Macroeconomic Data

We know about our economy through measurement of some key macroeconomic variables such as GDP (Gross Domestic Product), CPI (Consumer Price Index), unemployment rate, and so on. Macroeconomic data is the "realization" of these variables. Each variable measures one dimension of the economy. For example, GDP measures the total size of the economy, CPI measures the overall price level, and unemployment rate measures the extent of labor underuse.

On each dimension of our economy, there may be more than one variable that are relevant. For example, GNP (Gross National Product) is also a good measurement of the total size of the economy. Often these variables complement each other in describing a certain dimension of the economy. For example, GDP emphasizes geographic boundary while GNP emphasizes national ownership. Output of foreign enterprises located inside the country is counted in GDP, but not in GNP. Looking at both GDP and GNP (or equivalently, GNI (Gross National Income)) may give us a better picture of the size of the economy.

To each variable there is also a time dimension. So macroeconomic data are invariably time series, or "realizations" of stochastic processes. Variation of a macroeconomic variable on the time dimension characterizes the dynamics of the economy. For example, percentage change in GDP characterizes the speed at which the economy grows in size. For another example, percentage change in CPI characterizes inflation, or the speed at which money loses purchasing power.

Macroeconomic data are often systematically collected and compiled by national statistical bureaus, central banks, and other government agencies. In particular, GDP is a direct product of the *national accounting*, which is to measure economic activity of a nation using a consistent system of accounting technique. From 1952 to 1992, China used the Material Product System (MPS) that was prevailing in socialist countries back then. In 1992 China formally adopted the SNA (System of National Accounting) that was prevailing in western countries. There are two major differences between MPS and SNA. First, as the name suggests, MPS counts only goods output, exclusive of service. Second, SNA uses market prices in valuation of goods and services, while MPS has to rely on administered prices.

Macroeconomic data can be very general in scope. Basically any data that help us gauge the state of the economy can be called macroeconomic data. In addition to data from government agencies, market prices for interest rates, exchange rates, stock market valuations, and so on, are of course macroeconomic data. Indices based on surveys, such as Purchasing Managers' Indexes (PMI), are also macroeconomic data. It is also well known that output data from key industries can be reliable indicators for the state of the economy. In China, electricity consumption, volume of rail cargo, and total bank loan, are widely recognized as reliable indicators for the economy.

In this course, we focus on the principles and rules for computing three of most important macroeconomic variables: GDP, CPI, and unemployment rate. We also show time series dynamics and cross-country comparisons of these data. This would help us to gain some basic knowledge of

the economy of our country and the world.

National Accounts

National accounts include three parts: (1) GDP (Gross Domestic Product) and its components; (2) flow of funds table; (3) balance of payments table.

GDP (Gross Domestic Product) is essentially the total value of all transactions in the economy within a time interval (say, a quarter). There are three ways to view and calculate GDP: (i) the total value of final goods and services produced in the economy (the production approach); the total income generated in the economy (the income approach); (ii) the total expenditure on the economy's output of goods and services (the expenditure approach). To understand that total income must equal total expenditure, note that every transaction generates an income to the seller and an equal amount of expenditure to the buyer.

Using the production approach, GDP is defined as the *market value* of all *final* goods and services produced within an economy in a given period of time. Mathematically, we have

$$GDP_t = \sum_{i=1}^{M} q_{it} p_{it}, \qquad (1)$$

where q_{it} and p_{it} are quantity and price, respectively, of the i-th item produced period t. For example, if we have an economy of two trees, one apple tree and the other orange tree. If the apple tree produces 20 apples and the orange tree produces 10 oranges, with their market prices 0.5 and 1.0 RMB, respectively, then the GDP of the twin-tree economy is

20*0.5 + 10*1.0 = 20 RMB.

Note that only final goods are counted in GDP. Intermediate goods, which are part and parcel of final goods, are not individually counted. This is to avoid double accounting. It is clear that

GDP = value of final goods produced

= sum of *value added* at all stages of production.

To avoid double accounting, transactions of used goods are also not counted in GDP. Note that the "used" goods can be new goods to consumers. For example, suppose that GM produces a car in China but does not manage to sell it this year. Instead, GM puts the car into inventory and plans to sell it next year. In national accounting, the value of the car is counted in this year's GDP as inventory investment. When the car is finally sold next year, it would be treated as "used" and not counted in next year's GDP. If, however, it is a spoilable good (e.g., vegetables) that is produced but not sold, then it is not counted in GDP at all.

