CHAPTER

4 THE SYSTEM OF NATIONAL INCOME AND PRODUCT ACCOUNTS

Chapter Outline

Learning Objectives

- Understand how GDP is measured and why different measures of GDP are equivalent.
- Recognise the deficiencies of GDP as a measure of welfare.
- Derive CPI indexes and their rate of change.
- Interpret measures of income inequality.

4.1 Measuring National Output

The System of National Income and Product Accounts (NIPA) is the framework assembled by national statisticians for **measuring** economic activity.

In this chapter we look at national income accounting, that is, how we measure total national spending and its components as well as national income and its components. The most important measure of economic production is **gross domestic product** or GDP. Let us first provide a formal definition:

GDP is the measure of all final goods and services evaluated at market prices which are produced per period of time, say a quarter or a year.

Note that GDP is a flow measure. A month, quarter, and year are the most common periods over which the flow of production is measured.

Let us emphasise the most important parts of the definition:

- **Produced per period of time:** This includes only goods and services produced over the time period, and would exclude goods sold this period that had been produced previously. Hence GDP excludes sales of 'used' goods.
- **Final goods and services:** These are the goods and services sold to final users, whether they are consumers, firms, or government. Households buy final consumer goods and services; firms buy investment goods to increase capacity, and government buys goods and hires services. Intermediate goods and services are excluded. For example, an auto manufacturer buys tyres to put on new cars for sale. These are intermediate goods. If we were to count those tyres as part of GDP, and then count the value of automobiles produced, we would double count the value of tyres (since the value of the automobiles would include all the intermediate goods and services that go into producing the automobiles). For that reason, we count only the value of final goods and services.
- **Evaluated at market prices:** We calculate the value of final goods and services at market prices. This means that GDP is calculated at nominal values. We use another measure of GDP to take account of the impact of price changes, called **real GDP**. Note that unless specifically designated as 'real GDP', when we say GDP we mean nominal GDP calculated at current market prices. We will discuss real GDP below.

The statisticians who compile the NIPA must make many decisions about what to include and what to exclude. While the decisions are not arbitrary, it is important to recognise that they are conventions. In other words, there is nothing sacrosanct about them, and the conventions could be changed by international agreement.

For example, washing your own dishes at home is not included in GDP. However, if you hire your neighbour to wash your dishes, that should be counted in GDP as dishwashing services. Note that we said 'should' because if you pay your neighbour 'under the table' and neither of you report it, the transaction might not get captured in the official numbers. This makes some sense because in the first case there was no monetary exchange and no market price at which the service took place, while in the second there is the market price that you paid for the service. However, by excluding all the unpaid household services performed, including cleaning, repairs and upkeep, and child and elder care, the NIPA numbers exclude a huge proportion of the nation's production.

More importantly, it undercounts the contribution made to production by women because they perform a disproportionate amount of unpaid work. Many economists have called for reform of the accounting conventions to include more unpaid work in order to give greater recognition to the economic and social value of such so-called 'women's work'.

GDP also excludes the black market, grey market, and much of the production in the informal sector. This is largely to do with the difficulty of collecting the data. Black market transactions are illegal, even though the good or service *per se* may be legal. For example, the sale of cigarettes is only illegal if duty has not been paid. On the other hand, the drug and sex trades often involves illegal transactions in many countries in illegal goods and services.

In the grey market legal, non-counterfeit goods are sold outside normal distribution channels. For example, if a brand of cameras is very expensive in a particular country, an enterprising local trader may import them from a country where the price is low and sell them in competition with the local official supplier(s) of the camera. Many nations do attempt to estimate such activity and even include at least some of it in official measures of GDP.

Much of the informal activity is similar to household production discussed above. For example, in many developing nations, much of the food production does not reach formal markets. It is consumed by farmers and shared or sold in local markets without being subject to proper recording. Other activity is 'under the table' and goes unrecorded to escape taxes. While the size of the black market is sometimes estimated in countries, typically it is not included in their official measures of GDP. However in late 2014 the Office of National Statistics in Italy announced that the estimation of its GDP would in future include the best estimates it could make for illegal activities, notably "drug trafficking, prostitution and smuggling services (cigarettes and alcohol)" (*The Economist*, 2014).

Another problem is that GDP is not necessarily a good measure of production in terms of its contribution to economic well-being. For example, a widget factory might pollute the air and water supply while it is producing its output. The social, health and environmental costs are not deducted from the value of the output produced for the purposes of measuring GDP. However, if society had to hire workers and produce machinery in order to clean up the pollution coming from the producing factory, that would be counted toward GDP. Ironically, this production would then count twice toward GDP, once for the value of the widgets produced and secondly for the value of cleaning up the environmental mess.

Furthermore, if neighbours of the widget factory get sick from the pollution, then the healthcare spending required to treat them also gets counted in GDP. For that reason, GDP can be a poor measure of economic well-being, as polluting industries might make a negative contribution to our general living standards even though they increase GDP.

Another example is when a nation that produces great volumes of military equipment might record the same GDP as a nation that produces a lot of healthcare and educational outputs. Using the GDP measure as a proxy for national progress might be quite misleading in this case. It is highly likely that the latter nation has higher material living standards for its population.

Still another problem is inequality. It does not make any difference to the calculation of GDP whether almost all production goes to the top ten per cent of individuals or households, so that the bottom 90 per cent gets next to nothing, or vice versa. The GDP measure simply adds up national production without taking account of the distribution of the output. This can make GDP a bad measure for comparing living standards across countries.

