Chapter 6

National Income and Output

Chapter Introduction

In Chapter 5 we briefly looked at the topics that are covered in macroeconomics and in the rest of the book. In this chapter we start with an in-depth look at the concept of aggregate output (income). We learn how to measure aggregate output (income). It bears repeating that in economics, the terms income and output represent the same concept. These terms are interchangeable. Then we learn about two measures of the overall price level. These are the GDP deflator and the consumer price index.

The Circular Flow Diagram Revisited

We start by revisiting the Circular Flow diagram from Chapter 2.

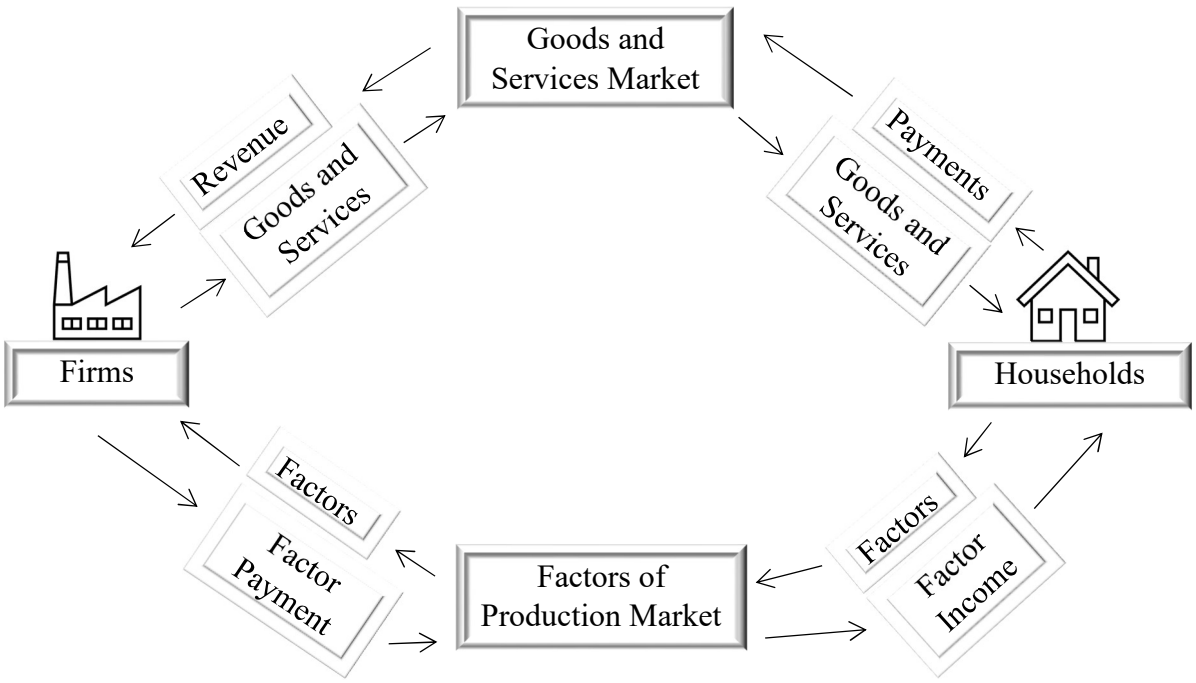

Figure 2.1: The Circular Flow Diagram

Source: M. Ashraf

Figure 2.1: Households demand goods and services and firms supply goods and services in the good and services market. The direction of the arrows shows the flow of goods and services. In return, households make payments which become the revenue of firms. Note the direction of the arrows. Households are the main consuming units and firms are the main producing units. To produce goods and services, firms demand and households supply factors of production—land, labor, and capital—in the factors of production market. Firms make payments for factors of production which become incomes of households who supply these factors of production. Note the direction of arrows indicating the flow of factors and payments.

Figure 2.1 shows that households demand goods and services and firms supply goods and services in the good and services market. The direction of the arrows shows the flow of goods and services. In return, households make payments which become the revenue of firms. Households are the main consuming units and firms are the main producing units. To produce goods and services, firms demand and households supply factors of production—land, labor, and capital—in the factors of production market. Firms make payments for factors of production which become incomes of households who supply these factors of production. Note the direction of arrows indicating the flow of factors and payments.

Note, again, that one economic agent's income is some other economic agent's expenditure, and vice versa. This means that we can either add up all the income or add up all the expenditure, end-result will be the same, except for statistical discrepancy. Keep this fact in mind while we study the various macroeconomic concepts.

National Income and Output

The Bureau of Economic Analysis (BEA) maintains detailed accounts of the nation's output/income. These data are reported in the National Income and Product Accounts (NIPAs). One of the most important variables that the BEA reports is the Gross Domestic Product (GDP).

Note that all the definitions and estimation procedures discussed here are based on the BEA's definitions and estimation procedures. You may access the access the *NIPA Handbook* by going to https://www.bea.gov/resources/methodologies/nipa-handbook.[1]

Gross Domestic Product (GDP)

GDP is the market value of all the final goods and services produced in an economy during a given period. These data are reported on quarterly and annual basis.

Note four points in this definition.

- Market value. When calculating GDP, we use the market value of goods and services produced. Market value is equal to the price of the good or service times the quantity of the good or service. Why do we use market value? Why do we not just add up all the goods and services produced in the economy? Here is why we use the market value.

[1] *NIPA Handbook*. https://www.bea.gov/resources/methodologies/nipa-handbook (Accessed: July 19, 2021)

Suppose that a hypothetical economy is producing only two goods—cars and coffee mugs. Furthermore, assume that both cars and coffee mugs are of only one type. That is, there aren't many varieties of these products. Suppose that during Year 1 this economy produced 10 cars and 10 coffee mugs, and it produced five cars and 15 coffee mugs in Year 2. If we were just to add the units of these two goods, the total output will be 20 unit during Year 1 and Year 2.

It is not hard to see that a lot more resources go into the production of a car as compared with the production of a coffee mug. This is why the price of a regular car is many times higher than the price of a regular coffee mug. Just adding these two goods one may get the wrong impression that the economy's output stayed the same from Year 1 to Year 2—20 units. In fact, the economy's output declined from Year 1 to Year 2.