Note also that in computing GDP, we use market prices, when available, to calculate the value of goods and services. When market prices are not available, we use imputed prices, which are estimates of market prices. For example, to calculate the value of housing service, it is common to impute the rent people have to pay to their landlords, who may be themselves if they own their homes. The value of government services, such as police and firefighting, also requires imputation. Typically, the national accounts value these government services in GDP by the wages paid to the

public servants.

What GDP Does NOT Include

It may be argued that "services" of durable goods, such as cars and refrigerators, should also be valued in GDP. But these are omitted for convenience. There are also good reasons to include the value of domestic work performed by house-wives and husbands, such as cooking and washing, into GDP. Typically, however, these are also omitted in practice.

GDP calculation also omits goods and services in the underground economy. The underground economic activity can be substantial. People have incentives to "hide" transactions either because these transactions are illegal, or for tax-avoidance purposes. Illegal transactions include illegal drug trade, human trafficking, and so on. For minor services such as babysitting, the tax administration has little incentive to enforce taxation.

As can be seen, GDP is an inaccurate measure of the size of the economy. In addition, although the general framework for GDP computation is the same across countries, substantial differences exist in details. As a consequence, comparing GDP across countries can be misleading. However, if the rules of calculation do not change over time, comparisons along the time dimension are meaningful.

Nominal and Real GDP

Note that in equation (1), we calculate GDP using current prices. We call the value of such calculation *nominal GDP*. The nominal GDP changes over time either because there is a change in the amount (real value) of goods and services or there are changes in the prices of those goods and services.

In contrast, *real GDP* measures the value of final goods and services at *constant prices*,

$$RGDP_t = \sum_{i=1}^{M} q_{it} p_{it_0}, \quad (2)$$

where t_0 stands for the *base year* and p_{it_0} is a constant for each i. The relationship between nominal and real GDP can be characterized by

$$GDP_t = P_t \cdot RGDP_t,$$

where P_t is called *GDP deflator,* or *implicit price deflator for GDP*. Taking *real* measurements is essential for gauging growth or improvement (e.g., real wage) in living quality.

One principle of calculating RGDP is that the base year should not be too far, so that prices will not be too out of date. For example, cell phone was a rare product 20 years ago. It would be absurd to use the price of cell phone 20 years ago to calculate today's GDP.

Since 1995, the US has been using chain-weighted measures of real GDP in the calculation of real GDP growth. The chain weight works as follows: Average prices in 2009 and 2010 are used to measure real growth from 2009 to 2010. Average prices in 2010 and 2011 are used to measure real growth from 2010 to 2011, and so on. In China, we change base-year every five years.

Figure 1 shows the real and nominal GDP of China from 1978 to 2012. Since the base year of real GDP is 2010, the lines of real and nominal GDP's cross at year 2010. We can see in the graph that China experiences rapid growth during the over 30-year period. The growth of nominal GDP is of course higher than that of real GDP, reflecting a rising price level. Figure 2 shows the quarterly year-over-year (YoY) growth rate of real GDP from 1992 to 2015. GDP is typically reported every quarter. The quarterly YoY growth rate is calculated as

$$R_t = \ln\left(\frac{RGDP_t}{RGDP_{t-4}}\right),$$

where t denotes quarter. The YoY growth rate naturally filters out seasonality.

Figure 1: The Real and Nominal GDP of China (Unit: RMB 100mil)