It is common to divide a nation's GDP by its population in order to derive the per capita GDP. We can rank nations according to their per capita GDP, measured in a common currency. We can classify some as rich, some as middle income, and some as poor. However, per capita GDP simply provides a measure of the average and that can be highly misleading as a guide to the standard of living of the typical resident of a nation.

For example, the average could be $35,000 per capita in two very different nations. In Country A, the share of GDP of the top one per cent might be 90 per cent, leaving the remaining 99 per cent of the population to share only ten per cent of the nation's output, while in Country B the distribution could be nearly equal, with 99 per cent of the population earning within a few thousand dollars of the $35,000 average. Clearly, economic well-being would be more widely shared in Country B, with very few poor people but also few people enjoying a living standard much above the average. The **Gini Coefficient**, which we discuss later in this chapter, is often used to measure income inequality.

There are alternative measures of economic well-being that attempt to get around these problems. Some try to measure household production. Others take account of inequality, poverty, and access to education and healthcare. Some measures deduct social, health, and environmental costs. For example, our hypothetical widget factory might actually make a net negative contribution to economic well-being, so it would be beneficial to close the factory and thereby increase social welfare even while forgoing the consumption of widgets.

As a real world example, tobacco smoking increases GDP due to sales of tobacco, spending to capture smoke to make indoor air cleaner, and high levels of spending on healthcare for tobacco users and all those who suffer from the effects of second-hand smoke. Eliminating tobacco use would undoubtedly enhance well-being but might reduce GDP. For these reasons, when addressing economic, social, and environmental well-being, we need alternative measures to GDP.

Still, GDP is the most commonly used measure and it does have one big advantage: it focuses largely on the monetary value of output. As we have discussed, the profit motive drives capitalistic production. It can be characterised as M-C-M'; that is, it begins with money (M) to produce commodities for sale (C) for more money (M'). For that reason, GDP is an appropriate measure for the capitalist sphere of production because it focuses on production for sale in exchange for money.

Yet GDP is not perfect even for that narrow purpose, because, as we have already noted, it includes imputed monetary values for some production that is not actually sold. The most important example is the 'services' of owner-occupied housing. The idea is that the homeowner 'consumes' housing services over time. If the home is not owned, we can use instead the rent paid as a value of the housing services consumed by the renter. However many families live in homes that they purchased so there are no market transactions taking place.

Note that when a new home is purchased, it is counted as residential investment (and is included in the investment category, not the consumption category – see the next section). It would not make sense to count the **entire** market value of a home as consumption over the period. Further, most homeowners have purchased a 'used' home, so that purchase will not show up in either the investment category or the consumption category. For that reason, the imputed monetary value of the housing services over the period is counted as consumption, whether or not the home is new. Still, by including imputed values, our measure of GDP deviates from the ideal of capturing the total value of production that is sold at market prices over the period.

4.2 Components of GDP

The National Income and Product Accounts (NIPA) divide the nation's output into four main categories, and add a fifth to account for foreign production that is available to the nation's residents. These are consumption, investment, government expenditure, exports and imports. Each of these can be further subdivided.

Consumption (*C*)

Consumption includes domestic consumption of goods and services by **households**. Keep in mind from our definition of GDP that only final outputs that are produced within a given time period – that is, currently produced final goods and services – are included. Intermediate goods and services are excluded, as are sales of used goods.

Generally speaking, all current period spending on new goods and services by households is included as consumption. The only major exceptions are the purchase of a newly built house, which, as noted, is included as investment spending, and the inclusion of 'imputed' housing services of owner-occupied homes, which is counted as consumption.

What is most confusing for students is that household 'investment' in shares and bonds is not included in GDP at all. This is because shares and bonds are not currently produced goods and services. Indeed, purchase of financial assets of any type is treated by the NIPA system as saving, not as spending.

Investment (*I*)

Investment includes three main categories: capital investment by firms, inventory investment by firms, and real estate investment by households. Investment expenditure increases the productive capacity of the economy and expands what we define as **potential GDP**. Therefore it adds to current spending but also increases the capacity of the economy to absorb increases in future spending without inflation.

Capital investment includes spending on plant and equipment; factories and machines, for example. Increasingly, investment includes purchases of software and other non-physical but long-lasting inputs to production.

As discussed, we do not want to include intermediate goods in GDP, so purchases of inputs that are 'used up' in the production process are not included as investment. Here we are referring to inputs such as electricity, oil and other natural resources, and marketing services. Note that the precise division between an intermediate input and an investment is somewhat arbitrary, and so it will rely on accounting conventions which will be related to the input's useful life.

Again, purchases of financial assets are not included as investment. For example, if one firm takes over another, that is not an investment for the purpose of measuring GDP. Also note that if a household buys a car it is counted as consumption, but if a business buys a car it is counted as investment, even if the firm operates out of a home office of the same household!

Unsold goods are referred to as inventories. A rise in inventories is also treated as an investment, even if the firm did not plan to change the stock of inventories. A firm may produce more output than it can sell during the accounting period, increasing investment in inventories. If a firm sells more output than planned, its stock of inventories falls. This is treated as negative investment. Swings of inventory investment can be quite wide because it is difficult for firms to sell precisely the amount that they planned.

Finally, real estate investment includes new construction of residential and non-residential buildings. Sales of existing homes as well as existing commercial buildings are not included as investment. Sales of land also would not be counted as investment.

When in doubt whether the purchase of an asset would be counted as investment or simply a purchase of an asset, a useful rule of thumb is to consider whether labour was used during the period to produce the asset. If it was, then this is investment; if not, then it is simply an asset purchase, which is treated as a portfolio adjustment, but not an investment. Newly produced machines, factories, houses, and apartment buildings all require current labour services to produce them, and hence count as investment. Sales of stocks, bonds, existing houses, or existing factories do not use labour in the current period to produce them, so they are not defined as investment.