Prices of various goods and services serve as weights. That is, price serve as the importance assigned to a good or service. Prices of goods and services also allow us to convert different goods and services into one single unit, i.e., the unit of currency, so that we can add up the various units.

- Final good and services. Goods and services may be divided into intermediate goods and services and final goods and services.

  Final goods and services are those goods and services that are used by the end user.

  Intermediate goods and services are those goods and services that are used to produce the final goods and services. In calculating GDP, we only add the market value of final goods and services. The reason is that the value of intermediate goods and services are already part of the value of the final goods and services.

  Take the example of new car. Suppose that the price of a new car is $25,000. Among numerous other parts that make a car, it has tires worth $1,000. The value of these tires is already included in the price of the car. If we were to the price of the car, $25,000, and the price of four tires, $1,000, the total will be $26,000. Note, however, that we are counting the value of tires twice. To avoid double counting, we only use the market value of the final goods and services.

  Suppose now that you purchased a set of new tires for $1,000 to replace the tires on your car. The value these tires, $1,000, will be added to the calculations of GDP. The reason is that you, as an end user, are buying these tires to replace old tires on your car.

- Within the geographic boundaries of an economy. While calculating GDP we are concerned about the market value of final goods and services produced within the geographic boundaries of the economy. We do not care who produces those goods and

services. So long as those goods and services are produced within the geographic boundaries of the economy, the market value of those goods and services is added to the calculation of GDP.

- A given period. We want to know the output produced during a given period. The BEA provides annual as well as quarterly estimates.

Gross National Product (GNP)

We noted above that so long as the output is produced within the geographic boundaries of the economy, the market value is added to the calculation of GDP of that economy. Another measure of the overall output is called Gross National Product (GNP) which looks at who produces the output, regardless of where it is produced.

GNP is the market value of all the final goods and services produced by the factors of production owned by the residents of an economy during a given period regardless of where the output is produced.

According to the BEA,[2]

> In the NIPAs, a distinction is made between "domestic" measures and "national" measures. Domestic measures cover activities that take place within the geographic borders of the United States, while national measures cover activities that are attributable to U.S. residents. Thus, domestic measures are concerned with where an activity takes place, while national measures are concerned with to whom the activity is attributed. For example, GDP measures the market value of the goods, services, and structures produced within the nation's economy in a given period, while gross national product (GNP) measures the market value of the goods, services, and structures produced by labor and property supplied by U.S. residents. GNP is equal to GDP plus income receipts from the rest of the world less income payments to the rest of the world, and it is conceptually equivalent to gross national income (though it is estimated using different source data). Thus, for an assembly plant that is owned by a Japanese auto company and located in the United States, all of its output is included in GDP, but only the portion of the value that reflects U.S. residents' labor and property is included

[2] Distinction between GDP and GNP. *NIPA Handbook*, page 2-6. https://www.bea.gov/resources/methodologies/nipa-handbook/pdf/chapter-02.pdf (Accessed: July 20, 2021)

> in GNP. And, for an assembly plant that is owned by a U.S. auto company and located in Great Britain, none of its output is included in GDP, but the portion of the value that reflects U.S. residents' labor or property is included in GNP.

An example will help. Suppose that Ford Motor Company has a plant in Japan. Assume also that all the workers are US residents, and all the machines and the buildings are owned by the US residents. Suppose that during a given year, this plat produced cars worth $10 million. These $10 million will be added to the Japanese GDP and the US GNP.

Analogously, the market value of the output of a Japanese plant in the US will be added to the GDP of the US and the GNP of Japan.

In the case of the US, who is considered a US resident? We, again, turn to the BEA for the answer. According to the BEA,[3]

> "U.S. residents" includes individuals, governments, business enterprises, trusts, associations, nonprofit institutions, and similar organizations that have the center of their economic interest in the United States and that reside or expect to reside in the United States for 1 year or more. (For example, business enterprises residing in the United States include U.S. affiliates of foreign companies.) In addition, U.S. residents include all U.S. citizens who reside outside the United States for less than 1 year and U.S. citizens residing abroad for 1 year or more who meet one of the following criteria: owners or employees of U.S. business enterprises who reside abroad to further the enterprises' business and who intend to return within a reasonable period; U.S. government civilian and military employees and members of their immediate families; and students who attend foreign educational institutions.

Below we will focus on GDP.

The BEA uses three ways to measure GDP. According to the BEA, one may measure GDP[4]

> [A]s the sum of goods and services sold to final users, as the sum of income payments and other costs incurred

[3] Definition of US residents. *NIPA Handbook*, page 2-6, footnote 17. https://www.bea.gov/resources/methodologies/nipa-handbook/pdf/chapter-02.pdf (Accessed: July 20, 2021)

[4] Methods to measure GDP. *NIPA Handbook*, page 2-7. https://www.bea.gov/resources/methodologies/nipa-handbook/pdf/chapter-02.pdf (Accessed: July 20, 2021)

> in the production of goods and services, and as the sum of the value added at each stage of production …. Although these three ways of measuring GDP are conceptually the same, their calculation may not result in identical estimates of GDP because of differences in data sources, timing, and estimation techniques.

Here, we will use the first method to calculate GDP. That is, we will add up all the expenditure made by the final users of goods and services. This is called the "Expenditure Approach" to measuring GDP. The BEA sums up all expenditures into the following five categories (italics original).[5]

- *Personal consumption expenditures*, which measures the value of the goods and services purchased by, or on the behalf of, persons—that is, households, nonprofit institutions that primarily serve households, private noninsured welfare funds, and private trust funds.
- *Gross private fixed investment*, which measures additions and replacements to the stock of private fixed assets without deduction of depreciation. Nonresidential fixed investment measures investment by businesses and nonprofit institutions in nonresidential structures, equipment, and intellectual property products. Residential fixed investment measures investment by businesses and households in residential structures and equipment, primarily new construction of single-family and multifamily units.
- *Change in private inventories*, which measures the value of the change in the physical volume of inventories owned by private business over a specified period, valued in the average prices of that period.
- *Net exports of goods and services*, which is calculated as exports less imports. Exports consist of goods and services that are sold, given away, or otherwise transferred by U.S. residents to foreign residents. Imports consist of goods and services that are sold, given away, or otherwise transferred by foreign residents to U.S. residents.
- *Government consumption expenditures and gross investment*, which comprises two components. Current

[5] Expenditure categories. *NIPA Handbook*, page 2-8. https://www.bea.gov/resources/methodologies/nipa-handbook/pdf/chapter-02.pdf (Accessed: July 20, 2021)

> consumption expenditures consists of the spending by general government in order to produce and provide goods and services to the public. Gross investment consists of spending by both general government and government enterprises for fixed assets (structures, equipment, and intellectual property products) that benefit the public or that assist government agencies in their productive activities.