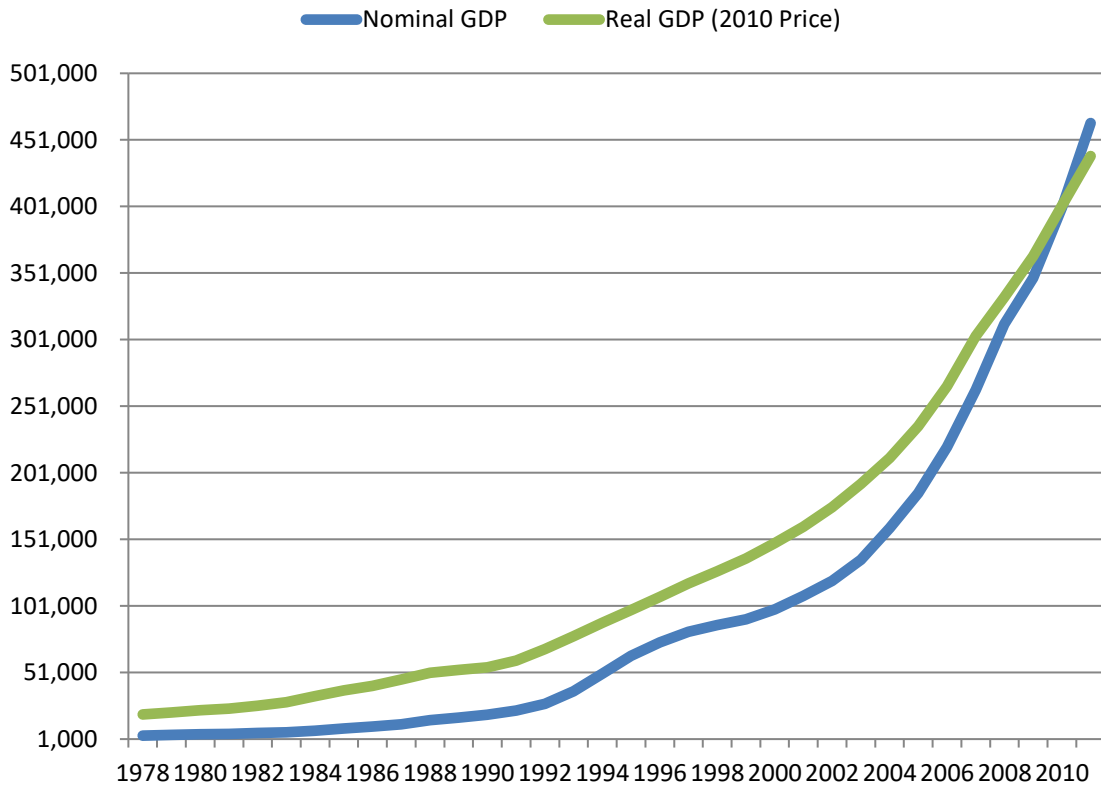
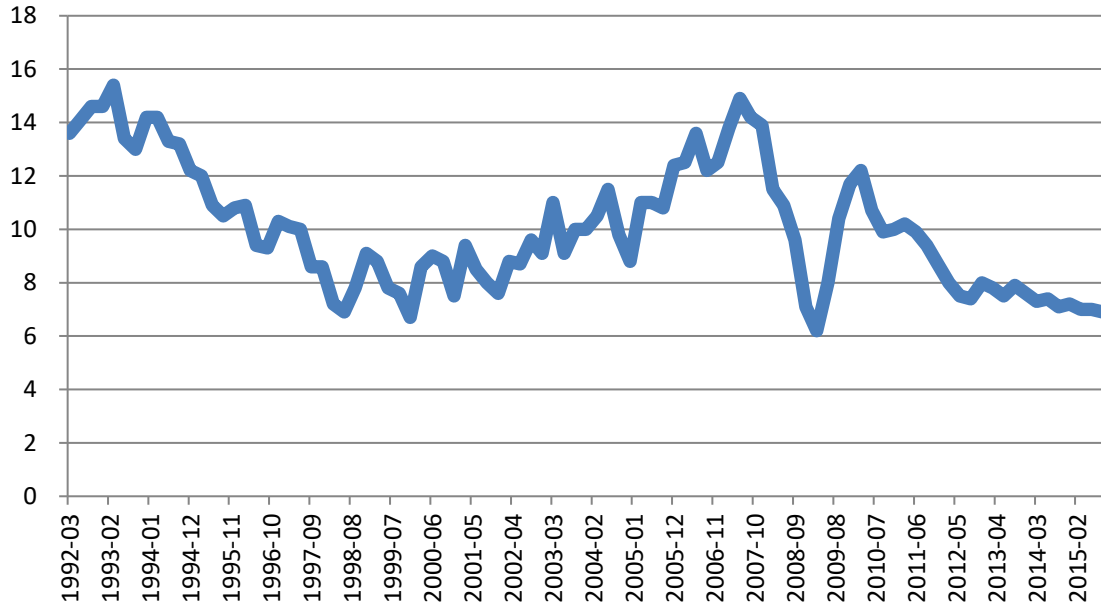


Figure 2: Real GDP Growth of China (Quarterly, 1992-2015)



Components of GDP (The Expenditure Side)