Government spending (*G*)

Government spending includes government purchases of final goods and services.

Note that it does not include government transfer payments, such as spending on welfare and social security. This is because if we were to include transfers we would double count, since most transfer payments will then be spent on consumption goods and services, and hence, included in *C* as described above. Government transfer payments are not purchases of currently produced goods and services, so are not part of GDP.

Government purchases can be further divided between 'consumption' and 'investment' (or capital) expenditures. The division between these two subcategories is somewhat arbitrary. Government consumption expenditures are for goods and services that are used relatively quickly (firefighting services, postal delivery, and air traffic control), while government investment purchases are for long-lasting improvements (fire trucks, roads, and airports). Typically, any spending whose impacts are exhausted within a 12-month period are considered to be consumption; otherwise they are classified as investment. Do not get confused by the use of the terms 'consumption' and 'investment' when applied to the division of government spending by type; these are under the *G* category and not under the *C* or *I* categories discussed above.

Exports (*X*) minus imports (*M*) or net exports (*NX*)

Exports are goods and services sold abroad; imports are goods and services produced abroad for domestic use. If imports are greater than exports, then net exports are negative; alternatively, if imports are less than exports, then net exports are positive. Again, these can be consumption-type goods or investment-type goods but if they are sold abroad or bought from abroad they are counted in the *NX* category and not in the *C* or *I* categories.

Exports add to domestic spending to stimulate production, whereas imports represent a drain on domestic spending.

4.3 Equivalence of Three Measures of GDP

GDP can be measured in three ways, namely the expenditure approach, the production approach, and the income approach. These approaches, subject to a statistical discrepancy, should give equal measures of GDP.

The expenditure approach is conceptually the simplest. It works on the principle that total expenditures denote the value of the product that has been bought, and given the inclusion of inventory investment in the definition of investment, it measures the value of total production. The production (or value added) approach is based on summing the gross outputs of every class of enterprise and then netting out intermediate consumption. The income approach works on the principle that the incomes of the productive factors (producers) must be equal to the value of their product, and thus measures GDP by summing all producers' incomes.

Expenditure approach

The expenditure approach estimates GDP by calculating the sum of final expenditures on goods and services measured in current market prices. As we discussed above, GDP (*Y*) is the sum of consumption (*C*), investment (*I*), government spending (*G*) and net exports (*NX* or (*X* – *M*)). This can be written as the following identity:

$$Y \equiv C + I + G + (X - M) \quad (4.1)$$

An *identity* is an algebraic equation which always holds because of the way the variables in the equation are defined. Here we are drawing on the fact that the total final expenditure which represents GDP can be broken down into a series of components, which have been defined.

Production approach

This approach measures gross value added. First it is necessary to calculate the gross value of domestic output over, say, a year. This will include the value of output contributed at all stages of production,[1] and will take account of intermediate consumption – the costs of (raw) materials, supplies and services which were used up in the production of gross output. We then subtract the intermediate consumption from the gross value of domestic output to obtain the gross value added. As before, note that if we do not subtract the intermediate consumption, then we fall into the error of double counting.

Consider a three-stage production process which culminates in the final sale of woollen coats to consumers. Initially sheep farmers incur costs of feed and the like in rearing the sheep, and pay wages to the shepherds and to the sheep shearers. They then sell the wool to a woollen mill, which processes it by the employment of labour and other producers. The woollen mills sell the processed wool to the manufacturer of the coats, which employs labour and other producers in the production of the woollen coats. For simplicity, we assume that the manufacturer then sells these final goods directly to consumers. At each stage of the production process the value added by the producers must be calculated, so for example, value added by the woollen mill is the value of sales of the processed wool minus the costs of buying the unprocessed wool and raw materials used to process the wool and the electricity costs incurred in the production process. Then we can write: value added in the production of woollen coats = gross value of output – value of intermediate consumption, which has been summed over all stages of production.

The sum of the value added across every class of enterprise is known as GDP at factor cost. GDP at factor cost plus indirect taxes less subsidies on products is GDP at producer price.

Income approach

The third way of measuring GDP is to calculate the sum of primary incomes distributed to resident producers of goods and services. This method adds together the producers' incomes that firms pay in exchange for their services, namely wages for labour, interest for capital, rent for land and profit for capitalists. This defines GDP at factor cost. It is then necessary to add indirect taxes minus subsidies to get a measure at market prices, and in turn depreciation (or capital consumption allowance) to obtain GDP.

Under the production approach, the value added at each stage of production is the additional income that is generated, so the equivalence of the production and income approaches to the measurement of GDP is clear.

4.4 GDP versus GNP

GDP is the total value of goods and services produced within a nation regardless of the ownership of the firm producing them; gross national product (GNP) is the total value of goods and services produced by residents of the nation regardless of the location of the production.

GDP includes earnings from production within the domestic economy that goes to foreigners.

GNP does not include earnings from production within the domestic economy that goes to foreigners, but includes foreign earnings of domestic firms and residents operating abroad. Thus the financial flows between the domestic and external sectors are not confined to net exports.

Until the early 1990s the USA tended to use GNP while many nations used GDP. However, since then the USA has conformed and adopted GDP, although it still reports GNP. For the USA, there is no major difference between GDP and GNP because earnings from production in the USA that go to foreigners are nearly balanced against foreign earnings of US residents. For many other nations however there is a large difference between GDP and GNP because, for example, their residents have large investments in factories operating abroad. Ireland is a standout example of a country where these two measures diverge because of the presence of many large foreign-owned firms that have been attracted to locate head offices in that nation as a result of its very low corporate tax regime.

