Chapter 1

GDP and Inflation

1.1 Objectives of this Chapter

We start this chapter by defining Gross Domestic Product, GDP. GDP is the most useful and important summary statistic describing aggregate domestic production. We explain the conceptual difference between nominal and real GDP and then document the historical behavior of both the nominal and real GDP data. We explain how the growth rate of real GDP is computed and then explain why, under certain conditions, growth in real GDP reflects aggregate changes to well-being.

Next, we show that GDP can be viewed as the sum of four components relating to spending by households, firms, and the government. These four components are Consumption, Investment, Government, and Net Exports. The description of GDP as the sum of these four components is commonly called the "the expenditure method" for computing GDP. We explain why disaggregating GDP into these particular components is useful, and discuss specific patterns in the historical data related to each component.

Next, we note that the rules of accounting imply that aggregate expenditures equal aggregate income. For this reason, GDP can also be measured as the sum of income accruing to all sources. This method of computing GDP is commonly referred to as the "income method." We divide aggregate income earned by all sources into income earned by capital and income earned by labor. We show that the shares of aggregate income earned by capital and labor have been roughly constant over history.

In the final part of the chapter, we define inflation – the rate of change of the price level – and show the historical data on consumer-price inflation in the United States.

1.2 GDP

1.2.1 Definition of GDP

The key difference between microeconomics and macroeconomics is that microeconomists tend to study one market at a time and in isolation, whereas macroeconomists study the interaction of all markets together.

The study of the interaction of all markets sounds like an impossibly complex project. How can we describe the interaction of the production of apples, bananas, computers, cars, airplanes, frozen orange juice, financial services, etc. in one book?

One possibility is to study, in great detail, each market separately and then try to make sense of it all. Macroeconomists employ a different tactic: They add up all of the output that is produced in all of the sectors of the economy (apples, bananas, computers, etc.) and study the sum. This sum is called GDP which stands for "Gross Domestic Product." Nominal GDP is the dollar value of all output – goods and services – produced in the United States. Real GDP is something else: Conceptually, real GDP measures the quantity of all goods and services that are produced.

Let's use a simple example to make these ideas concrete. Suppose everyone in the United States picks apples from trees. Denote the price of apples in U.S.$ in the year 2000 as $p_{a,2000}$ and the number of apples picked in 2000 as a_{2000}. Nominal GDP in U.S.$ in 2000 would equal $p_{a,2000} * a_{2000}$ (the price of apples times the number of apples picked), and real GDP would equal a_{2000}, the number of apples picked. Growth in nominal GDP between 2000 and 2001 would be

$$\frac{p_{a,2001} * a_{2001}}{p_{a,2000} * a_{2000}},$$

and growth in real GDP would be

$$\frac{a_{2001}}{a_{2000}}.$$

In this simple example, growth in nominal GDP is equal to growth in real GDP multiplied by growth in apple prices. Real GDP increases when more apples are picked. Nominal GDP increases more rapidly than real GDP when the price of apples increases.

Suppose that the only argument in the utility function of households in the United States is the quantity of apples. In this case, positive growth of real GDP tells us that standards of living have increased: There are more apples and thus more utility. Growth in nominal GDP is less informative about changes to standards of living. If nominal GDP increases because apple prices have increased, but the production of apples has not changed, then household utility is unchanged. Thus, a key idea in this chapter is that growth in real GDP, and not nominal GDP, is informative about changes to aggregate production.

It gets tricky to think about the relevance or even the measurement of something called GDP if more than one good is produced in the economy. Suppose that everyone in the United States either picks apples or bananas from trees. Denoting the price of bananas in U.S.$ in 2000 as $p_{b,2000}$ and the quantity picked of bananas in 2000 as b_{2000}, nominal GDP in U.S.$ in 2000 would equal $p_{a,2000} * a_{2000} + p_{b,2000} * b_{2000}$: This is the sum of the value of all apples picked and all bananas picked. In this sense, nominal GDP is quite easy to measure: Just add up the dollar value of everything that is produced![1]

But how would we go about defining and measuring real GDP such that changes to real GDP are informative of changes to aggregate production? For example, suppose 5 apples and 10 bananas are picked in 2000 and 4 apples and 11 bananas are picked in 2001. More bananas are picked in 2001 than in 2000, but fewer apples. Has aggregate production increased or decreased?

Here is an accurate approximation of the procedure that has been established. First, a base year (currently 2000) is arbitrarily chosen in which real GDP equals nominal GDP. Then, real GDP in 2001 is approximately[2] computed as the price of apples and bananas in 2000 times the quantity of apples and bananas picked in 2001:

$$p_{a,2000} * a_{2001} + p_{b,2000} * b_{2001}.$$

Given this definition, the percentage growth in real GDP in 2001 is computed as follows:[3]

$$\frac{\text{real } GDP_{2001}}{\text{real } GDP_{2000}} - 1.0 \quad = \quad \frac{p_{a,2000} * a_{2001} + p_{b,2000} * b_{2001}}{p_{a,2000} * a_{2000} + p_{b,2000} * b_{2000}} - 1.0.$$

With some algebra, real GDP growth from 2000 to 2001 reduces to an interesting and convenient expression:

$$= \left(\frac{p_{a,2000}*a_{2001}}{p_{a,2000}*a_{2000}+p_{b,2000}*b_{2000}}\right) + \left(\frac{p_{b,2000}*b_{2001}}{p_{a,2000}*a_{2000}+p_{b,2000}*b_{2000}}\right) - 1.0$$

$$= \left(\frac{p_{a,2000}*a_{2000}}{p_{a,2000}*a_{2000}+p_{b,2000}*b_{2000}}\right)\left(\frac{a_{2001}}{a_{2000}}\right) + \left(\frac{p_{b,2000}*b_{2000}}{p_{a,2000}*a_{2000}+p_{b,2000}*b_{2000}}\right)\left(\frac{b_{2001}}{b_{2000}}\right) - 1.0$$

$$= \widehat{\phi}_{2000}\left(\frac{a_{2001}}{a_{2000}}\right) + \left(1 - \widehat{\phi}_{2000}\right)\left(\frac{b_{2001}}{b_{2000}}\right) - 1.0.$$

[1] Although measuring nominal GDP seems easy, in practice it requires the full-time work of a staff of many economists.

[2] The way real GDP growth between 2000 and 2001 is computed in this example is not completely accurate for technical reasons discussed later.

[3] For any two numbers x_1 and x_2, the percentage difference of x_1 and x_2 is $(x_2 - x_1)/x_1 = x_2/x_1 - 1.0$.

The second equation follows from the first because a_{2001} is identically equal to $a_{2000} * \frac{a_{2001}}{a_{2000}}$ (and b_{2000} has a similar expression). In the third equation, we have defined the variable $\widehat{\phi}_{2000}$ as

$$\widehat{\phi}_{2000} = \frac{p_{a,2000} * a_{2000}}{p_{a,2000} * a_{2000} + p_{b,2000} * b_{2000}}.$$

$\widehat{\phi}_{2000}$ is the measured expenditure share on apples in 2000 – it is the fraction of nominal GDP attributable to the value of apples. Analogously, $1 - \widehat{\phi}_{2000}$ is the measured expenditure share on bananas in 2000.

In other words, we have shown that real GDP growth from 2000 to 2001 is equal to the measured expenditure share on apples in 2000 multiplied by the growth in the quantity of apples between 2000 and 2001 plus the measured expenditure share on bananas in 2000 multiplied by the growth in the quantity of bananas.

Real GDP growth from 2001 to 2002 is defined analogously:

$$\begin{aligned} \frac{\text{real } GDP_{2002}}{\text{real } GDP_{2001}} - 1.0 &= \frac{p_{a,2001} * a_{2002} + p_{b,2001} * b_{2002}}{p_{a,2001} * a_{2001} + p_{b,2001} * b_{2001}} - 1.0 \\ &= \widehat{\phi}_{2001} \left(\frac{a_{2002}}{a_{2001}} \right) + \left(1 - \widehat{\phi}_{2001} \right) \left(\frac{b_{2002}}{b_{2001}} \right) - 1.0. \end{aligned}$$

It is the measured expenditure share on apples in 2001 multiplied by the growth in the quantity of apples from 2001 to 2002 plus the measured expenditure share on bananas in 2001 multiplied by the growth in the quantity of bananas from 2001 to 2002.

It is important to emphasize that the level of real GDP is totally meaningless, since the base year for which nominal GDP and real GDP coincide is arbitrarily chosen. However, growth in real GDP does not depend on the base year baseline level of real GDP. One way to see this is to reconsider growth in real GDP between 2000 and 2001, but divide both the numerator and denominator of the mathematical expression by the price of apples in 2000, $p_{a,2000}$:

$$\frac{\text{real } GDP_{2001}}{\text{real } GDP_{2000}} - 1.0 = \frac{p_{a,2000} * a_{2001} + p_{b,2000} * b_{2001}}{p_{a,2000} * a_{2000} + p_{b,2000} * b_{2000}} - 1.0$$

$$= \frac{a_{2001} + b_{2001} * \left(\frac{p_{b,2000}}{p_{a,2000}}\right)}{a_{2000} + b_{2000} * \left(\frac{p_{b,2000}}{p_{a,2000}}\right)} - 1.0 \ .$$

The numerator and denominator of the expression above are equal to real GDP in 2001 and 2000, respectively, in units of apples at year-2000 prices (rather than real GDP in constant year-2000 dollars). The denominator represents the quantity of apples picked in 2000 assuming all bananas picked in 2000 are exchanged for apples at the market price for apples in 2000 (this is the $b_{2000} * (p_{b,2000}/p_{a,2000})$ term). The numerator represents the quantity of apples picked in 2001 assuming that all bananas picked in year 2001 can be exchanged for apples at year-2000 relative prices for bananas and apples.