From the perspective of expenditure, GDP can be decomposed into four components:
(1) Consumption spending by households (C)
(2) Investment spending by businesses and households (I)
(3) Government spending of goods and services (G)
(4) Net exports (or net foreign spending on domestically produced goods) (NX)
Let Y denote GDP. By definition we have

$$Y = C + I + G + NX. \quad (3)$$

We call this equation the *national income accounts identity*. Note that C, I, and G include the value of both imported and domestically produced goods and services. Let C^d be the consumption of domestic goods and services, and let C^f be the consumption of imported goods and services. We have $C = C^d + C^f$. Similarly, we have $I = I^d + I^f$ and $G = G^d + G^f$. Now we can have a more detailed decomposition of GDP:

$$Y = \left(C^d + C^f\right) + \left(I^d + I^f\right) + \left(G^d + G^f\right) + X - \left(C^f + I^f + G^f\right),$$

where X is export and obviously, $NX = X - \left(C^f + I^f + G^f\right)$.

Consumption (C)

The consumption component measures the value of all goods and services bought by households. It includes the value of durable goods, non-durable goods, and consumer service. Durable goods are those that last a long time, such as cars, refrigerators, and so on. Non-durable goods last a relatively short time, e.g., food and clothing. Consumer service refers to the work done for consumers by individuals and firms, such as housing, dry cleaning, air travel, and so on.

It is widely believed that the Chinese consumption data is underestimated. First, the consumption of "housing service" is measured in China by multiplying the building cost of the houses by a

depreciation rate (2% for urban houses and 3% for rural houses). This method underestimates the consumption of housing, since the building cost is usually only a fraction of market value and the depreciation rate may also be lower than the rental rate of houses. Second, the official statistics do not account for private consumptions that are paid for by company accounts and thus treated as either business costs or investment in the case of durable goods. Third, household consumption statistics are based on household surveys in which high-income households are significantly under-represented. High-income households are presumably big spenders in consumption goods.

Investment (I)

The investment component measures the value of total spending on goods bought for future use. There are two types of investment: one is fixed investment, which adds to the capital stock; the other is inventory investment, which adds to the inventory. The fixed investment conducted by firms is called business fixed investment, which is spending on plants and equipment that firms will use to produce goods & services. The fixed investment conducted by individuals and families is called residential fixed investment, which mainly consists of spending on apartments and houses. The inventory investment measures the change in the value of all firms' inventories

Fixed investment would increase the stock of capital. For firms, capital is one of the most important factors of production. The more capital a firm has, the higher capacity the firm has for future production. In aggregate this is also true. The more capital we have in the country, the higher potential we have for future production and consumption. Capital, however, depreciates. For example, machines wear and break down eventually. So investment on new capital is essential for maintaining and increasing the stock of capital.

For example, suppose that on 1/1/2016, an economy has a capital stock worth 500. During 2016, there is fixed investment worth 100 with depreciation worth 20. Then at the end of 2016, the economy has a capital stock worth: 500+100-20=580.

Stock and Flow

In economics and accounting, it is important to distinguish the "stock" variables and the "flow" variables. The stock variable measures the quantity at particular time points, while the flow variable measures the change in a given time period. It is in this sense that stock can also be called "level" and that flow can be called "rate".

In business accounting, the balance sheet (资产负债表) tabulates stock variables such as debt, equity, and so on. And both the income statement (利润表) and the cash flow statement (现金流量表) tabulate flow variables such as revenue, profit, cash inflow, wage layout, and so on. In national accounting, GDP is obviously a flow variable, since it measures the domestic output in a given time period. The unit of annual GDP is Yuan/Year. In contrast, the capital stock in a country is a stock variable with the unit Yuan.

We can meaningfully compare a stock variable with another stock variable, a flow variable with

another flow variable. However, it would be meaningless to compare a stock variable with a flow variable, since they have different units. Nonetheless, it is sometimes meaningful to calculate the ratio of a stock variable to a flow variable. For example, the ratio of total national debt to GDP is often compared. Since the unit of the ratio is "Year", the ratio can be understood as the number of years the country would take to pay off the debt, if all income (GDP) is devoted to debt payoff.

An apartment or house is a special piece of capital. It is used to produce consumer service which we call "housing service". Spending on new houses is counted under investment, not consumption. But the housing service the house provides is counted under consumption. Note that it is not double accounting that both the spending on new houses and on rents are counted in GDP. All fixed investment will help produce, in the future, goods or services that will be counted in the future GDP.