In Table 6.1, I show expenditure data for 2020. These data are in billions of US dollars.[6] Note that in reporting expenditure data, the BEA using four main categories of expenditures—"Personal consumption expenditure," "Gross private domestic investment," "Net exports of goods and services," and "Government consumption expenditure and gross investment." The value of "Change in private inventories" is a sub-category of Gross private domestic investment. Note also, that in Chapter 1, we defined "investment" as the addition to the existing stock of capital plus changes in inventory. If you compare the definition of investment in this chapter and the one provided in Chapter 1, you will notice that the definition provided in this chapter is a more detailed one.

[6] GDP data. https://apps.bea.gov/iTable/?reqid=19&step=2&isuri=1&categories=survey#eyJhcHBpZCI6MTksInN0ZXBzIjpbMSwyLDMsM10sImRhdGEiOltbImNhdGVnb3JpZXMiLCJTdXJ2ZXkiXSxbIk5JUEFfVGFibGVfTGlzdCIsIjUiXSxbIkZpcnN0X1llYXIiLCIyMDIwIl0sWyJMYXN0X1llYXIiLCIyMDIwIl0sWyJTY2FsZSIsIi05Il0sWyJTZXJpZXMiLCJBIl1dfQ== (Accessed: December 11, 2022)

Table 6.1: US GDP by Expenditure Category During 2020 (Billions of US Dollars)

Line	Variable	Value
1	**Gross domestic product**	**21060.5**
2	**Personal consumption expenditures**	**14116.2**
3	Goods	4670.1
4	Durable goods	1646.8
5	Nondurable goods	3023.3
6	Services	9446
7	**Gross private domestic investment**	**3642.9**
8	Fixed investment	3698.7
9	Nonresidential	2797.9
10	Structures	614.4
11	Equipment	1077.8
12	Intellectual property products	1105.7
13	Residential	900.8
14	Change in private inventories	-55.8
15	**Net exports of goods and services**	**-627.5**
16	Exports	2148.6
17	Goods	1420
18	Services	728.6
19	Imports	2776.1
20	Goods	2304.5
21	Services	471.6
22	**Government consumption expenditures and gross investment**	**3928.9**
23	Federal	1520.6
24	National defense	882.4
25	Nondefense	638.1
26	State and local	2408.3

Source: M. Ashraf. Data Source: NIPA Table 1.1.5 (Billions of US Dollars, November 30, 2022, revision.) Bureau of Economic Analysis (www.bea.gov). Accessed: December 11, 2022.

In this table the sum of lines 2, 7, 15, 22 is equal to line 1. Note the indentations. See whether the figures add up.

Refer to the definition of net exports of goods and services (and lines 15 through 21 in Table 6.1). Why do we deduct imports from exports? The reason is that we are trying to figure out how much output is produced in the domestic economy. Imports, by definition, are not produced in the domestic economy. When we added all the expenditure, however, we added the expenditure made on imported goods and services as well. To get an accurate account of how much output is produced in the economy we must deduct the amount spend on imported goods and services.

We can represent GDP calculations, using expenditure approach, by a simple equation.

$$GDP = C + I + G + NX \tag{6.1}$$

In Equation (6.1), personal consumption expenditures are represented by (C), gross private domestic investment is represented by (I), government consumption expenditure and gross investment is represented by (G), and net exports of goods and services are represented by (NX).

Per Capita GDP

Per capita GDP is obtained by dividing GDP by the country's population. That is,

$$\text{Per Capita GDP} = \frac{GDP}{Population}$$

Here is an example of per capita GDP. As reported in Table 6.1, according to the Bureau of Economic Analysis, the GDP of the US was $21,060,474 million. According to the US Census Bureau, the US population in 2020 was 331.5 million—331,449,281 to be more precise.[7] Using these figures, we get per capita GDP for the US during 2020 as,

$$\text{Per Capita GDP during 2020} = \frac{GDP}{Population} = \frac{\$21{,}060{,}474}{331.5} \approx \$63{,}530.8$$

(Note that in Table 6.1, the data are in billions of US dollars. That is, $21,060.5 billion. I encourage you to confirm it by going to the BEA's Website and changing the figures from billions to millions.)

Calculating GDP

Before we learn how to calculate GDP, we need to distinguish between Nominal GDP and Real GDP.

We know that GDP is the market value of all the final goods and services produced in an economy during a given period. And market value is just the price of a good or service times the quantity of that good or service. It is likely that from one year to the next, not only the quantities produced of goods and services has changed, but also the prices of goods and services. How does one separate the effect of changes in prices and the effects of changes in quantities? This is where the distinction between nominal GDP and real GDP comes in handy.

Nominal GDP versus Real GDP

Nominal GDP is calculated using current prices. That is, the prices of the year for which the GDP is calculated.

Real GDP, on the other hand, takes the impact of changes in prices out of the calculation. One way to think about it is that real GDP is calculated in terms of goods and services.

An example of a simply hypothetical economy will help clarify.

Assume that in this hypothetical economy there are only two goods that are being produced—Good A and Good B. Furthermore, we are looking at the GDP of only two years—Year 1 and Year 2.

[7] The US Census Bureau. www.census.gov (Accessed: July 13, 2023)

Table 6.2 shows data for this economy.

Table 6.2: GDP of a Hypothetical Economy

[1]	[2]	[3]	[4]	[5]
	$P_1 \times Q_1$	$P_2 \times Q_2$	$P_1 \times Q_2$	$P_2 \times Q_1$
Good A	\$1.00×5 = \$5.00	\$2.00×6 = \$12.00	\$1.00×6 = \$6.00	\$2.00×5 = \$10.00
Good B	\$2.00×11 = \$22.00	\$1.50×11 = \$16.50	\$2.00×11 = \$22.00	\$1.50×11 = \$16.50
Total	\$27.00	\$28.50	\$28.00	\$26.50

Source: M. Ashraf.