The simple example in Table 1.1 further highlights the irrelevance of the level of real GDP and the importance of growth in real GDP. Note the expenditure share on apples in 2000 in this table is 40 percent ($0.4 = \$100/\$250$) and the expenditure share on bananas is 60 percent. According to the expenditure share method, growth in real GDP between 2000 and 2001 is -2.0%:

$$0.4 * \left(\frac{4}{5}\right) + 0.6 * \left(\frac{11}{10}\right) - 1.0 = -0.02 \ .$$

In terms of constant \$2000, real GDP is \$250.00 in 2000 and \$245 in 2001. The \$245 value for real GDP in 2001 reflects -2% real GDP growth between 2000 and 2001, i.e. $\$245 = \$250 * (1.0 - 0.02)$.

Table 1.1: Simple GDP Example

Year	a	p_a	b	p_b	$a * p_a$	$b * p_b$	Nom. GDP	Real GDP $2000	Real GDP apple equiv.
2000	5	$20.0	10	$15.0	$100.0	$150.0	$250.0	$250.0	12.50
2001	4	$25.0	11	$15.5	$100.0	$170.5	$270.5	$245.0	12.25

If we were to compute real GDP in apple equivalents at year-2000 relative prices, we would compute real GDP to be 12.50 apple equivalents in the year 2000 and 12.25 apple equivalents in the year 2001:

$$\begin{aligned} \text{Year 2000:} \quad 12.50 &= 5 + 10 * \left(\frac{\$15.00}{\$20.00}\right) \\ \text{Year 2001:} \quad 12.25 &= 4 + 11 * \left(\frac{\$15.00}{\$20.00}\right) . \end{aligned}$$

Growth in real GDP when measured in apple equivalents is 12.25/12.50 - 1.0 = -0.02 (-2.0%), which is identical to growth in real GDP between 2000 and 2001 when GDP is measured in constant $2000. This example demonstrates that the growth rates of real GDP do not depend on whether the level of real GDP is measured in apple-equivalents or in constant $2000.

There are a few more facts about real GDP of which you should be aware

- In our examples, we updated the expenditure shares every year when calculating growth in real GDP. In other words, to compute real GDP growth from 2000 to 2001, we used year-2000 expenditure shares, and to compute real GDP growth from 2001 to 2002, we used year-2001 expenditure shares. If we had worked with quarterly examples, we would have updated expenditure shares every quarter. The period-by-period updating of expenditure shares is consistent with current practice at the government agency that constructs the GDP data, the Bureau of Economic Analysis (BEA).[4]

- As a technical aside, note that the BEA does not use previous-year expenditure shares to compute real rates of growth from period to period. Rather, the BEA averages expenditure shares

[4]Before 1996, the BEA held expenditure shares fixed at some base year, and the base year was updated every 5 years. This method led to large revisions in estimated real rates of growth after base years were updated – expenditure shares on certain items (for example, computer software) have changed markedly over time.

from the current and previous periods in its computations. I have defined real GDP growth using previous-period expenditure shares so the link between GDP growth and welfare is exact, discussed later in this chapter.

- In earlier decades, macroeconomists studied GNP, "Gross National Product," which is the output of all citizens, not all of which is necessarily produced on U.S. soil. In this book I focus on GDP, which has become the preferred measure.

1.2.2 GDP and Welfare

Growth in real GDP as we have calculated it provides a quick summary of the pace at which production of goods and services across the entire economy has been increasing. But, does real GDP growth (the way we have measured it) inform us of changes to living standards? It turns out, under certain assumptions, that we can map changes to utility with changes to real GDP growth.

As you may have learned in your microeconomics class, the mathematical function that determines a ranking of household preferences over different combinations of goods is called as a utility function; and, in your previous classes, you may have seen many different kinds of utility functions. For our purposes, suppose households have time-invariant preferences – preferences that do not change over time – for apples and bananas that is described by the following utility function

$$\phi \ln(a) + (1-\phi)\ln(b), \tag{1.1}$$

with $0 < \phi < 1$. Given production of a_{2000} apples and b_{2000} bananas in 2000, utility in 2000 is

$$u_{2000} = \phi \ln(a_{2000}) + (1-\phi)\ln(b_{2000}).$$

Likewise, utility in 2001 given a_{2001} apples and b_{2001} bananas produced in 2001 is

$$u_{2001} = \phi \ln(a_{2001}) + (1-\phi)\ln(b_{2001}).$$

How does u_{2001} compare to u_{2000}? $u_{2001} - u_{2000}$ is equal to

$$= [\phi \ln(a_{2001}) + (1-\phi)\ln(b_{2001})] - [\phi \ln(a_{2000}) + (1-\phi)\ln(b_{2000})]$$

$$(1.2) = \phi [\ln(a_{2001}) - \ln(a_{2000})] + (1-\phi) [\ln(b_{2001}) - \ln(b_{2000})]$$

$$(1.3) \qquad = \phi \ln\left(\frac{a_{2001}}{a_{2000}}\right) + (1-\phi)\ln\left(\frac{b_{2001}}{b_{2000}}\right)$$

$$(1.4) \qquad = \phi \ln\left(1 + \frac{a_{2001}-a_{2000}}{a_{2000}}\right) + (1-\phi)\ln\left(1 + \frac{b_{2001}-b_{2000}}{b_{2000}}\right)$$

$$(1.5) \qquad \approx \phi \left(\frac{a_{2001}-a_{2000}}{a_{2000}}\right) + (1-\phi)\left(\frac{b_{2001}-b_{2000}}{b_{2000}}\right)$$

$$(1.6) \qquad = \phi \left(\frac{a_{2001}}{a_{2000}}\right) + (1-\phi)\left(\frac{b_{2001}}{b_{2000}}\right) - 1.$$

Equation (1.3) follows from equation (1.2) because of the properties of the natural logarithm;[5] Equation (1.5) approximately follows[6] from (1.4) because of the properties of the derivative of the natural logarithm.[7] Equation (1.6) follows from (1.5) from simple algebra.

In the appendix, we prove that when households have preferences for apples and bananas as given by equation (1.1), ϕ is the optimal household expenditure share on apples and $1-\phi$ is the optimal household expenditure share on bananas. Assuming that $\widehat{\phi}$, the measured expenditure share on apples, is equal to ϕ, the household preference parameter, then the change in utility derived in equation (1.6) is the same as measured growth in real GDP. Restated, if household preferences are such that expenditure shares are constant over time, and all of GDP is consumed in each period (discussed later), then utility in 2001 is greater than utility in 2000 when measured real GDP growth from 2000 to 2001 is positive.

---

[5] See the appendix for details.

[6] The $\approx$ sign means "approximately."

[7] See footnote 5.

1.2.3 Historical Behavior of Nominal and Real GDP

Detailed data for nominal and real GDP and its components (described later in this chapter) are available in a collection of tables called the National Income and Product Accounts or NIPA. The government statistical agency in charge of collecting data used in the NIPA is the Bureau of Economic Analysis (BEA). The NIPA are available for free download at the BEA's web site, *http://www.bea.gov/*. Click on the "Gross Domestic Product (GDP)" link, then click on the "Interactive Tables: GDP and the National Income and Product Account (NIPA) Historical Tables" link, and then click on the "list of All NIPA Tables" link. The top-line estimates for GDP and its components are in tables 1.1.5 (nominal) and 1.1.6 (real). Details on the individual components of GDP are available in some of the other tables. In 2007, nominal annual GDP was \$13,841.3 billion and annual real GDP was \$11,566.8 billion (base year 2000).[8]

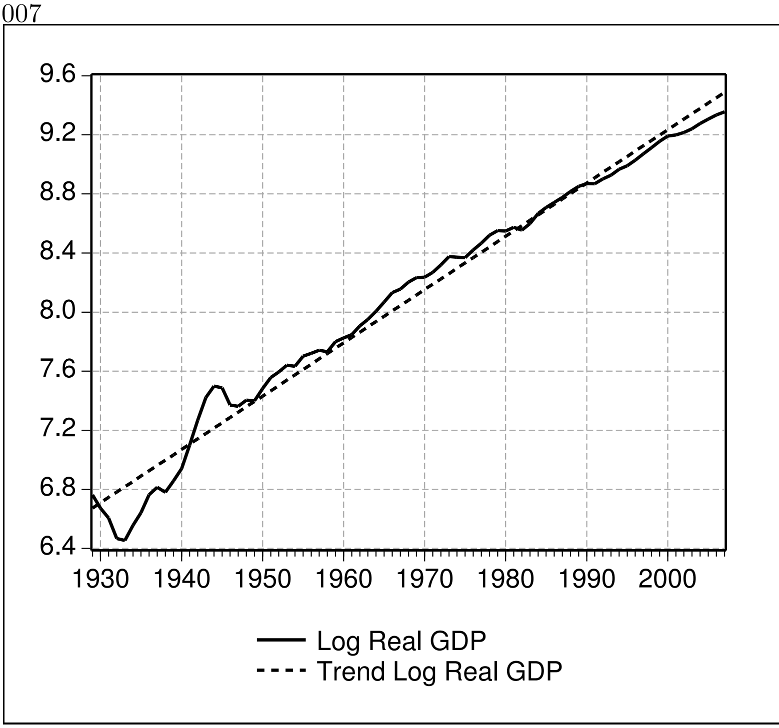
One of the interesting properties of real GDP is that real GDP has increased at a roughly a constant rate over the past century. The natural logarithm of annual real GDP (the solid line) is graphed in figure 1.1 from 1929, the first year of the annual NIPA data, to 2007. Also on the figure is a "trend" line, the dotted line, which represents the path for log real GDP if log real GDP had increased by a fixed amount in each year over history.