4.5 Measuring Gross and Net National Income

Measuring gross national income

We initially examine **gross national income** (GNI) from the perspective of what can be done with income: an individual can consume it, pay taxes, or save it. As a simplification we ignore the difference between GNP and GDP, so we can write:

$$Y \equiv C + S + T \equiv GDP = C + I + G + NX \tag{4.2}$$

Here we use Y to represent income. S is gross saving and T is total taxes paid. We can think of S as a residual: it is disposable (after tax) income that is not spent on consumption.

We can easily manipulate the above identity to obtain a useful identity based on Keynesian saving:

$$S \equiv I + (G - T) + NX \tag{4.3}$$

What is $G - T$? It is government deficit spending, the difference between government spending (G) and its total revenue from taxation (T).

We'll make more use of identity (4.3) later.

Measuring net national income

At the aggregate level, national income equals national output because as discussed previously, the production of output generates equivalent income. We will define net national income as NNI, and then will derive a number of subcategories of income.

It is more convenient to begin with GNP (so as to include foreign earnings of domestic residents). GNP equals gross national income, or GNI. To calculate NNI we need to subtract depreciation and taxes.

Over the course of a production period (month, quarter, or year) some of the production facilities (plants and equipment) 'wear out' or 'depreciate'. We subtract depreciation from our gross national product (GNP) to obtain net national product (NNP).

We then subtract indirect business taxes (sales and excise taxes) to obtain NNI. The reason for deducting depreciation and business taxes is to obtain a measure of national income that is actually available to purchase national output. We subtract the depreciation because producers must set aside a portion of gross income to replace the capital that is wearing out. We subtract indirect business taxes because these reduce the amount of income that can be paid out of production. To summarise:

> Begin with GNP
> Subtract depreciation = NNP
> Subtract indirect taxes (sales and excise taxes) = NNI

Next we want to obtain a measure of personal income (PI) flowing to households. We subtract corporate taxes, payroll taxes, and undistributed profits since the taxes go to government and undistributed profits are retained by producers, leaving us with the income to be paid out to households.

However we need to add transfer payments made by government to households as well as personal interest income received by households to obtain PI. To summarise these operations:

> Begin with net national income (NNI)
> Subtract corporate taxes and undistributed profits and payroll taxes
> Add transfer payments and personal interest income = PI

We need to get a measure of PI after taxes paid by individuals, so we subtract personal taxes from PI to obtain personal disposable income (PDI). This is the after-tax income available to individuals to spend and save.

Beginning from PDI we then subtract personal consumption, interest paid to business and transfer payments made to foreigners to give us personal saving (PS).

> We start from personal disposable income
> Subtract personal consumption
> Subtract interest paid to business
> Subtract personal transfer payments to foreigners = PS

Note that gross saving (S) (defined in Equation 4.3) is not the same as personal saving (PS), because it is based on total income (not PDI) and we have not deducted interest paid to business and transfers to foreigners.

4.6 GDP Growth and the Price Deflator

We have defined nominal GDP as a measure of the value of output at current market prices. We often want to measure economic growth, which is the growth of GDP over time. The problem is that prices as well as output change over time. If we find that GDP (nominal) today is 100 times greater than it was a hundred years ago, does that mean that we enjoy 100 times more physical output? Clearly not if prices have also risen. To take account of this, we often want to 'deflate' nominal GDP, that is correct our measure for the change in prices to get an idea of 'real' economic growth.

The idea is simple, but in practice this is a very difficult thing to do. Let us start with the conceptual problem.

Suppose we want to compare GDP in 2018 to GDP in 2002 to see how much 'real' output grew over the 16-year period. To find nominal GDP in each year we take the 'current' market price of that year and multiply by the quantity produced that year. For exposition purposes, we are simplifying here by taking the quantity and price of a single aggregate good we call GDP:

$$GDP_{2002} = P_{2002} \times Q_{2002} \tag{4.3a}$$

$$GDP_{2018} = P_{2018} \times Q_{2018} \tag{4.3b}$$

where GDP_t measures GDP at current prices in year t, based on production level (Q_t) and market price (P_t).

However we are interested in a comparison of levels of 'real' GDP over time in order to correct our measure for the change in prices. First we have to decide which year's prices to use as a 'base'. We always calculate 'real GDP' over time in terms of a base year. We could choose 2002 or 2018 or any other year as the base. Let us say we choose to use the prices of 1985 (this makes it clear that we do not have to use prices of 2002 or of 2018).

Then we do the following calculation:

(4.4a) $RGDP_{2002} = P_{1985} \times Q_{2002}$

(4.4b) $RGDP_{2018} = P_{1985} \times Q_{2018}$

where $RGDP_t$ denotes real GDP in year t based on 1985 prices.

So long as we have used the same base year to calculate real GDP for both 2002 and 2018, we can determine real GDP growth over the 16-year period, but the measure will reflect to some degree the choice of the base year prices when we consider many goods rather than a single good.

In practice, statisticians update the base year through time so that they will always use a fairly recent base year. Thus, you would be unlikely to use 1900 as the base year to calculate real GDP for 2018! The older the base year used for calculations, the greater the problems encountered in calculating real GDP. We will return to these problems shortly. Before we do, there are two other useful concepts related to calculation of real GDP.

First there is the GDP deflator, which is an indicator of price changes. It is defined in year t as follows:

(4.5) $GDPD_t = GDP_t/RGDP_t$

where $GDPD_t$ denotes the GDP deflator for year t.

Changes in the magnitude of the GDP deflator over time give us a measure of price changes for output as a whole. Note that it is possible for prices in general to go down as well as up. However, over the past century, deflations have been relatively rare and short-lived.