Table 6.2 has five columns. Column [1] lists the goods produced in this hypothetical economy, Columns [2]-[5] list the prices and quantities of the two goods produced. In this table, "*P*" is the price of the good, and "*Q*" is the quantity of the good produced. The subscripts—1 and 2—represent the year.

Start with Column [2]. In Year 1, this economy produced 5 units of Good A and the price was \$1.00 per unit. The market value of Good A in Year 1 was \$5.00. In Year 1, the economy produced 11 units of Good B and the price was \$2.00 per unit. The market value of Good B was \$22.00. Analogously, Column [3] represents the prices and quantities of the two goods in Year 2, and the market values of the two goods in Year 2.

The last row of Table 6.2 presents the total market value of the two goods produced in the economy during Year1 and Year 2. The total market value of both goods in Year 1 was \$27.00, and the total market value was during Year 2 was \$28.50. Recall that GDP is the market value of all the final goods and services produced in an economy during a given period. Since this economy is only producing two goods—Good A and Good B—Columns [2] and [3] of this table, present the GDP of this economy during Year 1 and Year 2, respectively. When GDP is calculated using current year's prices, it is called nominal GDP. When we compare the values of Columns [3] and [5], we notice that GDP increased from Year 1 (\$27.00) to Year 2 (\$28.50) by \$1.50. That is, nominal GDP increased from Year 1 to Year 2 by \$1.50. In percentage terms, nominal GDP increased by (approximately) 5.56% $\left(= \left(\frac{28.50-2\ .00}{27.00}\right) \times 100 \approx 5.56\%\right)$.

There is one issue here. This increase is composed of an increase in the price of Good A (from P_1 = \$1.00 to P_2 = \$2.00), an increase in the number of units produced of Good A (from Q_1 = 5 to Q_2 = 6), and a decline in the price of Good B (from P_1 = \$2.00 to P_2 = \$1.00). The number of units of Good B produced are unchanged.

One solution is to hold the prices of both goods, Good A and Good B, constant and let the quantities change. That is, evaluate both goods, Good A and Good B, in a particular year's prices. The year whose prices we pick to evaluate both years' goods is called Base Year. Let us start with evaluating both years' goods in Year 1's prices. That is, let us pick Year 1 as the Base Year.

Note that we have already evaluated goods of Year 1 in Year 1's prices in Column [2]. It is \$27.00. We now evaluate Year 2's goods using Year 1's prices. The calculations are presented in Column [4]. The total market value of Year 2's goods using Year 1's prices is \$28.00. Now

compare the total in Column [2] with the total in Column [4]. The value increased by $1.00—from $27.00 to $28.00. This increase only represents the change in quantity, and not prices. Why? This is because we have evaluated both years' quantities in the base year's prices, in this case, Year 1. Prices for both Good A and Good B are the same in both years; the only change is the quantities produced. This means that the resulting change in the total represent only the change in quantities. This helps us separate the change in prices from the change in quantities.

When GDP is calculated using base year's prices, it is called real GDP. The real GDP in Year 1 is $27.00 and in Year 2 is $28.00. Note that once we picked Year 1 as the base year, the total in Column [2], $27.00, also becomes real GDP for Year 1. The percentage change in real GDP from Year 1 to Year 2 is (approximately) 3.7% $\left(= \left(\frac{28.00 - .00}{27.00}\right) \times 100 \approx 3.7\%\right)$.

This procedure for calculating real GDP is called a fixed-weight procedure. By "weight" we mean the importance assigned to a variable or a group of variables. In this case prices of goods and services serve as weights. Since we evaluated the quantities of both Good A and Good B using Year 1's prices, we kept the weights fixed.

What happens when we pick Year 2 as the base year? That is, evaluating both years' quantities in Year 2's prices. We have already performed these calculations for Year 2's quantities in Column [3]—$P_2 \times Q_2$. The total is $28.50. Note that just as the total in Column [2] became real GDP of Year 1 once we picked Year 1 as the base year, the total is Column [3] becomes real GDP of Year 2 once we picked Year 2 as the base year. That is, the real GDP of Year 2 using Year 2 as base year is $28.50. In Column [5] we present calculations for Year 1 using Year 2 as the base year. That is, we use prices of Year 2 and quantities of Year 1—$P_2 \times Q_1$. The total is $26.50. This is the real GDP of Year 1 using Year 2 as the base year. Using Year 2 as base year, the percentage change in real GDP from Year 1 to Year 2 is (approximately) 7.55% $\left(= \left(\frac{28.50 - 26.50}{26.50}\right) \times 100 \approx 7.55\%\right)$.

This raises yet another concern; just by changing the base year, the percentage change in real GDP from Year 1 to Year 2 more than doubles—3.7% vs. 7.55%.

Substitution Bias and Fixed-Weight Procedures

A well-known issue with fixed-weight procedures is the substitution bias. When the relative price of a good or service declines, all else constant, consumers buy more of the product. If the price of the said good or service, however, is held fixed in the base year, as is the case with fixed-weight procedures, it will assign a larger weight.

In the example provided in Table 6.2, the price of Good A increased from Year 1 to Year 2, but the price of Good B declined from Year 1 to Year 1. The quantity of Good A increased from Year 1 to Year 2, but the quantity of Good B stayed the same from Year 1 to Year 2. This mix of changes led to the changes in real GDP, in percentage terms, from Year 1 to Year 2 when we change the base year—3.7% vs. 7.55%.