Note that if trend log real GDP increases by g units in each period, then the growth rate of trend real GDP increases by $100 * g$ percent in each period. To see this, denote y_t^* as trend real GDP. When $\ln\left(y_{t+1}^*\right) - \ln\left(y_t^*\right) = g$, this implies:

$$
\begin{aligned}
g = \ln\left(y_{t+1}^*\right) - \ln\left(y_t^*\right) &= \ln\left(\frac{y_{t+1}^*}{y_t^*}\right) \\
&= \ln\left(1 + \frac{y_{t+1}^* - y_t^*}{y_t^*}\right)
\end{aligned}
$$

[8]In the NIPA accounts, real variables (such as real GDP) are reported in units of "Billions of chained (2000) dollars."

Figure 1.1: Annual Log Real GDP and "Trend" Log Real GDP, 1929-2007



$$\approx \quad \frac{y^*_{t+1} - y^*_t}{y^*_t} \,,$$

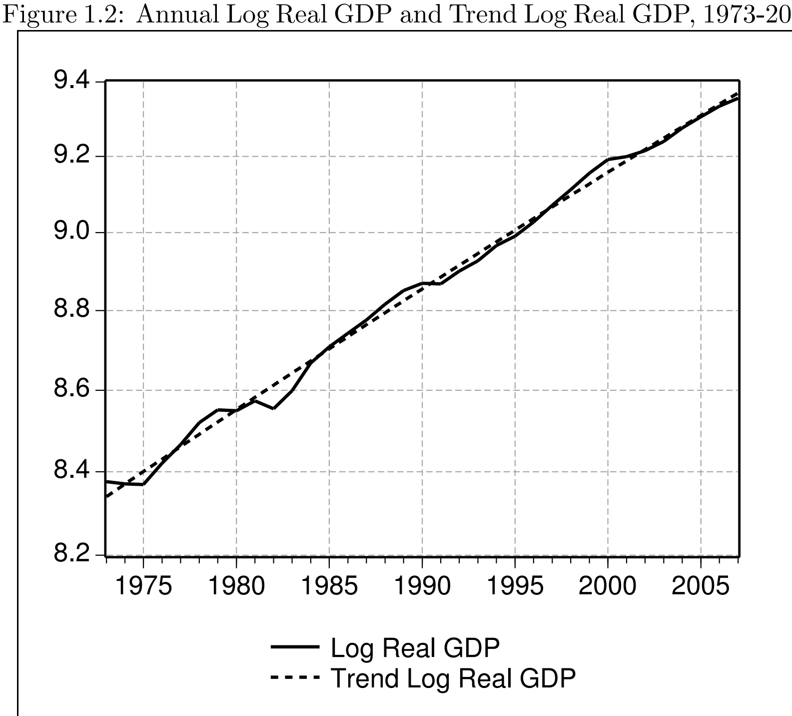
where $\left(y^*_{t+1} - y^*_t\right)/y^*_t$ is the rate of growth of trend GDP. The first two equations are from properties of the natural logarithm. The last equation is from the first-order Taylor series approximation that $\ln(1+z) \approx z$ for z close to zero.[9]

The constant change in trend log GDP shown in the dotted line in figure 1.1 is 0.036, implying that the average rate of growth of real GDP over the entire 1929-2009 period is 3.6 percent per year. As evidenced

[9]See the Appendix for details.

by the fact that log real GDP has been below the dotted-line trend since 1990, the trend rate of growth of real GDP has not been constant over the entire 1929-2007 period.[10] That said, it appears that trend real GDP growth has been about constant since 1973. When we re-estimate trend log real GDP the 1973-2007 period and graph log real GDP alongside its trend over this time period, we uncover quite a tight fit, shown in figure 1.2. The change in trend log real GDP over the 1973-2007 period is 0.030, implying real GDP increased on average by about 3.0 percent per year since 1973.

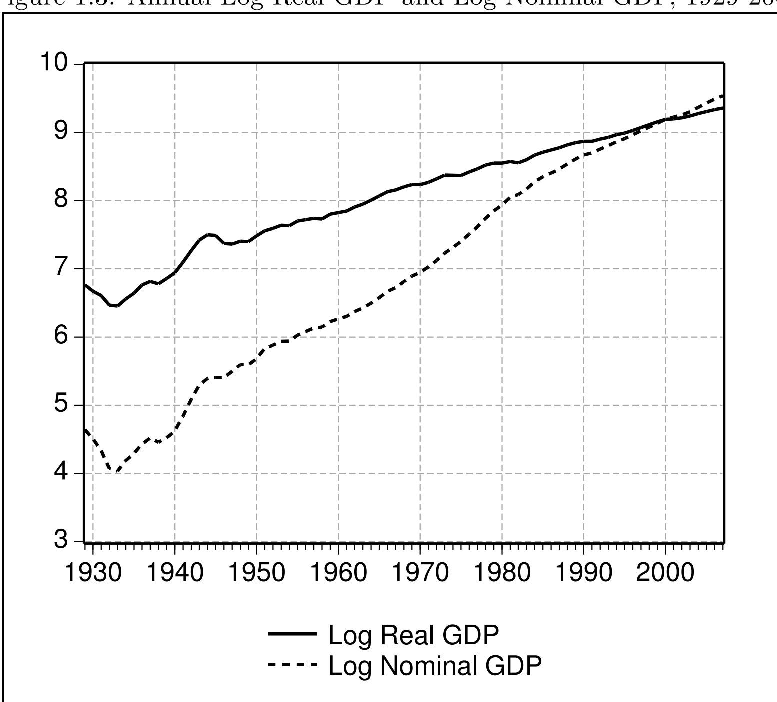
Figure 1.2: Annual Log Real GDP and Trend Log Real GDP, 1973-2007



[10]We discuss the issue of the measurement of trend log GDP in great detail in chapter 5.

Figure 1.3 graphs the natural logarithms of nominal and real GDP together. This figure shows that nominal GDP (dotted line) has increased at a faster rate than real GDP (solid line), especially after 1950. There have been two rather important episodes where prices of goods and services have increased relatively quickly: In the period following World War II, in which wartime price controls were relaxed and the average price of goods and services adjusted upward, and in the 1970s, when policymakers at the Federal Open Market Committee (FOMC) forgot how to control the rate of inflation.

Figure 1.3: Annual Log Real GDP and Log Nominal GDP, 1929-2007



1.2.4 Caveats

In practice, GDP does not measure all of the output produced in the U.S. economy. For example, all work done at home that is non-marketed but still produced (such as child-care, laundry, home-cooked meals, etc.) is not included as GDP. One reason that per-capita GDP of the richest set of countries in much higher than the per-capita GDP of the poorest set of countries – a fact we discuss further in chapter 2 – is that more goods and services tend to be produced at home rather than purchased in the marketplace in poorer countries.[11]

Second, growth in real GDP only tracks growth in living standards if all of GDP is consumed each period. If some of GDP is set aside as investment, then changes in GDP growth arising solely due to changes in investment rates are not necessarily linked to changes in current living standards. The concepts of consumption and investment are explained in more detail in the next section.

1.3 Components of GDP

As noted earlier, we are not going to separately keep track of all the apples, bananas, computers, etc. that go into GDP. But, we will keep track of the uses of GDP. Specifically, all of output (GDP) is used somehow, and the standard macroeconomic accounting for how GDP is divided into its uses is:

$$GDP \equiv C + I + G + (X - M). \tag{1.7}$$

(The triple equals sign means "is defined as.") C stands for private consumption; I for private investment; G for government spending (di-

[11]Under reasonable assumptions about how output is produced at home, accounting for the value of output produced at home reduces the gap of income per person between the richest and poorest countries. See Parente, S., R. Rogerson, and R. Wright, 2000, "Homework in Development Economics: Household Production and the Wealth of Nations," Journal of Political Economy, vol. 108, p. 680-687.

vided into government consumption and government investment for both federal and state and local governments); and $X - M$ for net exports or exports (X) less imports (M).[12] This is called the "expenditure method" for measuring GDP, since it measures output by keeping track of how output is spent.

Forget the net exports for a second: Here's the way to think about the other pieces. We combine capital, labor, and technology to produce output. This output is allocated by households, firms, and the government into government spending (G), private consumption (C), and private investment (I).