Unsold output goes into inventory, and is counted as "inventory investment", whether the inventory buildup was intentional or not. If total inventories are 10 at the beginning of the year, and 12 at the end, then inventory investment equals 2 for the year. Note that inventory investment can be negative, which means that inventories fall over the year.

Figure 3: Inventory Investment/GDP of China (1992-2015)

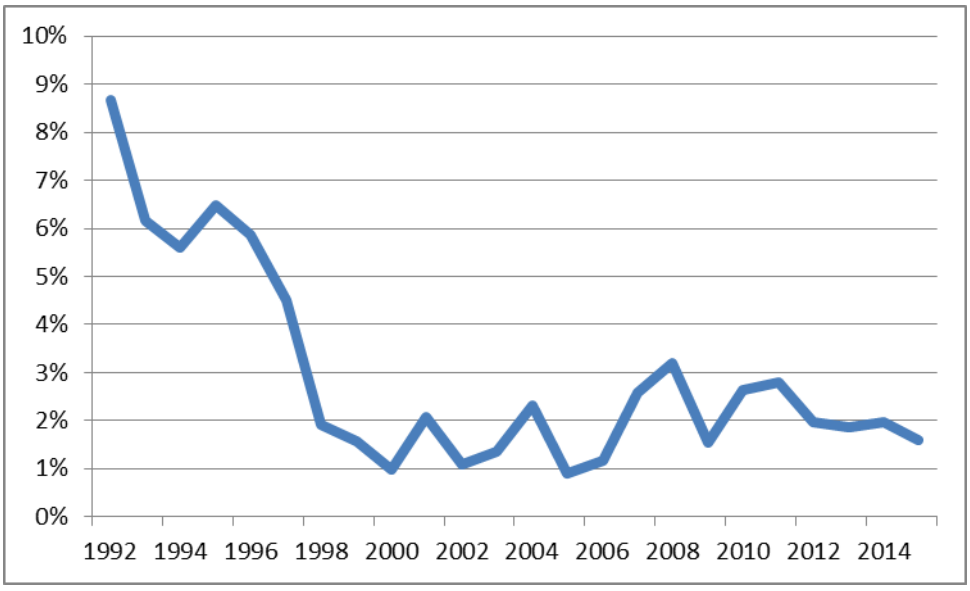


Figure 3 shows the ratio of inventory investment to GDP in China. In the early 1990s, the ratio of inventory investment was abnormally high, implying that a substantial amount of factory output ended up unsold. During the planed-economy era, this phenomenon was not uncommon. Since the economy was dominated by the state-owned enterprises (SOEs), which produced goods not to satisfy consumer demand, but to fulfill "plans", large-scale mismatch between production and demand persisted in the economy. Then the inventory ratio declined sharply at the end of 1990s. To explain the dramatic turn around, note that China reformed its state-owned enterprises (SOEs) at the end of 1990s. During the reform, many small SOE's was sold to the private sector, and large

SOE's was reformed and consolidated into modern corporations. As a result, the managerial efficiency of the corporate China improved dramatically. The sharp decline of inventory is one indicator of the success of the SOE reform in 1990s.

Government Spending (G)

Government spending includes all government spending on goods and services. To avoid double-counting, G excludes transfer payments (转移支付) such as unemployment insurance payments. Transfer payments are, however, included in "government outlays" in national budgetary process.

Net Export (NX)

Net export, or balance of trade, equals the total value of export minus that of import in a given period of time. It represents the net foreign expenditures on goods and services produced in our country. If the net export is positive, we say that the country has a *trade surplus*. Otherwise we say that the country has a *trade deficit*.

Generally speaking, trade surplus is good, implying that the tradable sector of the country is competitive. A moderate trade deficit, however, is not necessarily bad. It may be caused by the competitiveness of the financial products offered by the country. If the trade deficit becomes excessive (say, 5% of GDP) and persistent, then some adjustment would have to occur, say, the exchange rate would have to depreciate.

The Income Side of the National Accounts

GDP can also be calculated by summing up the income distributed by domestic producers to households. GDP calculated this way is also called gross domestic income (GDI). In principle, GDI should be equal to GDP (sum of expenditures). In practice, however, these two numbers differ by a small measurement error called *statistical discrepancy*,

$$\text{Statistical discrepancy} = \text{GDP} - \text{GDI}.$$

A more important measure of aggregate income is the gross national income (GNI), which is the sum of household income in a given period. The relationship between GNI and GDP is as follows,

$$\text{GNI} = \text{GDP} + \text{net factor payment from abroad}.$$

GNI is conceptually the same as the gross national output (GNP). In international statistics, GNI has gradually replaced GNP.