Chain-Weighted Procedure

To deal with substitution bias, in 1996, the Bureau of Economic Analysis of the U.S. Department of Commerce started using a new procedure to calculate real GDP. It is called Chain Weighted Procedure. This procedure updates the prices of goods and services continuously. In this procedure one sets the nominal GDP equal to real GDP in some base year, and "chains" it forward and backward. The estimates do not depend upon the choice of the base year. Here is the formula that is used to calculate the chain weighted real GDP.

$$Q_t = Q_{t-1}\sqrt{\frac{\sum_{i=1}^{n} P_t^i Q_t^i}{\sum_{i=1}^{n} P_t^i Q_{t-1}^i} \times \frac{\sum_{i=1}^{n} P_{t-1}^i Q_t^i}{\sum_{i=1}^{n} P_{t-1}^i Q_{t-1}^i}} \tag{6.2}$$

In Equation (5.2) is called the "ideal" chain index.[8] In this equation, Q_t is the real GDP at time t, $Q_{t\text{-}1}$, is the real GDP of the previous year, P_t^i and Q_t^i are the price and quantity of good or service i at time t, and t-1 is the previous year's price and quantity, respectively. The first term, $\frac{\sum_{i=1}^{n} P_t^i Q_t^i}{\sum_{i=1}^{n} P_t^i Q_{t-1}^i}$, under the square root is called the Paasche index, and the second term, $\frac{\sum_{i=1}^{n} P_{t-1}^i Q_t^i}{\sum_{i=1}^{n} P_{t-1}^i Q_{t-1}^i}$, under the square root is called the Laspeyres index. Note that in Equation 6.2, we take the geometric average of the Paasche index and the Laspeyres index.

The chain weighted procedure of calculating real GDP comes with its own caution; it is "non-additive." The details of this caution are beyond the scope of a principles-level textbook. Curious reader, however, is encouraged to refer to Whelan (2000) for details.

Index

An index is a procedure in which we set the value of a variable, or a group of variables, equal to some other value, usually 1 or 100. The year whose value is set equal to a particular value is called the Index Year. We can create an index for any variable. You may want to create an index for your GPA. Creating an index makes it easier to compare values.

GDP Quantity Index

Let us take an example. Suppose that we want to crate a quantity index for GDP for Year X, where X stands for the year whose index we want to create. We use the following formula.

$$GDP\ Quantity\ Index\ for\ Year\ X = \left(\frac{Market\ Value\ of\ Final\ Goods\ and\ Services\ in\ Year\ X}{Market\ Value\ of\ Final\ Goods\ and\ Services\ in\ Index\ Year}\right) \times 100 \tag{6.3}$$

Let's go through the details of this calculation. In calculating the GDP quantity index, we divide the market value of all the final goods and services (recall the definition of GDP) of a year by the market value of all the final goods and services of the index year. If we multiply this resulting value by 100, the index value will be set equal to 100. If we did not multiply it by 100, then the value would have been set equal to 1. Note that we can set this resulting value by any number we

[8] (Whelan, 2000)

want, such as, 20, or 215, or whatever you prefer. Setting it equal to either 1 or 100 makes it easier to compare values across time.

Suppose we want to create an index for real GDP using the values from Table 6.2. For this example, we will use the real GDP calculated using the fixed-weight procedure. Assume, now, that our base year is Year 1, and our index year is also Year 1. That is, we evaluate both goods, Good A and Good B, in our example in Year 1's prices, and we set the value of Year 1's real GDP equal to 100. We use Equation (6.3).

$$Real\ GDP\ Quantity\ Index\ for\ Year\ 1 = \left(\frac{Market\ Value\ of\ Final\ Goods\ and\ Services\ in\ Year\ 1}{Market\ Value\ of\ Final\ Goods\ and\ Services\ in\ Index\ Year}\right) \times 100 = \left(\frac{\$27.00}{\$27.00}\right) \times 100 = 100$$

$$Real\ GDP\ Quantity\ Index\ for\ Year\ 2 = \left(\frac{Market\ Value\ of\ Final\ Goods\ and\ Services\ in\ Year\ 2}{Market\ Value\ of\ Final\ Goods\ and\ Services\ in\ Index\ Year}\right) \times 100 = \left(\frac{\$28.00}{\$27.00}\right) \times 100 \approx 103.7$$

As we saw earlier while calculating real GDP using values in Table 6.2, that the real GDP, for Year 1 was $27.00, using base years as Year 1—Table 6.2, Column [2]—and the real GDP for Year 2 was $28.00—Table 6.2, Column [4]. Since we assumed that our index year was Year 1, we divided both years' real GDPs by $27.00, the market value of all the final goods and services in the index year. As a result, the real GDP quantity index for Year 1 is 100, and the real GDP quantity index for Year 2 is (approximately) 103.7.

Why do we want to calculate an index? The reason is that it makes it easier to compare values across time. Using this example, we can calculate the percentage change in real GDP from Year 1 to Year 2 just by deducting the index value of Year 1 from the index value of Year 2. Doing this we find that the real GDP increased from Year 1, the index year, to Year 2 by 3.7% (=100.00 – 103.7).

To verify, we can calculate percentage change from Year 1 to Year 2, using the formula for calculating percentage change that we learned in Chapter 1.

Percentage Change in real GDP from Year 1 to Year 2 = $\left(\frac{[Real\ GDP\ in\ Year\ 2 - Rea\ \ GDP\ in\ Year\ 1]}{Real\ GDP\ in\ Year\ 1}\right) \times 100 = \left(\frac{[103.7-100]}{100}\right) \times 100 = 3.7\%$.

To further solidify the reason behind formulating an index, as opposed to calculating percentage change using actual data, in Table 6.3, I present real GDP data for the US from 2011 to 2021. These data are in billions of chained 2012 US dollars.

Table 6.3: US Real GDP, in billions of chained 2012 US dollars

Year	Real GDP
2011	15891.534
2012	16253.970
2013	16553.348
2014	16932.051
2015	17390.295
2016	17680.274
2017	18076.651
2018	18609.078
2019	19036.052
2020	18509.143
2021	19609.812

Source: M. Ashraf. Data Source: U.S. Bureau of Economic Analysis, Real Gross Domestic Product [GDPCA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDPCA (Accessed: November 29, 2022).

The data presented in Table 6.3 are in billions of US dollars. A small mistake in entering the data to calculate percentage change can lead to a large miscalculation. In Table 6.4, I present the same real GDP data for the US, except that in this case the data are converted into an index, with the value of 2012 set equal to 100.