Our goal has been to develop a method for adjusting GDP for price changes. In practice it is much more difficult than suggested by the earlier discussion. As noted, we were using a simplification to calculate nominal GDP as 'Price times Quantity' of a single 'aggregate GDP' good.

However, GDP is defined as the value of total output measured at current prices. Conceptually we have a set (vector) of prices (one for each good or service sold) and a set (vector) of quantities (an entry for every item sold), and then we sum each individual sale ($P^i \times Q^i$ for the ith item) to obtain GDP. That does not seem too difficult; we simply recognise that output is heterogeneous and so it can only be aggregated in nominal terms, not in 'quantity' terms.

In practice, major problems are created if we try to measure the value of real GDP in terms of another year's prices. Let us say we use 1985 as our base year, and apply 1985 prices to the goods and services sold in 2018. How do we put a 1985 price on an iPad sold in 2018? There were no iPads sold in 1985, and indeed nothing comparable existed.

To reverse the problem, how can we find a 1985 price for manual typewriters sold in 1900 to value real GDP that year (in terms of 1985 prices)? Clearly, the composition of output changes both in terms of what is sold and the quality of items sold (the typical personal computer sold today is very much faster than one sold in 1990 even though the nominal price has hardly changed). It should be obvious that the older the base year chosen, the more acute the problem. That is why in recent years statisticians have increasingly favoured the use of a chain weighted measure of GDP which involves a lag of only one year. In the next section we discuss this measure in more detail.

4.7 Measuring Chain Weighted Real GDP

The chain weighted real GDP can be defined as follows:

$$RGDP_t = \{(P_{t-1} + P_t)/2\} \times Q_t$$

This measure averages the prices over two consecutive years and, as we discuss below, this is particularly useful for measuring real GDP growth.

In practice, economists are more interested in real GDP growth than in levels of real GDP. This favours the chain weighted measure even more over the calculation of real GDP with a base year that is periodically changed. Every time the base year is changed, real GDP needs to be recalculated for every year. That, in turn, will change the calculations of real GDP growth rates over time. In an important sense economic history is 'rewritten' every time the base year is changed.

With the chain weighted approach, however, the calculation of real GDP growth is invariant to changes of the base year. Changing the base year will change the calculated levels of real GDP but not the growth rate for the historical series of real GDP that will instead use the chain weighted measure.

Changes in this measure are calculated using the weights of adjacent years. These annual changes are 'chained' (multiplied) together to form a time series that allows for the effects of changes in relative prices and in the composition of output over time. Thus, the US Bureau of Economic Analysis (BEA) is able to calculate an index that uses weights that are appropriate for each period. It thereby avoids the rewriting of economic history that results from updating the base period of a fixed weighted index as well as the substitution bias that is inherent in fixed weighted indexes (Landefeld and Parker, 1997: 59–60).

In other words, once the BEA has calculated real GDP growth for any set of years using the chain weighted approach, it will not need to do any recalculations because the base year prices used for that set of years will not change. This is still more difficult than it sounds, but we will not go into further details here.

4.8 Measuring CPI Inflation

The CPI index

In this section we look at the measurement of the prices of consumer goods (bought by households) and make brief reference to producer goods (bought by firms, including raw materials and intermediate goods to be used in production). These prices could go down, but the usual trend is for rising prices.

The index most commonly used to calculate inflation of consumer goods prices is the Consumer Price Index, or **CPI**. It is defined as follows:

An index based on the cost of a fixed basket of consumer goods and services.

In the construction of the CPI index, the statistician needs to decide what consumer goods and services to include, their respective quantities (weights) and how to calculate the corresponding prices. The chosen basket of goods and services is intended to be representative of the purchases made by a typical household, and is periodically updated. The statistician chooses a base year (much like the choice of the base year to be used in calculating real GDP). The CPI then represents the cost of a market basket of consumer goods and services.

The measure is usually expressed for a specific spatial area such as a capital city or a weighted average of all capital cities in a nation.

The items included in the Australian CPI published by the Australian Bureau of Statistics in March 2016 are shown in Table 4.1. Within each major group there are many items included.

Table 4.1 Items in Australian CPI, March 2016

Food and non-alcoholic beverages
Alcohol and tobacco
Clothing and footwear
Housing
Furnishings, household equipment and services
Health
Transport
Communication
Recreation and culture
Education
Insurance and financial services

Source: Australian Bureau of Statistics, Consumer Price Index, http://www.abs.gov.au/AUSSTATS/abs@.nsf/mf/6401.0

If the prices of all the items in the basket changed at the same rate from one period to the next, then the change in the cost of the basket would be easy to calculate, period by period. But in reality, the individual prices generally change at different rates, so that relative prices are also changing. The statistician thus needs a single summary measure to determine whether the basket overall is rising in cost or not. That is the role that the price index plays. It is a weighted average of the price movements in the given basket relative to some base period.

In compiling a summary measure such as the CPI, the statistician must choose whether to use base weighting or current weighting to compile the index.

A base weighted index examines the shifts in prices of the basket of goods and services using the base period quantities purchased. It is referred to as a *Laspeyres* index after the German economist who first compiled such measures. The base weighted index allows us to see how much a basket that consumers bought in the base period would cost in the current period.

A current weighted index uses the current quantity purchased of each good and service in the basket as the weight to compile the average measure. This is commonly called a *Paasche* index after the German statistician who developed this measure. The current weighted index allows us to see how much a basket that consumers buy in the current period would have cost in the base period.

These measures provide different ways of estimating the change in the cost of a basket of goods and services over time. However, statisticians tend to favour the use of the *Laspeyres* index to calculate the CPI because it requires less information. The only new data that are required are the current prices of the items in the basket. The quantities making up the basket and the corresponding base year prices are already known.