1.3.1 Private Consumption

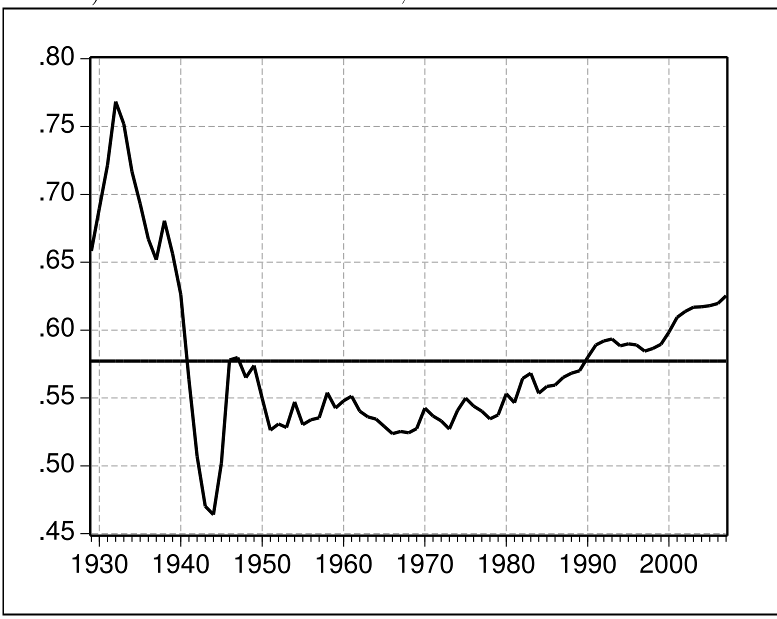
Private Consumption, hereafter called consumption, is anything that gives us utility this period, that cannot also give us utility next period. An easy example of consumption is the eating of an apple. When we eat an apple, we receive some utility. Once the apple is fully eaten, it does not provide any more utility.

In future chapters, when we define our theory of household behavior, our utility functions will have consumption as an argument. We will assume that the utility our households receive in period t is explicitly linked to period t consumption. This means that quarter-to-quarter movements of real GDP (inclusive of consumption, investment, government spending, and net-exports) will not exactly track quarter-to-quarter changes to utility and welfare, since GDP can change when investment changes, holding consumption constant.

In terms of measurement, sometimes consumption is reasonably easy to measure: haircuts, restaurant meals, electricity used, etc. A few components of consumption are quite tricky to measure, specifically the consumption services generated by a durable good, such as a

[12] This equation exactly holds for nominal GDP but may not exactly hold for real GDP for relatively unimportant reasons.

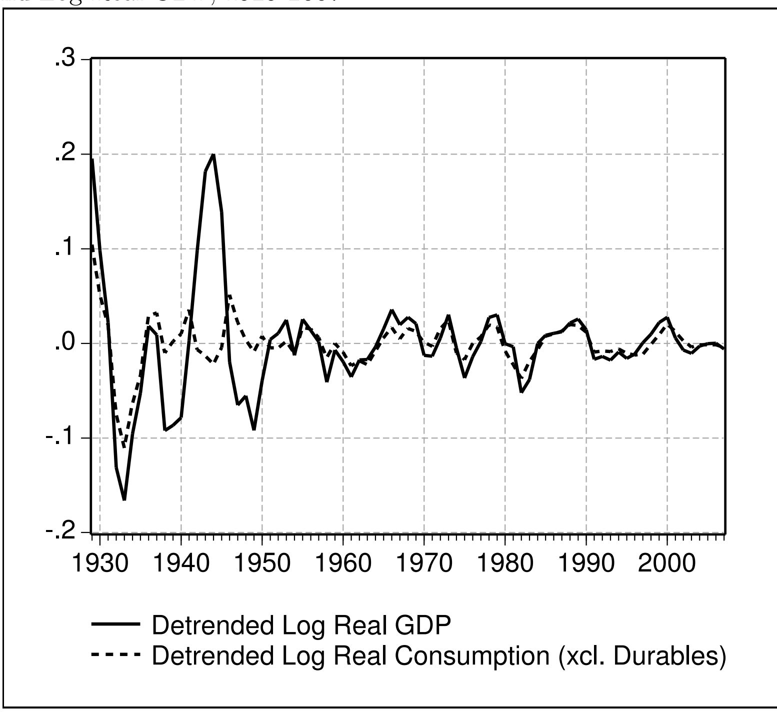
Figure 1.4: Ratio of Annual Nominal Consumption (Excluding Durables) to Annual Nominal GDP, 1929-2007



house. In the case of housing, economists try to measure the value of a flow of nonstorable services that housing spins-off each period. Explaining, houses can last 80 years or more, so we wouldn't want to include the whole value of a house as consumption today – because we know that the same house will provide some consumption services tomorrow. Instead, we try to measure how much it would cost to rent the house for one period. That rental price is counted as the value of consumption of housing services for that house for the current period. For this reason, GDP includes imputed rents to owner-occupied housing as part of consumption.

Unfortunately, the BEA gets the accounting wrong, for lack of a better word, with other durable goods such as cars, furniture, eyeglasses, etc. In the NIPA accounts, the BEA assumes that households consume

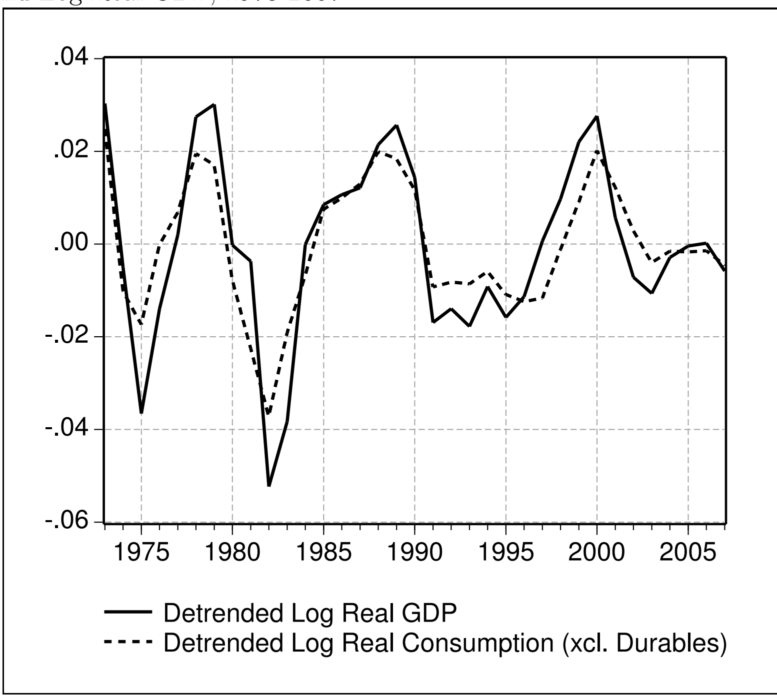
Figure 1.5: Detrended Log Real Consumption (Excluding Durables) and Log Real GDP, 1929-2007



all the value of these other durable goods in the period in which the purchase occurs, which is clearly incorrect since durable goods provide services over the course of many years. In the case of automobiles, for example, a better measurement system might use leasing rates to determine period-by-period consumption.[13]

[13]The BEA knows that it is incorrectly computing the consumption flow from durables. However, the BEA follows the internationally-approved standards of National Income Accounting known as "SNA 93," and the international body that sets these standards refuses to recognize that cars, furniture, and other durable goods produce services that last longer than one quarter.

Figure 1.6: Detrended Log Real Consumption (Excluding Durables) and Log Real GDP, 1973-2007



For the past 50 years or so, consumption (excluding the line-item "consumption of durable goods," which, as discussed, is not properly-measured consumption) has accounted for about 58 percent of GDP, shown in figure 1.4.[14] In 2007, annual nominal consumption exclusive of durables was \$8,656.0 billion and annual real consumption exclusive of durables was approximately \$7,042 billion (base year 2000).

One of the interesting and important properties of real consumption is that it fluctuates less around its trend than real GDP – Using jargon, economists say that consumption is "smoother" than GDP. To

[14]The exact average over the 1929-2007 period is 57.7 percent.

show the relative magnitude of the fluctuations, figure 1.5 plots deviations of log real consumption (exclusive of real durable-goods purchases) from its trend – called "detrended log real consumption" in the graph – alongside deviations of log real GDP from its trend (detrended log real GDP). By graphing the detrended log series, the graph shows the volatility of percentage changes to real consumption and real GDP.[15] Certainly prior to 1950, real GDP was more volatile than real consumption, but this has also been true in more recent years as well. Figure 1.6 plots the same data as figure 1.5, but for the 1973-2007 period. In the 1973-2007 sample, consumption is about 72 percent as volatile as GDP.[16]

Recall that GDP is defined as $C + I + G + (X - M)$. Since consumption is less volatile than GDP, the extra volatility in real GDP must arise from volatility in private investment, government spending, or net exports.

1.3.2 Private Investment

Investment does not provide us with any utility today. Rather, investment is anything that we store away today for the purposes of producing consumption at some point (or at all points) in the future.

A straightforward view of production that we expand on in chapter 2 of this book is that we combine labor, technology, and capital to produce output. Investment maintains or increases the stock of productive capital. In other words, there is a tight accounting relationship between the stock of capital we use to produce output and the flow of

---

[15] Both annual log real consumption and annual log real GDP have been detrended using the "HP-Filter" with smoothing parameter $\lambda = 100$. We discuss the HP-Filter and issues relating to the detrending of variables in detail in chapter 5.