Table 6.4: US Real GDP Quantity Index (2012 = 100)

Year	Real GDP
2011	97.770
2012	100.000
2013	101.842
2014	104.172
2015	106.991
2016	108.775
2017	111.214
2018	114.490
2019	117.116
2020	113.874
2021	120.646

Source: M. Ashraf. Data Source: U.S. Bureau of Economic Analysis, Real Gross Domestic Product [NB000334Q], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NB000334Q (Accessed: November 29, 2022).

Notice the ease with which one can calculate percentage changes from one year to the next.

Price Level

There are several measures of overall price level. Here we will focus on two measures—GDP deflator and Consumer Price Index (CPI).

GDP Deflator

Once we have calculated nominal and real GDP, calculating GDP deflator (also known as Implicit Price Deflator) is just a matter of dividing the nominal GDP by real GDP. Then we can multiply this quantity by 100 to get the figures in 100s.

$$GDP\ Deflator = \left(\frac{Nominal\ GDP}{Real\ GDP}\right) \times 100 \tag{6.4}$$

Using the data in Table 6.2, and Equation (6.4), we can calculate the GDP deflator as follows.

GDP Deflator for Year 1: $\left(\frac{Nominal\ GDP\ Year\ 1}{Real\ GDP\ Year\ 1}\right) \times 100 = \left(\frac{\$27.00}{\$27.00}\right) \times 100 = 100$

GDP Deflator for Year 2: $\left(\frac{Nominal\ GDP\ Year\ 2}{Real\ GDP\ Year\ 2}\right) \times 100 = \left(\frac{\$28.50}{\$28.00}\right) \times 100 \approx 101.8$

Note that we are assuming that the base year is Year 1. Note also that we have set the value of Year 1 equal to 100. In this example, the price level increased from Year 1 to Year 2 by (approximately) 1.8%.

Table 6.5 presents data nominal and real GDP data along with GDP deflator for the US from 2010 to 2021.

Table 6.5: US GDP Deflator

Year	Nominal GDP	Real GDP	GDP Deflator
2010	15048.970	15648.991	96.166
2011	15599.731	15891.534	98.164
2012	16253.970	16253.970	100.000
2013	16843.196	16553.348	101.751
2014	17550.687	16932.051	103.654
2015	18206.023	17390.295	104.691
2016	18695.106	17680.274	105.740
2017	19477.337	18076.651	107.749
2018	20533.058	18609.078	110.339
2019	21380.976	19036.052	112.318
2020	21060.474	18509.143	113.784
2021	23315.081	19609.812	118.895

Source: M. Ashraf. Data Sources: Nominal GDP: U.S. Bureau of Economic Analysis, Gross Domestic Product [GDPA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDPA (Accessed: November 26, 2022).
Real GDP: U.S. Bureau of Economic Analysis, Real Gross Domestic Product [GDPCA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDPCA (Accessed: November 27, 2022).

In this example, the value of GDP deflator for 2012 is set equal to 100. For instance, note that, in Table 6.5, GDP deflator increased from 2012 to 2013 by 1.751 percent. We can find this increase just by deducting the 2012 value—100—from the 2013 value—101.751. To verify, we can

calculate percentage change from 2012 to 2013 as we learned in Chapter 1, Equation 1.5. I reproduce Equation 1.5 here for your convenience.

$$Percentage\ Change\ in\ X = \left(\frac{x_2 - x_1}{x_1}\right) \times 100 \quad (1.5)$$

Using this formula, we can calculate percentage change in GDP deflator as follows.

Percentage Change in GDP Deflator from 2012 to 2013 =
$\left(\frac{[GDP\ Deflator\ in\ 2013 - GDP\ Deflator\ in\ 2012]}{GDP\ Deflator\ in\ 2012}\right) \times 100 = \left(\frac{[101.751 - 100]}{100}\right) \times 100 = 1.751\%.$

Similarly, GDP deflator increased from 2012 to 2014 by 3.654%. Note, however, that you cannot find the percentage change between 2013 and 2014 by simply deducting the value of 2013 from 2014. If we were to deduct the value of 2013—101.751—from the value of 2014—103.654, we will get 1.903. This, however, is not the percentage change from 2013 to 2014. Using the percentage formula, we get,

Percentage Change in GDP Deflator from 2013 to 2014 =
$\left(\frac{[GDP\ Deflator\ in\ 2014 - GDP\ Deflator\ in\ 2013]}{GDP\ Deflator\ in\ 2013}\right) \times 100 = \left(\frac{[103.654 - 101.751]}{101.751}\right) \times 100 \approx 1.87\%.$

Why is there a difference? Look at the formula carefully. The reason is that when we compare the value with the index year value, which is 100, and then multiply it with 100, the 100 cancels out.

Consumer Price Index (CPI)

While GDP deflator accounts for the prices of all the goods and services produced within the geographic boundaries of the country, the CPI looks at the prices of goods and services that the typical urban consumer purchases. It is the value of the market basket of goods and services purchased by the typical urban consumer. The CPI "is based on the expenditures of almost all residents of urban or metropolitan areas, including professionals, the self-employed, the poor, the unemployed, and retired people, as well as urban wage earners and clerical workers." [9] These urban consumers represent 93 percent of the US population. Officially it is called CPI-U, where "U" stands for urban.

Note that expenditure by "people living in rural nonmetropolitan areas, farming families, people in the Armed Forces, and those in institutions, such as prisons and mental hospitals,"[10] are not included in the calculation of CPI.

The Bureau of Labor Statistics (BLS), the body that conducts the survey on monthly basis and constructs the index. The BLS divides the goods and services purchased by the urban consumers into 211 categories of goods and services that make the market basket. This basket is divided

[9] Individuals included in the CPI. (https://www.bls.gov/cpi/technical-notes/ Accessed: December)
[10] Individuals living in rural and nonmetropolitan areas are excluded from CPI. (https://www.bls.gov/cpi/technical-notes/ Accessed: December)

into eight major groups.[11] These eight groups, along with their weights and examples, are presented in Table 6.6.