This allows for a more timely publication of the CPI, which is desirable since it is an important policy variable used by central bankers and treasuries in formulating monetary and fiscal policy, not to mention its use in labour and other contracts, and for indexing the values of transfers, such as pensions and other benefits.

To simplify our analysis, imagine a basket of goods and services comprises two items: bread and cheese. (We are glossing over the obvious question of "Don't these people wear clothes?")

Table 4.2 shows the hypothetical data we will be working with to illustrate the construction of the price index.

Table 4.2 Hypothetical data for basket of goods and services

	Price per unit	Quantity	Expenditure	Expenditure based on quantities in other year
	(1) $	(2) Units	(3) $	(4) $
Year 1				
Cheese	4	3	12	16
Bread	2	9	18	20
Total			30	36
Year 2				
Cheese	5	4	20	15
Bread	3	10	30	27
Totals			50	42

In Year 1, the price per unit of cheese is $4 and three units are consumed overall. So total expenditure on cheese in Year 1 is $12. The price of a loaf of bread is $2 and nine units are consumed in Year 1, making total expenditure on bread $18. Overall, the basket of goods costs $30 in Year 1 (Column 3).

In Year 2, cheese rises to $5 per unit and four units are consumed whereas bread rises to $3 per loaf and ten units are consumed. Overall, the basket of goods in Year 2 now costs $50 (Column 3).

Note that if we wanted to know what the quantities purchased in Year 1 would cost in Year 2, we multiply each quantity by its price in Year 2. Column (4) provides that answer ($42), which we calculated using the following data:

Cheese $5 × 3 = $15

Bread $3 × 9 = $27

Total = $42

Conversely, Column (3) shows the expenditure in Year 2 based on Year 2 prices and Year 2 purchases.

Similarly, if we wanted to know what the basket would cost in Year 1 based on Year 1 prices and Year 2 purchases we would look to Column (4).

What would be the price index values in this example? Our answer will depend on whether we use base weighting or current weighting.

Base weighted CPI

Using base weights (Year 1 quantities), we will set the index in Year 1 to 100.

In Year 2, the index would be (using Year 1 weights):

$CPI_{Year\ 2} = CPI_{Year\ 1}$ × Total expenditure in Year 2 (Column 4) divided by Total expenditure in Year 1 (Column 3)

$CPI_{Year\ 2} = (100 \times \$42)/\$30 = 140$

Current weighted CPI

Using current weights (Year 2 quantities), we will again set the index in Year 1 to 100. In Year 2, the index would be (using Year 1 weights):

$CPI_{Year\ 2} = CPI_{Year\ 1}$ × Total expenditure in Year 2 (Column 3) divided by Total expenditure in Year 1 (Column 4)

$CPI_{Year\ 2} = (100 \times \$50)/\$36 = 138.9$

Thus we can see that it does make a difference which weighting approach we use.

Rate of growth of the CPI index

We have generated two CPI indexes (one base weighted and one current weighted) over two years, so we can calculate a measure of the overall movement in prices, and provide a measure of the change in the cost of living. The growth rate of the CPI measures the rate of inflation (if positive) or deflation (if negative), acknowledging that strictly inflation(deflation) is an ongoing, rather than a one-off, increase(decrease) in the price level.

We can write the percentage rate of inflation(deflation) as:

$$(4.6) \quad CPI_{Gt} = 100 \times [(CPI_t - CPI_{t-1})/CPI_{t-1}]$$

where CPI_t denotes the index magnitude at time t and CPI_{Gt} denotes the change of the CPI from time $t - 1$ to time t (say, one year). So the rate of change can be expressed as 100 multiplied by the change in the index, divided by the initial value of the index.

It can be readily shown using the data in Table 4.2 that the respective rates of change for the base and current weighted price indexes between Year 1 and Year 2 are 40 per cent and 38.9 per cent.

You will appreciate that the current weighted index takes into account changes in prices and the quantities purchased following these price changes, whereas the base weighted approach considers price changes only and ignores the fact that people will change their expenditure patterns over time as relative prices change.

In practice, household expenditure patterns change and new goods and services are sold, so statisticians periodically revise the weights in the basket of goods and services in line with other information that they collect. They have complex methods to splice the new and the old indexes together. In the next subsection we explore the biases associated with using the CPI to accurately measure inflation.

Finally it should be recognised that there are other published price indexes, including those based on wholesale and retail prices. For example, the US Producer's Price Index is based on the wholesale prices of approximately 3,000 items, including raw materials and semi-finished goods.

Difficulties in using the CPI to accurately measure inflation

Measurement biases

There are many difficulties in using the CPI to get an accurate measure of inflation. For example, if consumers increase the percentage of purchases at 'discount' outlets, the CPI will overstate the actual rate of inflation experienced by the typical consumer. This is called the *'outlet substitution bias'* because the index does not adequately consider such shifts.

In addition, over time consumers will change the composition of the basket of consumer goods which they purchase. The composition of the basket used to calculate the price index is revised on an irregular basis, which results in a bias. Economists identify three different kinds of bias associated with changing baskets: substitution bias, quality change bias, and new product bias. In addition, there is growing recognition of a fourth kind of bias – the formula bias.

Substitution bias refers to the impact that changing relative prices would have on the composition of the basket. If for example, the price of tea rises relative to that of coffee, economic theory suggests that consumers will substitute coffee for tea. However, as the CPI basket might be changed only once per decade, it may be some time before the switch to coffee is reflected. The index will be calculated as if no substitution had occurred, leading to an overstatement of inflation due to a *substitution bias*.