The national income (NI) is defined as

$$\begin{aligned}\text{NI} &= \text{GDI} + \text{net factor payment from abroad} - \text{depreciation} \\ &= \text{GNI} - \text{depreciation} - \text{statistical discrepancy}.\end{aligned}$$

Case Study: Difference between GDP and GNI (GNP)

Message to take home: For large countries with diversified industries, GDP and GNI should be similar. Small countries with one or two dominant industries (e.g., oil, banking), GDP and GNI can

differ substantially.

Personal income is defined as the income received by all individuals or households from all sources (e.g., wage, dividend, interest, etc.) in a given period of time (say, a year). Disposable personable income (or simply, disposable income) is defined as the personal income minus personal tax and nontax payments. Disposable income can be decomposed into consumption and saving. If we define saving by S=Y-C-G, using the decomposition on the expenditure side, then disposable income roughly corresponds to the component "Y-G".

Inflation

Inflation is a sustained increase in the general price level of goods and services in an economy over a period of time. In this section we discuss two popular measures of the general price level, CPI (Consumer Price Index) and GDP deflator.

CPI

CPI is an index that measures the overall level of prices for consumers. A government agency (统计局 in China, Bureau of Labor Statistics in US) determines a vector of weights that reflect the proportions of each item in a basket of goods and services consumed by a typical customer. Using this weight vector, the agency then computes an index,

$$\mathrm{CPI_t} = c_0 \sum_{i=1}^{N} w_i p_{it},$$

where w_i is the weight for i-th item in the consumption basket, p_{it} is the price of i-th item at time t, and c_0 is a constant. In particular, we may choose $c_0 = \sum_{i=1}^{N} w_i p_{i,t-1}$. In this case, CPI represents the (gross) change of the total price of the same consumption basket.

For example, in our twin-tree economy, the apple tree produces 20 apples and the orange tree produces 10 oranges. All these fruits are consumed every year. Their prices are

Year	Apple	Orange
2016	0.5	1
2015	0.4	0.8

Then the CPI for 2016 is given by

$$CPI_{2016} = \frac{0.5 * 20 + 1 * 10}{0.4 * 20 + 0.8 * 10} = \frac{20}{16}.$$

The rate of change in CPI is inflation. In the above example, the inflation is given by $\frac{20}{16} - 1 = 25\%$.

The inflation data is typically published monthly. Within each year, inflation exhibits strong

seasonality. In China, for example, the price level reaches the high point during the Spring Festival every year. As a result, seasonal adjustment is often necessary before any analysis of inflation based on CPI. The problem for Chinese economist, however, is that the CPI level data is not published at the monthly frequency. Instead, the following Year-on-year (同比) inflation rate is published every month:

$$\frac{\sum_{i=1}^{M} w_i p_{it}}{\sum_{i=1}^{M} w_i p_{i,t-12}} \times 100\%.$$

Here the subscript t represents month. This statistic does not eradicate, only mitigates, the seasonality problem, because the Spring Festival may fall in different months. Furthermore, it loses information on month-to-month (环比) variation.

The so-called "core inflation" measures the increase in the price of a consumer basket that excludes food and energy products, the price of which are largely determined by some key commodities (e.g., corn, oil, etc.) and thus often very volatile.

The composition of the consumption basket and the weights assigned to each item are determined by statistical survey of the households in a country. Obviously, the composition of the basket has to change over time. For example, as income per capita increases, the proportion of income spent on food would fall (i.e. Engel's law). As a result, the share of food in the basket should decrease during the course of economic growth. Even within the category of food, the share of grain would decrease and that of meat would increase, as people's lives improve. In China, the CPI basket is adjusted every five year.

The fact that a country calculates its CPI using one basket implies that the CPI reflects the price level facing an "average consumer". For a diverse country like China, this average consumer is elusive. It is natural that many people would feel that the CPI gives a biased measure of the living cost. In most cases, since price increases are more infuriating and news-worthy, people would feel that the CPI under-states inflation systematically.

There are, however, good reasons to argue that CPI tends to overstate inflation. First, there is the so-called substitution bias. Since the CPI uses fixed weights, it cannot reflect consumers' ability to substitute toward goods whose relative prices have fallen. In other words, when one item in the consumption basket becomes more expensive, the weight of this item should decrease. But the CPI calculation ignores this possibility. Second, the introduction of new goods makes consumers better off and, in effect, increases the value of the money. But this does not reduce the CPI, also due to the fixed weights. Third, quality improvements increase the value of the money, but they are also conveniently ignored.