[16] Specifically, the standard deviation of detrended log real consumption (excluding durables) in the 1973-2007 sample is 1.4. The same statistic for detrended log real GDP is 1.9.

investment we use to maintain and increase our stock of capital. This relationship is as follows:

$$K_{t+1} = K_t - \delta K_t + I_t.$$

The above equation says that the stock of capital in period $t+1$, K_{t+1}, is equal to the stock of capital in period t, K_t, less some capital that has depreciated (i.e. become worn out or obsolete during the period) defined as δK_t, plus the flow of any new investment during the period I_t. The parameter δ represents the depreciation rate on capital.

Figures 1.7 and 1.8 graph the ratio of investment ("Gross Private Domestic Investment") to GDP from 1929-2007 and the detrended log real investment and detrended log real GDP over the sample period 1973-2007.[17] The share of GDP attributable to private investment has been roughly stable since 1950 at about 16 percent; including the pre-1950 data lowers the average investment share to 14 percent. In 2007, annual nominal investment was $2,125.4 billion and annual real investment was $1,825.5 billion (base year 2000). Figure 1.8 shows that even in the relatively stable 1973-2007 period, the standard deviation of detrended log investment is about 4-1/2 times more volatile than that of detrended log real GDP.[18]

1.3.3 Government Spending

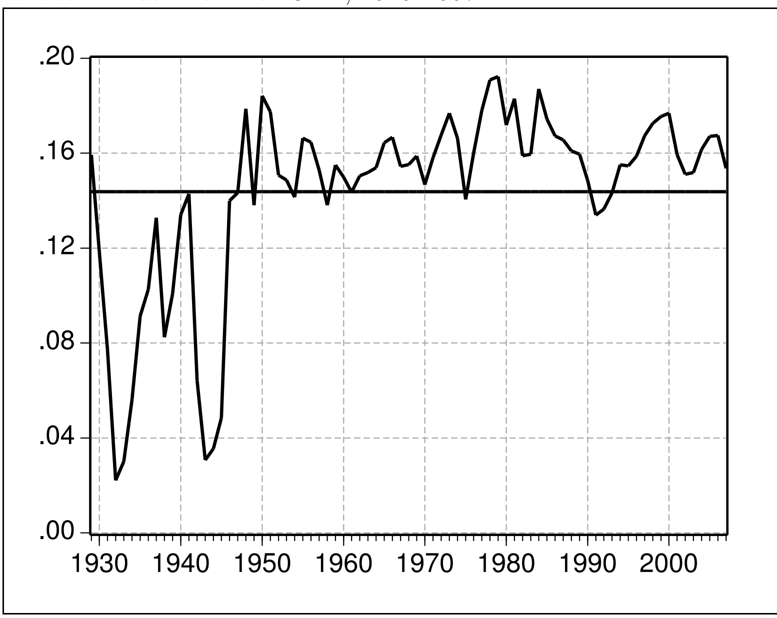
Government spending in the NIPA is subdivided into spending by the federal government on national defense and non-defense items, and,

---

[17] Detrended log real investment is defined analogously to detrended log real consumption and detrended log real GDP. I omit data prior to 1973 because these data are a more extreme version of the post-1973 data.

[18] The ratio of the standard deviation of detrended log real investment to detrended log real GDP in the 1973-2007 period is 4.44. As in the case of figure 1.6, both annual log real GDP and annual log real investment have been detrended using the HP-Filter with smoothing parameter $\lambda = 100$.

Figure 1.7: Ratio of Annual Nominal Gross Private Domestic Investment to Annual Nominal GDP, 1929-2007

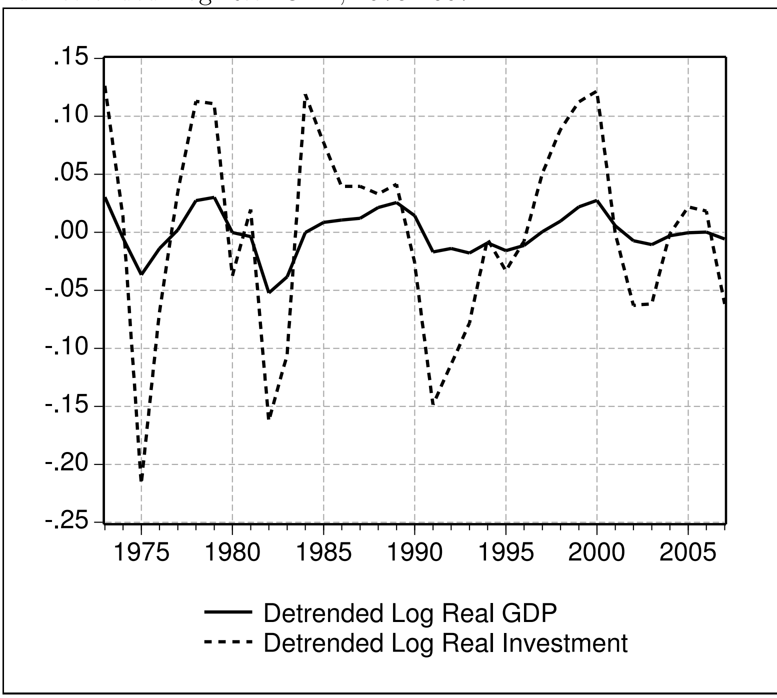


spending by state and local governments. The spending itself is further classified as consumption or investment: For details, see NIPA table 3.9.5, "Government Consumption Expenditures and Gross Investment." Although the share of GDP accounted for by government expenditures has been relatively stable since 1950 at about 20 percent (not shown), the percentage of government expenditures accounted for by the state and local governments (as compared to the federal government) has varied quite a bit.

Table 1.2 shows how the BEA classifies nominal annual government spending in the NIPA in 2007. Notice that in 2007 state and local consumption accounts for most of government spending.[19] It might seem

[19]Much of state and local consumption spending is dedicated to educational

Figure 1.8: Detrended Log Real Gross Private Domestic Investment and Detrended Log Real GDP, 1973-2007



odd that state and local expenditures account for most of government expenditures, even though the federal government collects quite a bit more in taxes.[20] The reason is that much of the tax revenue and other

spending. According to NIPA table 3.16, in 2006 state and local governments spent \$577 billion on education (elementary, secondary, and higher). A case can be made that this spending is actually investment – the government is educating a work force, and the education itself is a long-lived asset that economists call "Human Capital."

[20]According to NIPA tables 3.2 (Federal) and 3.3 (State and Local), in 2007 the federal government collected \$2,673.5 billion in receipts and state and local governments collected \$1,886.4 billion.

receipts collected by the federal government is simply transferred back to people via social security or Medicare; it is never actually "spent" by the federal government. This is less true for state and local governments.

Table 1.2: Annual Nominal Government Expenditures in 2007

Federal: National Defense	Consumption	\$578.9
	Investment	\$81.2
Federal: Nondefense	Consumption	\$277.2
	Investment	\$38.7
State and Local	Consumption	\$1,365.9
	Investment	\$347.9

The fact that government expenditures, as measured in the NIPA, are not necessarily linked to tax revenues is related to another important point, which is that government expenditures in GDP-accounting are also not related to government tax surpluses or deficits. Suppose we are in an economy where the government is running a deficit and is financing purchases via some fresh debt in addition to income taxes. Also suppose for simplicity that net exports $(X - M)$ in the economy are zero. Assuming households use what is left of their income to purchase consumption or investment, or to purchase the newly issued government debt, income-accounting at the household level looks like:

$$C + [I + B] = [Y - T]\,. \tag{1.8}$$

Disposable income, income net of taxes collected by the government, is defined as $Y - T$. This income-accounting equation simply says that income net of taxes $(Y - T)$ is either consumed C or saved by households. Households save when they purchase new investment goods (I) or purchase bonds from the government B. Government bonds are a form of saving by households since the government is committing to repay the bonds, with interest, at some point in the future. In this example, we have assumed, for simplicity, that all new debt that the government issues B is bought by households in the U.S.

Since we have set $X - M = 0$, we can use equation (1.7) to rewrite the household budget constraint in a way that makes GDP-accounting clear. As long as aggregate pre-tax household income Y is equal to GDP, then

$$C + I + [T + B] = Y.$$

Thus, NIPA accounting implies that government spending G is equal to tax revenues raised plus net debt issuance, $T + B$. The fact that the government did not collect enough tax revenue to finance its spending does not affect our accounting of overall government spending.

If you stare at equation (1.8) long enough, you might convince yourself that government deficits B crowd out (replace) private investment I. The thinking might go like this: Households decide how much they want to save out of after-tax income, and that household saving is split between private investment I and new government bonds B. So the higher government debt and B is, the lower private investment and I will be. That said, a different view is as follows: There is a fixed amount of output in the aggregate that can be produced in any given year, and the government claims some of that output. If the government claims more of aggregate output for its own use – that is, G increases – that leaves less output for households to spend on either C or I.[21] Because households might like to keep their consumption C roughly constant and smooth – a property of consumption we noticed in the data – then private investment I might decline. In this sense,

[21] This is consistent with a view of production that suggests that, at any given time, the economy-wide resources that can be used for production, capital and labor, are essentially fixed. Thus, if the government wants more missiles (say), then the capital and labor used to make missiles cannot simultaneously be used to make private consumption or investment goods.

government purchases might crowd out private investment. But this is not the same as government debt, since government spending can be financed with either debt or taxes

1.3.4 Net Exports

We discuss trade and net exports in chapter 4 of the book. For now, I don't have much to say about net exports other than net exports allow the sum of C, I, and G to be greater or less than GDP. Recall the GDP accounting equation

$$\text{GDP} \equiv C + I + G + (X - M).$$

Suppose for simplicity that government spending G is zero. Now suppose that C is equal to GDP. This does not imply that investment is zero. Rather, GDP accounting requires that investment, I, is equal to imports less exports $M - X$. In the situation we have described, foreigners (the suppliers of imports) are financing all domestic investment and thus foreigners own claims to the stock of capital in the U.S. This observation directly follows from the capital-accounting equation,

$$K_{t+1} = K_t - \delta K_t + I_t.$$

Since I_t is financed by non-U.S. residents, they acquire a claim to the stock of capital in the U.S. Therefore, in this scenario (which is not too far removed from the situation in the U.S. in 2007) (a) consumption is high and (b) net exports are negative. This implies that U.S. residents are selling their stock of capital to finance investment.