Often when prices rise, this reflects increases of the quality of products (products might last longer or provide a higher level of services). In most cases, it is very difficult to calculate what portion of a price increase should be attributed to quality changes. The Bureau of Labor Statistics (BLS), for example, does not even attempt to calculate this for many products. Thus, inaccurate measures of quality change introduce a *quality change bias*, which would normally be expected to overestimate inflation, because it underestimates the quality changes that justify higher prices.

Thirdly, new products are introduced all the time. The BLS includes these in the basket only with long and variable lags, which introduces a *new product bias* into the CPI. In the case of some goods a considerable bias results. For example, many high technology consumer goods follow a price cycle that begins with very high prices for goods sold to high income classes, then prices fall rapidly as the goods are introduced to lower income classes, and then prices gradually rise again as the market matures. If the BLS introduces the goods into the basket only after prices have reached their minimum, the CPI will not capture the period during which prices fell rapidly, but will include the mature period over which prices rise. In recent years, this bias would be expected to be quite important due to the introduction of new consumer electronics (and the speed with which these can become obsolete).

There is yet another source of bias called the *formula bias*. This bias results because price data are collected on a disaggregated basis and then aggregated in a very complex manner that can introduce anomalies. For example, the calculation method used in recent years gives too much weight to items on sale; somewhat paradoxically, this generates formula-induced inflation as the items go off sale. The degree of this bias can increase with the frequency of rotation (of outlets included in the sample), because the bias results from short-run price variability and the use of a method that gives greater weight to lower-than-average prices.

Researchers had noticed that surveys of average prices actually paid by consumers showed rates of inflation well below the rates of inflation reported by the CPI for relatively disaggregated components of the consumer basket. While part of this could be attributed to the outlet substitution bias, most of it could not. Estimates of the formula bias run as high as six-tenths of a percentage point for owner occupied housing and one percentage point for apparel, an item often on sale.

The housing component

The housing component of the CPI is very large; in the US it is above 40 per cent of the index and during high inflation periods it contributes up to half of measured inflation. There are two ways to calculate the contributions of the housing sector to a price index: the flow of services approach or the homeowner or 'user' cost approach.

The method currently used in the US, imputed rental cost, is based on the flow of services approach and has been in place since 1983. Previously, the BLS had tried to calculate the user cost of housing, but it was believed that this method mixed the investment and consumption features of home ownership.

The largest portion of the housing component is 'shelter' services, which accounts for more than two-thirds of the housing component. Nearly three-quarters of the shelter component reflect owner-occupied costs, since most Americans own their own homes, and the rest are renters' costs. Most homeowners' costs are based on the owners' equivalent rent.

The BLS uses a survey of rental units to obtain data regarding changes of rental price. The results are adjusted through a weighted averaging process, and quality adjustments are made to deal with ageing and improvements. The imputation of renter's costs to be included in the CPI is therefore straightforward.

However, the method used for owners' equivalent rent (OER) is more complicated. Field agents ask owners for the rental price that the homeowner believes the house could secure. Agents may enter their own estimate if they believe the owner's estimate is unreasonable. These survey data are used to establish the base year imputed rent. Subsequent values of implicit rent for a given unit are obtained by applying the rate of increase of prices of rental units that are thought to be similar in certain respects (location, structure type, and quality) to the owner-occupied home.

There are situations in which this method of calculating 'inflation' of the housing component could lead to erroneous results (for example, where the statisticians impute high inflation when actual housing prices are falling). We need not go into that here. Instead, what we want to make clear is that the construction of an index is difficult, subject to controversial decisions, and to error.

Further, it is important to understand that the CPI comprises components that have 'imputed prices', prices formulated by statisticians rather than being obtained from markets. This is because statisticians want to obtain a measure of the cost of a relatively complete consumer basket that includes items that are not bought annually such as housing 'services' enjoyed by those who own their own homes.

There is a trade-off made between calculating a CPI that takes a 'hedonic' approach, by seeking to put a price on the 'enjoyment' received from the entire consumption basket, and one that attempts to focus on what is happening to the market prices of purchased items. The problem with the first is that statisticians must make many guestimates. The problem with the second is that it does not deal adequately with quality adjustments.

What all this means to the student is that you should take CPI measures of the inflation rate with the proverbial grain of salt! Especially at low measured rates of inflation, we cannot be sure if the prices of things people buy are truly rising, steady, or falling.

4.9 Measuring National Inequality

As discussed above, our measures of national output (GDP) and income (GNI) do not directly take account of the distribution of output and income. Economists typically use the **Gini coefficient** which is derived from a **Lorenz curve** as an index of income distribution. The Gini coefficient was developed by the Italian statistician and sociologist Corrado Gini in 1912. The Lorenz curve was devised by the American economist, Max Lorenz in 1905.