The National Bureau of Statistics of China also publishes a PPI (producer price index) that measures the average price changes of the industrial goods from domestic producers. The rules of calculating PPI is the same as CPI, with a different basket that contains a representative list of wholesale goods. For historical reasons, China's PPI basket does not contain agricultural goods and services. Because many industrial goods are inputs to the production of consumption goods, PPI is widely believed to be a leading indicator for CPI.

GDP Deflator

There is another statistic that can be used to measure inflation, the GDP deflator. Recall that we define GDP deflator by

$$P_t = \frac{Y_t}{y_t} = \frac{\sum_{i=1}^{M} q_{it} p_{it}}{\sum_{i=1}^{M} q_{it} p_{i,t_0}}$$

where y_t is the value of output at price level of the year t_0 (base year), q_{it} is the output of i^{th} item in year t. If we define $w_{\text{it}} = q_{it} / \sum_{i=1}^{M} q_{it} p_{i,t_0}$, then we obtain $P_t = \sum_{i=1}^{M} w_{it} p_{it}$, which is a weighted average of prices just like CPI.

However, there are two differences between CPI and GDP deflator. First, the basket for GDP deflator contains all final goods and services produced domestically. The weight of each item is proportional to the total output of each item. But the CPI basket contains only those goods and services consumed by an "average consumer". The weight of each item is proportional to the consumption of the item by the average consumer. An increase in the price of goods bought only by firms or the government will show up in the GDP deflator, but not in the CPI. Imported goods are not a part of GDP and therefore don't show up in the GDP deflator. Second, the weight for GDP deflator changes every year, while that for CPI changes much more slowly.

Figure 4: Inflation in CPI and GDP Deflator

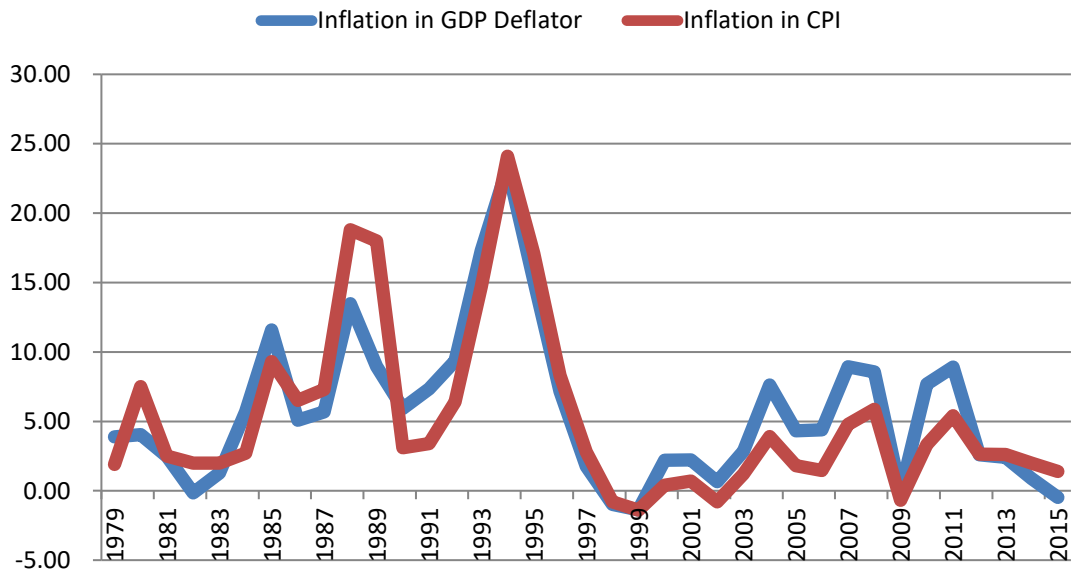


Figure 4 shows the annual inflation measured by CPI and GDP deflator. From 1978 to 2015, there are about eight cycles of inflation. The four inflation cycles before mid-1990s are more volatile, while those after mid-1990s are moderate. While CPI inflation and GDP deflator inflation generally move together in each cycle, there are substantial quantitative differences.