Table 6.6: Goods and Services Groups Included in the CPI-U

Goods and Services Group	Examples	Weight
Food and Beverages	Breakfast Cereal, Milk, Coffee, Chicken, Wine, Full-Service Meals, Snacks	14.259
Housing	Rent of Primary Residence, Owners' Equivalent Rent, Utilities, Bedroom Furniture	42.363
Apparel	Men's Shirts and Sweaters, Women's Dresses, Baby Clothes, Shoes, Jewelry	2.458
Transportation	New Vehicles, Airline Fares, Gasoline, Motor Vehicle Insurance	18.182
Medical Care	Prescription Drugs, Medical Equipment and Supplies, Physicians' Services, Eyeglasses and Eye Care, Hospital Services	8.487
Recreation	Televisions, Toys, Pets and Pet Products, Sports Equipment, Park and Museum Admissions	5.108
Education and Communication	College Tuition, Postage, Telephone Services, Computer Software and Accessories	6.406
Other Goods and Services	Tobacco and Smoking Products, Haircuts and Other Personal Services, Funeral Expenses	2.737

Source: M. Ashraf. Data Source: https://www.bls.gov/cpi/tables/relative-importance/home.htm#Weights. (Accessed: December 2, 2022). Examples of goods and services also come from the BLS.

Note that "Housing" accounts for the largest expenditure in the market basket of goods and services for the typical urban consumer, over 42%. It includes not only, the rent, if a household is renting, an estimate of equivalent of rent if the household owns the place, fuels needed to heat or cool the place, and expenditure on furnishings.

Figure 6.1 graphically presents the relative importance (wight) of each category.

[11] Basket of goods and services. https://www.bls.gov/opub/hom/cpi/concepts.htm (Accessed: December 2, 2022)

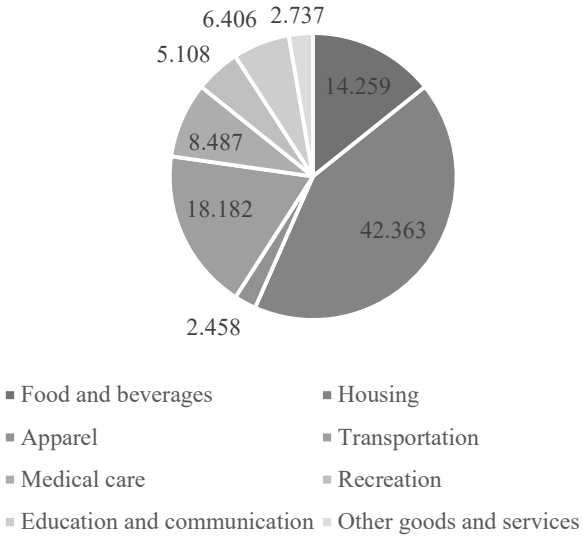

Figure 6.1: Category Weights in CPI-U

Source: M. Ashraf.

Data Source: https://www.bls.gov/cpi/tables/relative-importance/home.htm#Weights. (Accessed: December 2, 2022)

Figure 6.1: A pie chart that shows the relative importance, i.e., weights, of various goods and services that are included in the market basket of goods and services purchased by a typical urban consumer.

In the market basket of goods and services, food and energy prices fluctuate significantly, that may lead to a distorted picture of the price changes from month to month. To control for this, the Bureau of Labor Statistics produces the "Core" CPI. In core CPI, the prices of food and energy are removed from the calculation.

Note that the "CPI excludes income tax and other direct taxes; however, it does include the effects of changes in sales taxes and other indirect taxes paid on consumer products. No attempt is made to reflect changes in the quantity or quality of government services paid for through taxes."[12]

Other Measures of Price Level

As noted above, the price level measure that we just discussed is called CPI-U. The Bureau of Labor Statistics also constructs CPI for urban wage earners and clerical workers. It is called CPI-W. This includes a subset of all urban consumers. The weights in the basket of goods and services purchased by the wage earners and clerical workers differ slightly.

[12] Expenditure on taxes. https://www.bls.gov/opub/hom/cpi/concepts.htm. (Accessed: December 4, 2022)

Notice that these price indices are fixed-weight measures. Because the quality of various goods and services changes, and over time certain goods and services may not be available, in calculating the CPI, the Bureau takes special care of quality adjustments. Furthermore, the purchasing patterns of consumers may also change over time. As a result, while the BLS adjusts the weights periodically, these weights may not represent the most recent purchasing patterns of consumers. Consumers may start purchasing more a good whose relative price has decreases. Recall from our discussion of GDP, this is called substitution bias. To deal with this issue, the BLS constructs Chained-CPI. It is referred as C-CPI-U. In the Chained-CPI, the weight in the basket of goods and services are more recent. That is, the basket represents more current patterns of purchases. How much do these measures differ from each other? Figure 6.2 plots CPI-U, CPI-W, and C-CPI-U.

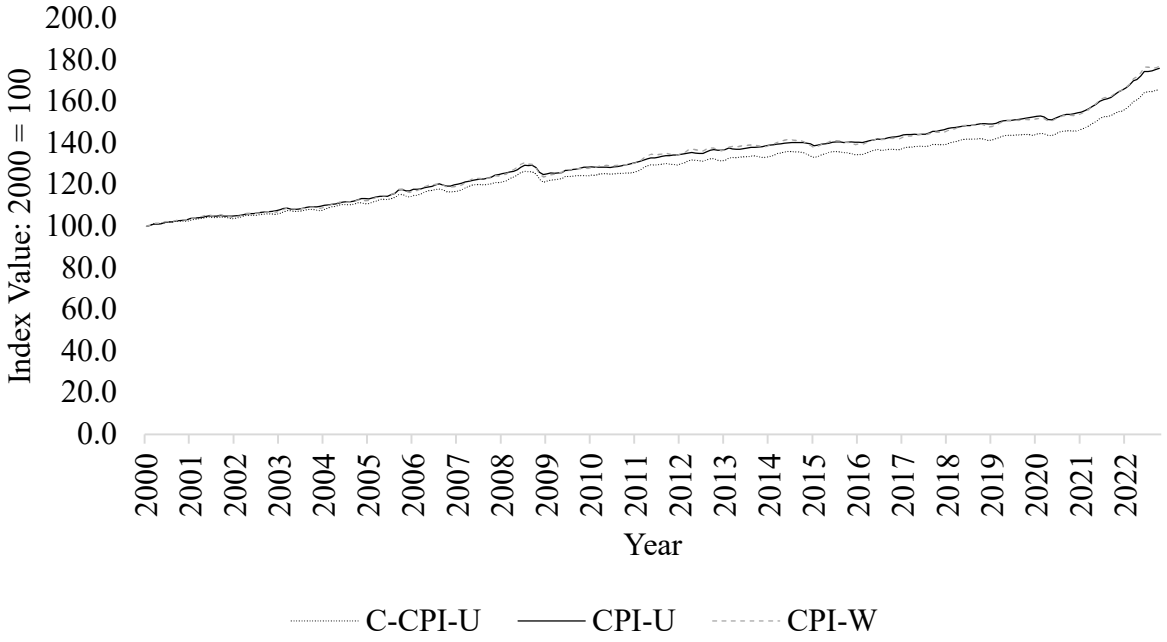

Figure 6.2: Three Consumer Price Indices—CPI-U, CPI-W, and C-CPI-U

Source: M. Ashraf.