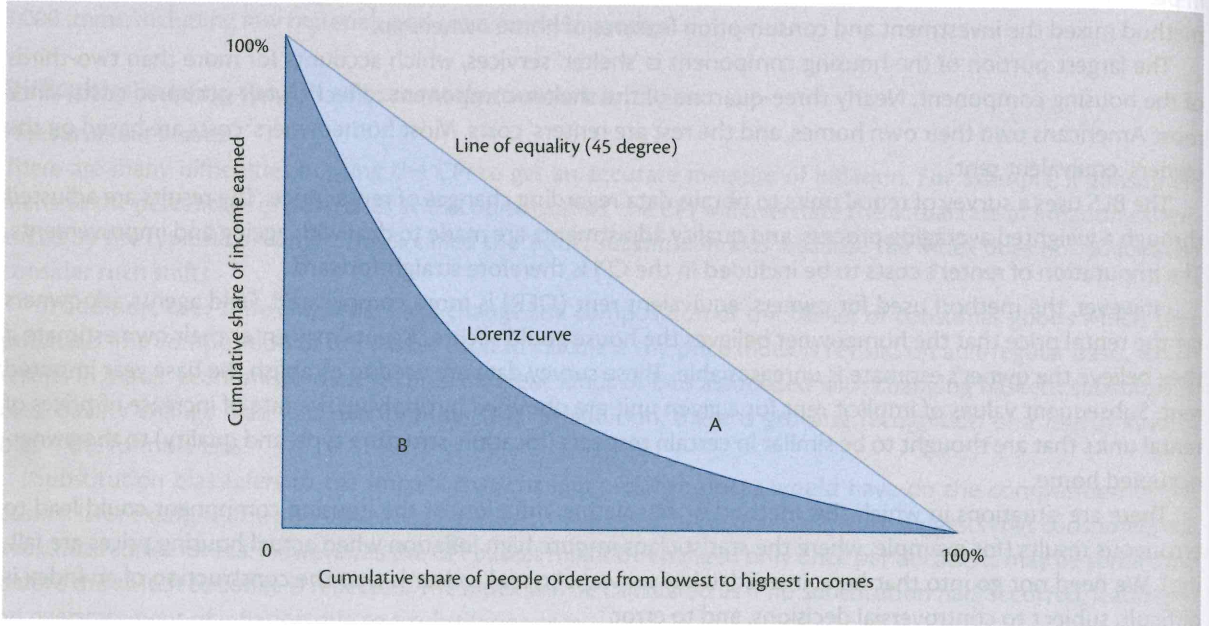
The Lorenz curve plots the share of total income received (vertical axis) by the lowest X per cent of income earners (horizontal axis) (see Figure 4.1). It is easy to see that in our example the distribution is not equal because as we move from the origin at the left end of the horizontal axis, the share of income going to those with the lowest income initially increases slowly. As we move to the higher-income people, the cumulative share of income increases more rapidly. The 45 degree line shows the case of perfect equality, so that 30 per cent of people have 30 per cent of total income; 60 per cent of people have 60 per cent of total income and so on.

We can calculate the Gini coefficient as a ratio, using the two areas, A and B in Figure 4.1:

$$\text{Gini coefficient} = A/(A + B) \quad (4.7)$$

Different-shaped Lorenz curves can generate the same value of the Gini coefficient. In addition, there are different ways to measure income, for example before or after taxes, and before or after income transfers. The Gini coefficient can also be represented by an algebraic formula. There are also alternative indexes to the Gini coefficient.

Figure 4.1 The Lorenz curve



It is important to realise that different indexes exhibit different properties and the choice of which index to use should be made in light of the objectives associated with measuring inequality.

A Gini coefficient of zero means that income is perfectly equally distributed as the Lorenz curve coincides with the line of equality. Alternatively, a Gini coefficient of one means that income is perfectly unequally distributed: that is, one person has all the income.

Table 4.3 shows the Gini coefficients for all the nations that belong to the Organisation for Economic Co-operation and Development (OECD), for which comparable data is available for the years 2004 and 2012. The data are based on disposable income after taxes and transfers. The Gini coefficients mostly range between the values of 0.25 to 0.50. There is considerable diversity among these nations with respect to income inequality. Sweden had the least inequality in 2004, while Mexico had the highest inequality in both years. The USA has the highest inequality of the rich developed nations, while the Scandinavian countries tend to enjoy the lowest inequality. Note also that inequality increased in many nations between 2004 and 2012, while it declined in other nations (indicated by the + and – signs).

Table 4.3 Gini coefficients for several OECD nations, 2004 and 2012

Country	2004	2012	Change
Australia	0.315	0.324	+
Austria	0.269	0.276	+
Belgium	0.287	0.262	–
Czech Republic	0.269	0.252	–
Estonia	0.346	0.326	–
Finland	0.267	0.261	–
France	0.283	0.306	+
Germany	0.285	0.289	+
Greece	0.336	0.340	+
Iceland	0.262	0.252	–
Ireland	0.323	0.302	–
Italy	0.331	0.326	–
Luxembourg	0.263	0.299	+
Mexico	0.474	0.482	+
Norway	0.276	0.253	–
Poland	0.381	0.300	–
Portugal	0.383	0.341	–
Slovak Republic	0.266	0.249	–
Slovenia	0.247	0.251	+
Spain	0.332	0.335	+
Sweden	0.234	0.274	+
United Kingdom	0.331	0.351	+
United States	0.360	0.389	+

Source: Data from OECD Statistics. Gini coefficients for 2012 are based on a new definition of income that includes a more detailed breakdown of "current transfers received and paid by households as well as a revised definition of household income, including the value of goods produced for own consumption as an element of self-employed income." (OECD, 2016).

Conclusion

This chapter introduced the system of National Income and Product Accounts (NIPA), the framework adopted by countries to measure economic activity. Gross domestic product (GDP) and gross national income (GNI) were defined, and the components of each were examined. Some of the difficulties of measuring output were discussed. Alternative ways of measuring growth and inflation were presented, including most importantly the use of the consumer price index. Finally, the text discussed the Lorenz curve, and the Gini coefficient, which is used to measure national inequality.

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Endnote

1. If the production of all final output is vertically integrated, so a single firm is responsible for all stages of the production for each good or service, then there is no intermediate consumption.

Visit the companion website at www.macmillanihe.com/mitchell-macro for additional resources including author videos, an instructor's manual, worked examples, tutorial questions, additional references, the data sets used in constructing various graphs in the text, and more.