When net exports in the United States are negative, as they are now, a lot of opinion pieces in the newspapers suggest that U.S. residents are wasteful and irresponsible. That is, the overwhelming desire for consumption today in the U.S. has led to a big trade deficit, which itself implies that U.S. residents are financing current consumption by selling off wealth (and thus potentially reducing future prosperity). This kind of rhetoric is effective in scaring folks that have a fairly advanced background in economics.

In a sense, this rhetoric is correct – the U.S. is selling assets to finance consumption. But, a different and more optimistic story about health of the U.S. economy, and the responsibility of its consumers, can be told. Suppose that non-U.S. residents want to hold U.S. assets in their portfolio, so much so that they are willing to pay a premium for the assets over-and-above what U.S. residents are willing to pay for the same assets. Since non-U.S. residents are paying U.S. residents a premium for the assets, U.S. residents are happy to sell the assets to them. However, when the assets are sold, something needs to be bought. This means that in return for the assets that are sold, consumption or investment goods are received in return. In sum, when the United States runs a big trade deficit – meaning $X - M < 0$ – at the same time that its residents are enjoying a lot of consumption and saving relatively little (as was the case in 2007), this is not necessarily indicative of bad things to come to U.S. residents. It could simply mean that non-U.S. residents are demanding U.S. assets at relatively high prices, and when assets are sold, something must be received in return.[22]

1.3.5 Miscellany

Two other minor points to keep in mind:

- Real C, I, G, and $X - M$ are computed in an identical fashion to the apples-bananas example in section 1.2.1. For example,

[22]Trade is potentially beneficial whenever two countries have different relative prices for two goods. In this paragraph, I've assumed the implied interest rate on U.S. assets is higher for United States residents than in the rest of the world. Since the interest rate is the price of consumption today relative to consumption in the future (as we show in chapter 4), any decline in the interest rate on U.S. assets (that is induced by non-U.S. residents purchasing the U.S. capital stock and increasing the price of this capital) will be associated with an increase in current consumption of U.S. residents.

if apples and bananas were two investment goods, then in the examples of section 1.2.1 we would have computed real investment in apples and bananas.

- Equation (1.7) exactly holds for nominal GDP, C, I, G, and $X - M$, but for technical reasons it only approximately holds for the real variables. The gap between real GDP and the sum of real C, I, G, and $X - M$ is reported in line 25 of NIPA table 1.1.6. As a percent of real GDP, this gap has been less than 5 percent in the post-war period.

1.4 More GDP Accounting

Every time a dollar is spent a dollar is earned. So a different method to calculate GDP involves adding up all the income earned from all sources: This is often called the "Income method." In practice, the income method and the expenditure method do not quite equal each other, and the difference is named in the NIPA as "The Statistical Discrepancy."

As mentioned earlier, macroeconomists model output as being produced using a combination of technology, capital, and labor. For simplicity, it is assumed the technology is freely available to all, and since it is freely provided it earns no income. On the other hand, capital and labor are costly inputs to production. If we view output as being produced using only two costly inputs, it is convenient to try to measure income earned to each of the two inputs separately. Therefore, we will divide all income earned (which is roughly the same as GDP) into two pieces that correspond to our model of production: capital income and labor income.[23]

[23]Note that – ignoring the possibility of foreign ownership of capital – households own all the capital and provide all the labor, so after-tax capital income and labor income both accrue to households. In other words, the income variable Y in equation (1.8) refers to the sum of capital and labor income.

Dividing income, as it is classified and measured in the NIPA, separately into neat buckets corresponding to capital and labor income is a bit tricky. This is because in the reporting of income in the NIPA, income is not labeled exactly as capital income or labor income. NIPA table 1.10, reproduced below, lists the various components of aggregate income. A few line items in this table are straightforward to classify as either capital or labor income. For example, line 2 of this table, "Compensation of employees, paid," represent unambiguous payments to labor. Five of the other lines in the table represent unambiguous payments to capital:[24]

- Net interest and miscellaneous payments, domestic industries, line 13
- Business current transfer payments (net), line 14
- Rents of persons with capital consumption adjustment, line 16
- Corporate profits with inventory valuation and capital consumption adjustments, domestic industries, line 17
- Consumption of fixed capital, line 23

In contrast, the other categories of income on this table are hard to unambiguously classify:

- Taxes on production and imports, line 9, less Subsidies, line 10
- Proprietors' income with inventory valuation and capital consumption adjustments, line 15[25]

[24] This section is taken largely from Cooley, T. and E. Prescott, 1995, "Frontiers of Business Cycle Research," Princeton University Press, p. 18-19. Those familiar with that book will realize that I am not exactly following the procedure they document.

[25] Proprietors' income sounds like labor payments to a proprietor, but since it takes capital as well as labor to be a proprietor, it is not unambiguous labor income.

- Current surplus of government enterprises, line 22
- Statistical Discrepancy, line 26

We determine capital's share of income by assuming that capital's share in the ambiguous categories of income is the same as capital's share of income in the overall economy. Denote the economy-wide share of capital income as α. Then, given the categories of unambiguous capital income (lines 13, 14, 16, 17, and 23) and ambiguous income (lines 9, 10, 15, 22, and 26), an estimate of α is:

$$\begin{aligned} \alpha &= \frac{\text{Unambiguous Capital Income} + \alpha * \text{Ambiguous Income}}{\text{Gross Domestic Income}} \\ &= \frac{\text{Unambiguous Capital Income}}{\text{Gross Domestic Income} - \text{Ambiguous Income}} \qquad (1.9) \end{aligned}$$

When we take equation (1.9) to the data, we uncover an estimate of $\alpha = 0.32$ that is fairly constant over history: see figure 1.9. We will use this estimate of $\alpha = 0.32$ throughout the book.

1.5 Inflation

Inflation does not refer to the level of prices. Inflation is the rate of change of the price level.

The word "inflation" in everyday language is not as tightly defined as GDP. The word inflation can refer to the rate of change of all prices, some prices, or just one price. This is why discussions of inflation can be confusing or wrong.

Going back to our discussion in section 1.2.1 , the inflation rate in the price of apples between 2000 and 2001 is easy to define: It is the rate of change of apple prices,

$$\frac{p_{a,2001}}{p_{a,2000}} - 1. \qquad (1.10)$$

Likewise, the inflation rate of the price of bananas between 2000 and

2001 is

$$\frac{p_{b,2001}}{p_{b,2000}} - 1. \tag{1.11}$$

The inflation rate on a "basket" or bundle of apples and bananas between 2000 and 2001 is defined as

$$\widehat{\phi}_{2000}\left(\frac{p_{a,2001}}{p_{a,2000}}\right) + \left(1 - \widehat{\phi}_{2000}\right)\left(\frac{p_{b,2001}}{p_{b,2000}}\right) - 1. \tag{1.12}$$

As before, $\widehat{\phi}_{2000}$ is the measured expenditure share on apples and $\left(1 - \widehat{\phi}_{2000}\right)$ is the measured expenditure share on bananas. So the inflation rate on a bundle of goods is defined exactly analogously to the growth rate of real GDP for a bundle of goods – that is, the way that we average price growth across commodities to define an average inflation rate for all goods and services is the same as the way we average quantity growth across commodities to define a growth rate for real GDP.

Equation (1.12) illustrates that not all prices have to increase for the overall rate of inflation to be positive. Imagine that apple prices increase but banana prices fall a little. If the expenditure share on apples is high enough, the increase in the price of apples might more than offset the decrease in the price of bananas, and the inflation rate on the bundle of apples and bananas will increase.

Policy-makers tend to look at the rate of change in the price of all consumption items taken together. The most widely followed data on changes in consumer prices is the Consumer Price Index (CPI), produced by the U.S. Department of Labor, Bureau of Labor Statistics (BLS). The BLS samples data from urban consumers (representing about 87% of the population). The current CPI release can be found at *http://www.bls.gov/news.release/cpi.htm.* The NIPA also produces a price index for all consumption items: See NIPA table 2.3.4. The NIPA price index is based on underlying BLS data, but growth in the NIPA price index for all consumption items are based on economy-wide expenditure shares that are updated each quarter.[26]

Figure 1.10 plots the annual growth rates of two similar measures of consumer price inflation from the NIPA. The first (solid line) includes all consumption goods including consumer durables, line 1 of NIPA table 2.3.4. The second (dotted line) excludes food and energy from the bundle, line 23 of NIPA table 2.3.4. Until very recently, the Federal Reserve appears to have focused on this second measure of inflation when thinking about the course of future monetary policy; as you can see, the two consumer-price inflation series track each other closely over long periods of time, but food and energy prices can be more volatile, especially at the monthly frequency. Since 2003, the inflation rate for all consumption goods has been about one-half percentage point per year higher than the measure that excludes food and energy, shown in figure 1.11. Recent statements by U.S. policy makers indicate that, relative to previous years, they are paying more attention to the inflation rate for all consumption goods and services and less attention to the inflation measure excluding food and energy.[27] Notice from figure 1.10 that the inflation rate of consumer prices has almost always been positive since the second world war.

