text{Big Mac price in Foreign Country (foreign currency)}}$$

[2]Though not fully: the price of Big Macs includes the location, cleanliness, etc. of the McDonald's restaurant and these vary across countries.

Exercises

1.1 **Accounting**

How does GDP accounting record the following events? For each of them, describe how they would be computed in GDP accounts using the income method, the production method and the expenditure method.

(a) A car manufacturer buys components from Japan for $1 to be used in production later on and stores them at its warehouse.

(b) A car manufacturer buys components from Japan for $1 and uses half of those components in the production of a car, that it sells to Andy for $2. It stores the rest of the components.

(c) An army battalion is deployed to the border to repel a threatened Canadian invasion. The soldiers earn wages of $10,000 and use ammunition that the government buys for $5,000. The ammunition is produced using $2,000 of imported steel and 100 hours of work, for which the workers were paid $1,000.

(d) Walmart sells 1000 bottles of Coca-Cola for $1,500. It had previously paid $1,200 for them.

(e) A shipyard builds a cruise ship. It pays wages of $200,000, interest on loans (from US residents) of $100,000 and $300,000 for imported raw materials. The ship is sold for $1,000,000 to a cruise company. In the same year, the cruise company has revenue for $50,000 from operating cruises, pays wages of $20,000 to its workers and has no other expenses. Half the cruise revenue comes from tourists who reside in the United States and half comes from tourists who reside abroad.

(f) The government collects $1000 in income taxes from Roger.

(g) Roger earns $4000 for working as a babysitter and pays $1000 in income taxes.

1.2 **Comparisons Across Time and Across Countries**

Suppose these are the prices (in US dollars) and quantities of goods A and B produced in the US in 2017 and 2018:

	p_A	q_A	p_B	q_B
2017	4	5	3	3
2018	1	10	4	2

(a) What was nominal GDP in 2017?

(b) What was nominal GDP in 2018?

(c) What was real GDP in 2018 at 2017 prices (computed using fixed 2017 prices)? Using this measure, how much did GDP grow between 2017 and 2018?

(d) What was real GDP in 2017 at 2018 prices (computed using fixed 2018 prices)? Using this measure, how much did GDP grow between 2017 and 2018? What explains the difference between the two measures?

(e) How much did GDP grow between 2017 and 2018 using the chain-weighted method?

In Thailand, prices (in Thai baht) and quantities in 2017 were:

	p_A	q_A	p_B	q_B
2017	30	1	10	2

(f) What was nominal GDP in Thailand in 2017, expressed in baht.

(g) Suppose the exchange rate in 2017 was 25 baht per dollar. What was GDP in Thailand in 2017, expressed in US dollars at market exchange rates?

(h) What was GDP in Thailand in 2017 at PPP? What accounts for the difference between the market exchange rate measure and the PPP measure?

(i) What was the PPP exchange rate between the baht and the dollar?

1.3 Chained GDP

The country of Fructus produces Apples, Bananas and Cherries. Its production statistics are given below:

	Apples		Bananas		Cherries	
	quantity	price	quantity	price	quantity	price
2000	100	40	50	30	200	20
2001	103	39	47	35	206	20
2002	107	39	47	38	213	19
2003	109	39	45	38	215	18
2004	112	40	46	41	224	18
2005	112	39	46	39	227	17
2006	114	40	47	36	237	16
2007	115	40	46	42	249	16
2008	119	40	43	44	255	16
2009	118	42	40	46	262	15
2010	116	43	41	44	268	15
2011	118	42	40	50	280	15
2012	117	42	41	50	289	15
2013	119	43	40	53	290	14
2014	120	44	40	56	297	13
2015	125	45	41	59	308	13
2016	128	45	38	66	320	13
2017	129	46	38	61	330	13
2018	131	47	37	64	344	13
2019	136	47	37	61	353	13
2020	143	47	34	61	361	12

(you can download them as an Excel spreadsheet from the book website)

(a) Compute a real GDP series at year-2000 prices using base year prices and using the chained method.

(b) Plot both series and comment on any differences.

(c) What was the average growth rate according to each method?

1.4 **Drugs and Prostitution**

Read the following article: http://www.economist.com/news/finance-and-economics/21603073-italys-inclusion-illicit-activities-its-figures-excites-much-interest-sex. What do you think? Should drug production and prostitution be included in the calculation of GDP?

1.5 **Changes in Relative Prices**

We saw that using an earlier year as the base year to compute real GDP results in a high rate of growth if the sectors that are expanding most are those whose relative price is falling. Can you think of reasons why that should be the case (i.e., economic forces that make the same types of goods become relatively cheaper and be produced in higher quantities)? Can you think of reasons why the opposite should be the case (i.e., economic forces that make the same types of goods become relatively *expensive* and be produced in higher quantities)?