Unemployment

The unemployment rate is a measure of how difficult one can find a job. It is defined as the

percentage of the labor force that is unemployed:

$$\text{Unemployment rate} = \frac{\text{Number of the unemployed}}{\text{Labor force}}.$$

The labor force is defined as the sum of the employed and unemployed. The latter is defined as someone who wants to work but cannot find a job.

A related concept is the labor-force participation (LFP) rate, which is the percentage of the adult population who are in the labor force:

$$\text{Labor force participation} = \frac{\text{Labor force}}{\text{Adult population}}.$$

For example, in 2008, the US labor statistics broke down as follows:

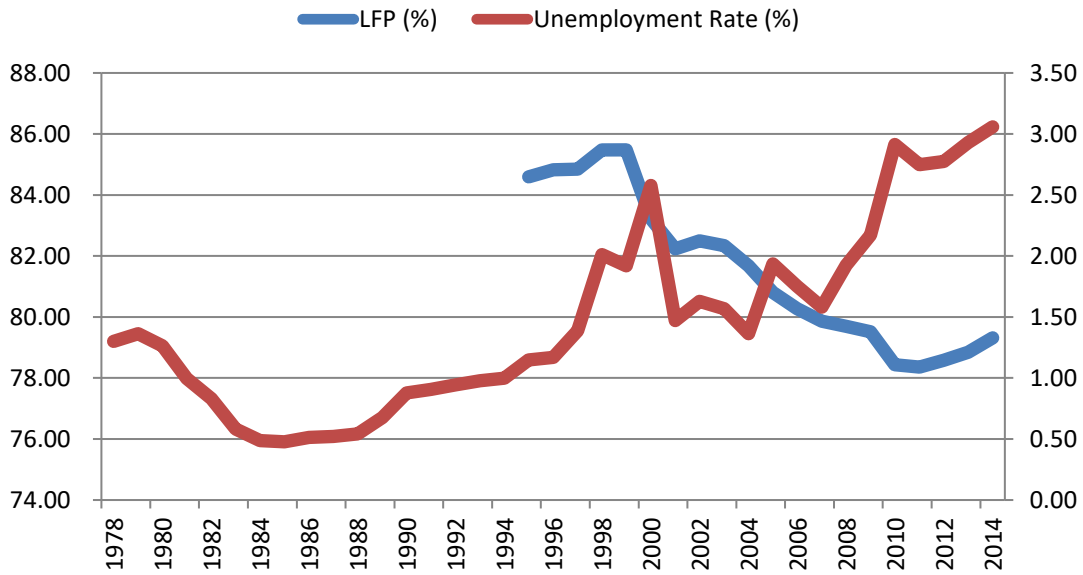
Labor Force = 145.0 (Employed) + 10.1 (Unemployed) = 155.1 million

Unemployment Rate = (10.1/155.1) x 100 = 6.5%

Labor-Force Participation Rate = (155.1/234.6) x 100 = 66.1%

Figure 5 shows the labor force participation rate and unemployment rate in China. It is generally believed that China's unemployment rate is unreliable, due to outdated method of survey. The LFP experienced a notable drop from around 85% in the late 1990s to below 80% in 2010s, possibly due to the expanded matriculation of universities and colleges. And partly due to the high LFP for women, LFP in China is much higher than in the US.

Figure 5: Labor Force Participation and Unemployment in China



Exercises:

1. Categorize each of the following transactions into one of four components of GDP: (household) consumption, investment, government consumption, and net export.
   a) Lenovo sells a computer to the army.
   b) Lenovo sells a computer to Taobao.

c) Lenovo sells a computer to a Shanghai resident named Junhui Qian.
d) Lenovo sells a computer to the federal government of USA.
e) Lenovo assembles a computer but fails to sell it this year (hopefully sell it next year).

2. A farmer grows a ton of wheat and sell it to a miller for 500 RMB. The miller uses the wheat (the only input) to produce flour and sells the flour to a baker for 1000 RMB. The baker uses the flour to make bread. Consumers buy these bread for 3000 RMB.
   a) What is the value-added in each stage of the production of bread?
   b) If the farmer, miller, baker, and the consumers constitute an economy, what is the GDP for this economy?
3. Find Chinese GDP data and list the shares of consumption, investment, government consumption, and net export in 1980, 1995, and 2010. (Note: The online China Yearly Book: http://www.stats.gov.cn/tjsj/ndsj/)
4. Find nominal and real GDP of China, calculate and plot the annual GDP deflator from 1978 to 2016. Compare the inflations of CPI and GDP deflator.