As we discuss in chapter 6 of the book, policy makers in the U.S. appear to implicitly focus on consumer price inflation; the rate of change of the price of investment goods appears to receive less consideration. Many investment goods prices have been falling rapidly for quite some time – see figure 1.12 for a graph of the inflation rate of equipment

---

[26] In contrast, the expenditure shares in the CPI are updated only every two years. For example, starting with the January 2008 release of the CPI, the expenditure weights are fixed at a 2005-6 base level.

[27] See, for example, the speech by James Bullard, President of the Federal Reserve Bank of St. Louis, "Remarks on the U.S. Economy and the State of the Housing Sector," made at the Wisconsin School of Business on June 6, 2008. The text of the speech is available at *http://www.stlouisfed.org/news/speeches/2008/06_06_08.html*.

and software (from NIPA table 1.1.4, line 10), which has been negative in recent years. However, shown in Figure 1.13, the price of one very important investment good, owner-occupied housing, increased very rapidly from 1997-2006, and has fallen somewhat since 2007. The inflation rate of housing does not show up in the CPI or the NIPA consumption inflation rate because a house is an investment good. That is, since a house generates services that last many years, the purchase of a house is considered an investment. Instead, the change in rental rates for housing is included as a component in the measurement of consumer-price inflation. The rental rate is the price of a unit of housing services for a fixed amount of time (say one year), so it measures the price of the housing services consumed over a one-year period.

With the exception of various sections of chapters 4 and 6, in the remainder of this book we abstract completely from inflation. There are two reasons for this.

- In one sense, inflation is very easy to understand. Suppose that in our economy we only produce and consume apples. Suppose also that we purchase apples with dollar bills. If the government doubles the number of dollar bills in circulation, but the number of apples in the economy is fixed, then the price of an apple in dollars will double. Thus, in this world view, inflation is ultimately caused by the printing of money, but the inflation rate itself is not correlated with real consumption or production (that is, the consumption or production or apples).

- Second, in a different sense, inflation is very hard to understand. That is, one group of economists argue that at two- to four-year horizons, the overall rate of inflation is correlated with real activity (that is, the production and consumption of apples). A second group argues that no such link exists. And, a third group argues that a link exists, but the reason for it is fundamentally different than believed by the first group. Anyway, it seems we will not have consensus on this topic for quite some time, so I pass on the issue entirely.

1.6 Further Reading

- Quite a lot has been written about the history and construction of GDP, and more generally the National Income and Product Accounts. For more details and some history, I suggest readers start at the BEA's web site, specifically *http://www.bea.gov/methodologies/index.htm.* Readers may find the articles in the "Concepts" section useful, specifically "A Guide to the National Income and Product Accounts of the United States" (dated September, 2006).

- You may have read or heard about alternatives to GDP that might more closely track changes to human welfare or well-being. You may also have heard about measurement procedures aimed at improving current estimates of GDP. The OECD (Organization for Economic Cooperation and Development) has a working paper on its web site on this topic by Boarini, et. al., 2006, "Alternative Measures of Well-Being," available at *http://www.oecd.org/dataoecd/13/38/36165332.pdf* which may serve as a jumping-off point on this topic for interested readers.

- Over the years, the computation of accurate rates of inflation for many different types of goods and services has occupied the attention of a number of serious economists. Since payments from some government programs (such as Social Security) are indexed to the rate of inflation, any biases – up or down – in the computation of inflation rates are of interest to many people and politicians. In the mid-1990s, the "Boskin Commission" produced the most widely studied document on biases in the computation of CPI inflation rates (produced by the BLS), and a link to the report is at *http://www.ssa.gov/history/reports/boskinrpt.html*. Note that the BLS has since addressed some of the concerns listed in this report.

- There is evidence from different countries and in different time periods that a very high rate of inflation, called "hyperinflation," is destabilizing to a country's economy. Wikipedia's entry on the topic is interesting, and includes a list of countries that have experienced a bout of hyperinflation, see *http://en.wikipedia.org/wiki/Hyperinflation*.

1.7 Homework

1. Definitions:

   a. What does GDP stand for? Write down and then define the four major expenditure components of GDP.

   b. Define consumer price inflation. What causes consumer price inflation over long periods of time? Why?

2. Households in Minneapolis pick apples a and bananas b from trees each period. For 2000 and 2001, data on apples picked a, bananas picked b, and the price of apples p_a and the price of bananas p_b in Minneapolis is

Year	a	p_a	b	p_b
2000	25	\$1.00	30	\$2.50
2001	26	\$1.02	31	\$2.566

   a. What is nominal GDP in Minneapolis in 2000 and 2001?

   b. What is the growth rate of real GDP in Minneapolis from 2000 to 2001?

   c. What is the inflation rate in Minneapolis from 2000 to 2001?

d. Suppose that households in Minneapolis have preferences for apples and bananas of

$$\phi \ln(a) + (1.0 - \phi) \ln(b)$$

What do you think ϕ is?

3. Consider an economy where everyone picks apples, bananas, or cherries. The prices and quantities picked of apples, bananas, and cherries for the years 2000, 2001, and 2002 are reported in the table below.

	Apples		Bananas		Cherries	
Year	Price	Quantity	Price	Quantity	Price	Quantity
2000	\$10	100	\$20	100	\$35	200
2001	\$11	103	\$19	102	\$35	200
2002	\$12	104	\$20	103	\$36	206

a. What is nominal GDP in each of the years?

b. Using the expenditure-share approach, what is the growth rate of real GDP and inflation in each year? NOTE: Do not forget to update the expenditure share.

c. Using the growth rates of real GDP you have just computed, what is real GDP in each of the years for GDP in (a) base year 2000 and (b) base year 2002?

d. What is the growth rate of real GDP and inflation excluding cherries in each year?

4. Fill in the empty cells:

	Apples		Bananas		Nominal	Real GDP	*Ann. Growth Rates in %*	
Year	Quan.	Price	Quan.	Price	GDP	(in \$2005)	Real GDP	Infl.
2005	10	\$2.00	5	\$1.00			NA	NA
2006	11	\$2.02	6	\$1.05				
2007	12	\$2.05	7	\$1.12				

5. The country of "Fruitcake" produces apples and bananas. Fruitcakes have time-invariant preferences for pounds of apples a and pounds of bananas b of

$$0.2 \ln(a) + 0.8 \ln(b)$$

a. You have been told that nominal GDP in Fruitcake is \$100 in the year 2005, \$105 in the year 2006, and \$110 in the year 2007. Assuming households maximize utility, and all apples and bananas are consumed in each year, what are nominal expenditures on apples in dollars in 2005, 2006, and 2007?

b. You have given the following data on the price of one pound of apples p_a and bananas p_b in Fruitcake:

	p_a	p_b
2005	\$1.0000	\$5.000
2006	\$1.0300	\$5.100
2007	\$1.0815	\$5.253

Given the answer to part a., determine the inflation rate and the growth rate of real GDP in Fruitcake between 2005 and 2006 and again between 2006 and 2007.

6. In *Fredonia*, apples and bananas are produced. Between 1920 and 1921, the expenditure share on apples was 20 percent and the price of apples increased by 50 percent. The overall price level between 1920 and 1921 increased only by 5 percent, however. What happened to the price of bananas in *Fredonia* between 1920 and 1921?

7. Over the 1947:Q1 through 1996:Q4 period, what is the average of the ratio of nominal investment in residential structures to nominal GDP? What was the average of the ratio from 1997:Q1 through 2007:Q4?

8. According to the NIPA data, approximately what fraction of total income has accrued to capital (as opposed to labor) over the 1929-2007 period?

9. A German friend named Dirk from Stanford gives you a table of income accruing to various sources that he has put together for Germany in 2003. By Dirk's reckoning, German national income in 2003 can be attributed to various sources as

Source	Amount
Capital Income	\$27
Labor Income	\$63
Ambiguous Income	\$10
Total Income	\$100

Calculate capital's share of income in Germany implied by Dirk's data.

10. Dirk has computed his table of national income and believes that income in Germany in 2007 can be attributed to various sources as

Source	Amount
Capital Income	\$32
Labor Income	\$63
Ambiguous Income	\$5
Total Income	\$100

Calculate capital's share of income for Germany in 2007.

11. Using annual data on real GDP from the NIPA over the 1973-2007 period, calculate the "output gap,"

$$\ln(GDP_t) - \ln(GDP_t^*)$$

for the years 1982 and 2001. NOTE: To calculate $\ln(GDP_t^*)$, regress $\ln(GDP_t)$ against a constant and a time trend over the 1973-2007 period[28] and assume the fitted value of this regression is exactly equal to $\ln(GDP^*)$.

[28] A time trend is a variable that increments by 1 in each period, i.e. is 1 in 1973, 2 in 1974, 3 in 1975, and so forth.