Monthly data from January 2000 to October 2022. The index value for January 2000, is set to 100. Data Source: U.S. Bureau of Labor Statistics, Chained Consumer Price Index for All Urban Consumers: All Items in U.S. City Average [SUUR0000SA0], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/SUUR0000SA0. (Accessed: December 4, 2022.)

Figure 6.2: Three Consumer Price Indices—CPI-U, CPI-W, and C-CPI-U. The values of January 2000, of the three indices are set to 100. The solid line in the figure is the CPI-U, the most cited measure of price level in the news. The values represented by the "broken" line are CPI-W, and the values represented by dotted line are C-CPI-U. While all three measures point in the same

direction, the C-CPI-U is a little below the other two; CPI-U and CPI-W practically overlap throughout the series.

In Figure 6.2, I have plotted values of three Consumer Price Indices—CPI-U, CPI-W, and C-CPI-U. The values of January 2000, of the three indices are set to 100. The solid line in the figure is the CPI-U, the most cited measure of price level in the news. The values represented by the "broken" line are CPI-W, and the values represented by dotted line are C-CPI-U. While all three measures point in the same direction, the C-CPI-U is a little below the other two; CPI-U and CPI-W practically overlap throughout the series. What it means is that the values of CPI-U and CPI-W overestimate inflation, and cost of living, as compared with C-CPI-U. Research shows that this overestimation is due to the use of a fixed-weight procedure in CPI-U and CPI-W. While the BLS resets the weights periodically and corrects for quality in calculating the CPI, the correction still does not account for the changes in the purchase patterns by consumers.

It is important to note that all three measures are estimates of the cost of living, individuals' costs of living may differ. And while C-CPI-U uses the most recent weights, it still is an estimate.

Finally, the Bureau of Labor Statistics also collects data for the producers' input costs. The Bureau collects data at various stages of production. Using these data, the Bureau publishes numerous Producer Price Indices.

Differences Between the Consumer Price Index and the GDP Deflator

While the CPI and the GDP deflator (and other measures of price level) point in the same direction, there are some important conceptual differences between CPI and the GDP deflator.

First, recall that GDP is the market value of all the final goods and services produced within the geographic boundaries of the economy; using the expenditure approach, we deduct the market value of imports. GDP deflator is the ratio of nominal GDP to real GDP. In other words, GDP deflator does not include the prices of imported goods and services.

As consumers, however, we consume, not only domestically consumed goods and services, but also imported goods and services. So, when we want to calculate the cost of living, we include the prices of imported goods and services that we consume. That is, CPI includes the prices of imported goods and services. It is quite likely that the computer that you are using to read this book and do your homework, was produced in some other country, and so was your iPhone or Android phone.

Second, in calculating GDP deflator, we include the market value of all the final goods and services. In calculating CPI, as mentioned earlier, we use the basket of goods and services consumed by the typical urban consumer. It is unlikely that horse feed will be in the basket of an urban consumer, whereas it is quite likely that dogfood will be in the basket, even if it is imported.

Inflation, Deflation, and Disinflation

Now that we understand price level, it is time to define inflation, deflation, and disinflation.

Inflation is an increase in the overall price level.

Deflation is decrease in the overall price level.

Inflation rate (or rate of inflation) is the percentage increase in the overall price level. Analogously, deflation rate is the percentage decrease in the overall price level. In fact, we have already calculated inflation rate using GDP deflator as a measure of the overall price level. Recall that the GDP deflator increased from 2012 to 2013 by 1.751%, and from 2013 to 2014 by 1.87 percent.

Disinflation is a decrease in the rate of increase in the overall price level. That is, while the price level is still increasing, it is increasing at a lower rate that the period before.

You should calculate the inflation, inflation rate, deflation, deflation rate, and disinflation using the GDP deflator data in Table 6.5. You should also perform these calculations using the CPI-U, CPI-W, and C-CPI-U data used in Figure 6.2. Use the data source provided below the Figure 6.2 to access these data.

Chapter Conclusion

In this chapter we learned the definition of gross domestic product (GDP), a measure of the nation's output, and how to calculate GDP. We also learned about gross national product (GNP), and the difference between GDP and GNP. We learned about various measures of price level and focused on two measures—GDP deflator and Consumer Price Index (CPI). We also learned how to calculate GDP deflator and CPI.

A Review of Terms

- Gross Domestic Product (GDP): It is the market value of all the final goods and services produced withing the geographic boundaries of the economy during a given period.
- Gross National Product (GNP): It is the market value of all the final goods and services produced by the factors of production owned by the residents of an economy during a given period regardless of where the output is produced.
- Real GDP: GDP calculated after taking effects of prices out.
- Nominal GDP: GDP calculated using current year's prices.
- Per Capita GDP: GDP divided by the population of a country.
- Fixed-Weight Procedure: A procedure that keeps the weights fixed from one period to the next.
- Chain-Type Procedure: A procedure that changes weights from one period to the next.
- Weight: The importance assigned to a variable or a group of variables.
- Index: A value assigned to a variable or a group of variables, usually either 1 or 100.
- GDP Deflator: It is the ratio of nominal GDP to real GDP, times 100.
- CPI: It is the value of the market basket of goods and services purchased by a typical urban consumer.
- Inflation: An increase in the overall price level.
- Inflation Rate: Percentage increase in price level.
- Deflation: A decrease in the overall price level.
- Disinflation: A decrease in the rate of increase in the overall price level.