Bureau of Economic Analysis
National Income and Product Accounts Table

Table 1.10. Gross Domestic Income by Type of Income

[Billions of dollars]

Today is: 6/24/2008 Last Revised on May 29, 2008 Next Release Date June 26, 2008

Line		2006	2007
1	**Gross domestic income**	**13,212.8**	**13,818.9**
2	**Compensation of employees, paid**	**7,454.8**	**7,888.2**
3	Wage and salary accruals	6,032.2	6,395.7
4	Disbursements	6,024.7	6,373.2
5	To persons	6,015.3	6,363.1
6	To the rest of the world	9.4	10.0
7	Wage accruals less disbursements	7.5	22.5
8	Supplements to wages and salaries	1,422.6	1,492.5
9	**Taxes on production and imports**	**967.3**	**1,008.5**
10	**Less: Subsidies** [1]	**49.7**	**47.1**
11	**Net operating surplus**	**3,225.3**	**3,282.7**
12	Private enterprises	3,239.2	3,297.2
13	Net interest and miscellaneous payments, domestic industries	791.3	837.4
14	Business current transfer payments (net)	90.2	94.2
15	Proprietors' income with inventory valuation and capital consumption adjustments	1,006.7	1,042.6
16	Rental income of persons with capital consumption adjustment	54.5	65.4
17	Corporate profits with inventory valuation and capital consumption adjustments, domestic industries	1,296.4	1,257.7
18	Taxes on corporate income	453.9	466.6
19	Profits after tax with inventory valuation and capital consumption adjustments	842.5	791.0
20	Net dividends	623.1	659.5
21	Undistributed corporate profits with inventory valuation and capital consumption adjustments	219.4	131.5
22	Current surplus of government enterprises[1]	-13.9	-14.5
23	**Consumption of fixed capital**	**1,615.2**	**1,686.6**
24	Private	1,347.5	1,398.7
25	Government	267.7	287.9
	Addendum:		
26	Statistical discrepancy	-18.1	22.4

Figure 1.9: Capital's Share of Income (α), 1929-2007

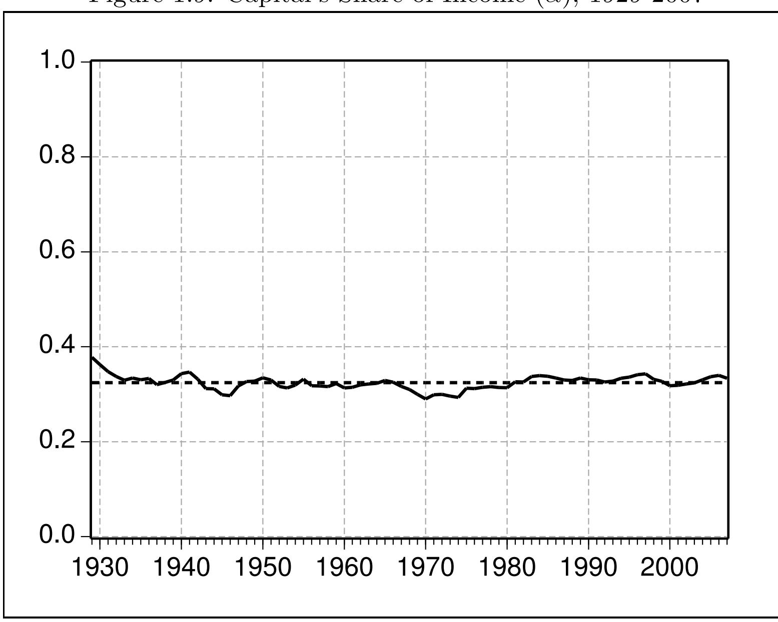


Figure 1.10: Annual Inflation Rate, All Consumption and Consumption Excl. Food and Energy,1930-2007

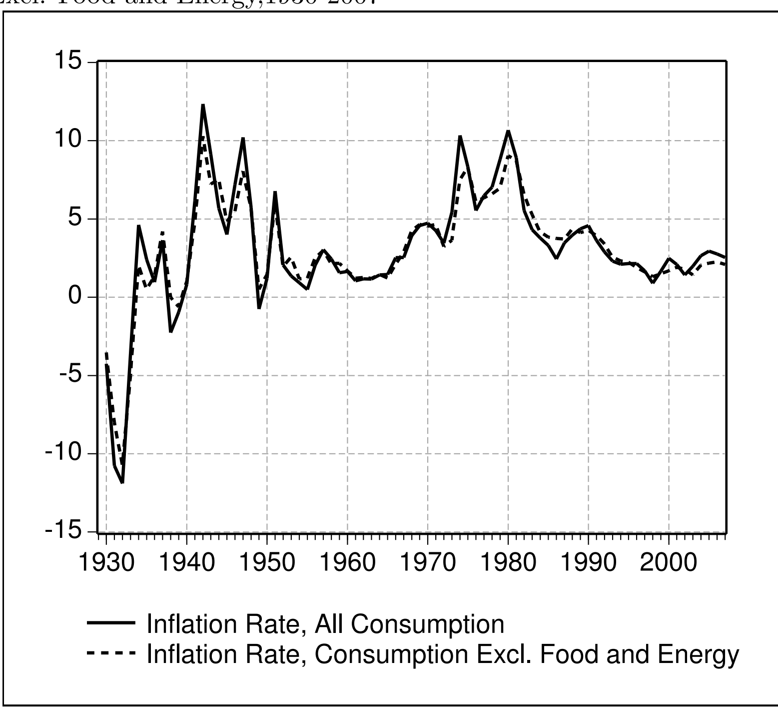


Figure 1.11: Annual Inflation Rate, All Consumption and Consumption Excl. Food and Energy,1997-2007

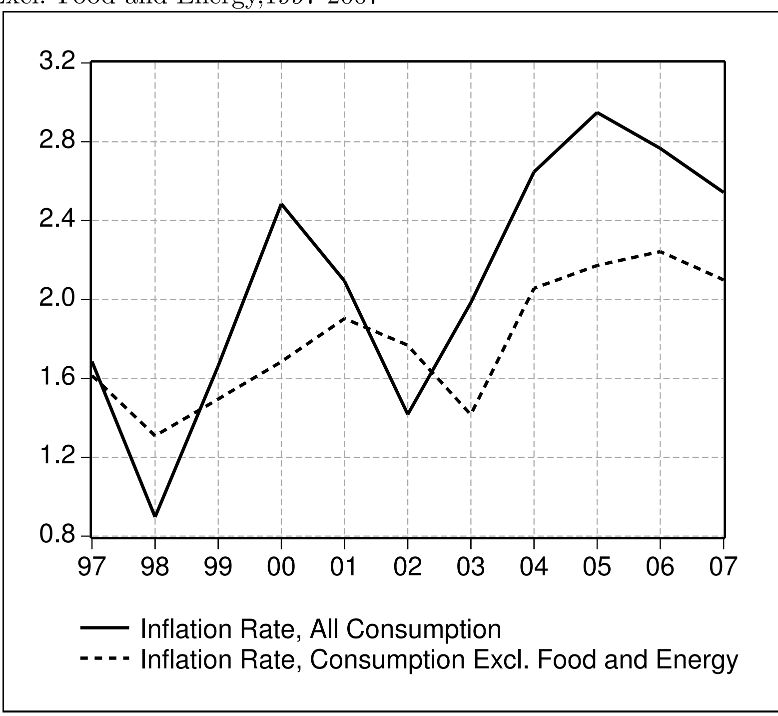


Figure 1.12: Annual Inflation Rate, Investment in Equipment and Software, 1930-2007

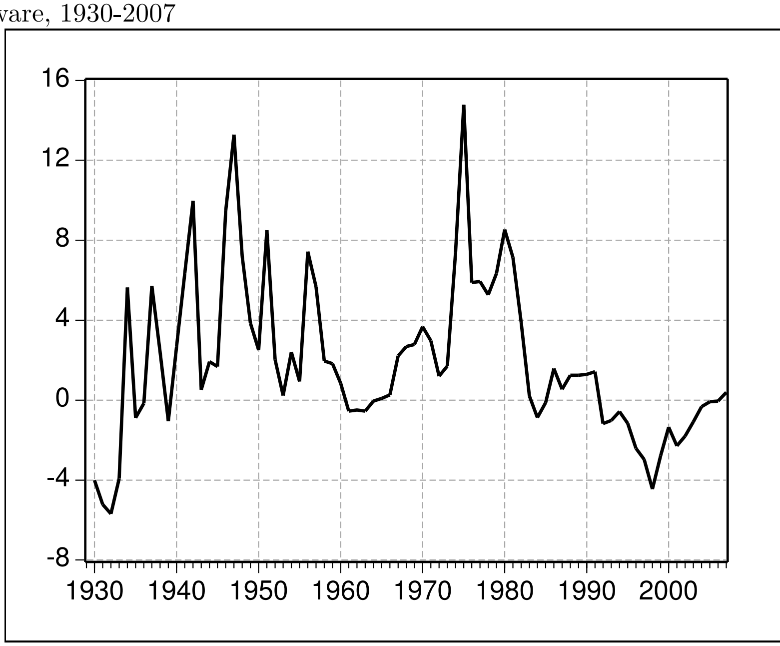


Figure 1.13: Annual Inflation Rate, Owner-Occupied Housing (from www.ofheo.gov), 1975-2007