Topic 5: Nominal and Real GDP

PRINCIPLES OF MACROECONOMICS

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The GDP is market value of all final goods and services for a given year within a region.

If \( P \) is the price level of an economy and \( Q \) is the production, then \( \text{GDP} = P \times Q \)

For 2004, \( GDP_{2004} = P_{2004} \times Q_{2004} \)

Imagine now how it will be for several years (say for 2000 to 2005)

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>( P_{2000} \times Q_{2000} = 220 )</td>
</tr>
<tr>
<td>2001</td>
<td>( P_{2001} \times Q_{2001} = 250 )</td>
</tr>
<tr>
<td>2002</td>
<td>( P_{2002} \times Q_{2002} = 280 )</td>
</tr>
<tr>
<td>2003</td>
<td>( P_{2003} \times Q_{2003} = 295 )</td>
</tr>
<tr>
<td>2004</td>
<td>( P_{2004} \times Q_{2004} = 323 )</td>
</tr>
<tr>
<td>2005</td>
<td>( P_{2005} \times Q_{2005} = 337 )</td>
</tr>
</tbody>
</table>

Most of the time we want to know what happened to \( Q \). That is, we want to know if production went up or down and by how much.

Why?

Because as I pointed out before production is equal to income. Income is very important because it is a proxy for happiness.
However, the table in the previous slide does not help us much. It only tell us what happened to the multiplication of P and Q but not what happened only to Q. For instance from 2003 to 2004 GDP increase by $28. However, it could have been because production when up and prices went down, or prices went up and production down, or all both went up.

In other words, I cannot distinguish between changes in P and changes in Q.

In order to solve this problem we are going to calculate GDP using the same price. That is, we are going to use a constant price. This is called Real GDP.

Real GDP is the market value of all goods and services for a given year and region using **constant prices**.

Nominal GDP is the market value of all goods and services for a given year and region using **current prices**.
In order to get constant prices we need to pick one year and that will be the price level that we will use. We can really choose any year we want, so I am going to use the year 2004.

The real GDP will then be:

<table>
<thead>
<tr>
<th>Year</th>
<th>Real GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>$P_{2004} \times Q_{2000}$</td>
</tr>
<tr>
<td>2001</td>
<td>$P_{2004} \times Q_{2001}$</td>
</tr>
<tr>
<td>2002</td>
<td>$P_{2004} \times Q_{2002}$</td>
</tr>
<tr>
<td>2003</td>
<td>$P_{2004} \times Q_{2003}$</td>
</tr>
<tr>
<td>2004</td>
<td>$P_{2004} \times Q_{2004}$</td>
</tr>
<tr>
<td>2005</td>
<td>$P_{2004} \times Q_{2005}$</td>
</tr>
</tbody>
</table>

I multiply each quantity by the same price so the difference of GDPs between two years is due only to change in Q (it is the only thing changing). Note that I have omitted the value of the real GDP because we will do that later.
The graph on the left shows the importance of using Real GDP when looking at what has happened to GDP through time.

If we were only looking at Nominal GDP (the higher red line) we would conclude that GDP in 2008 increased.

However, if we look at Real GDP (the lower blue line) we can see that Real GDP in 2008 decreased. That is, production in 2008 actually decreased.

What happened?
In 2008 production decreased (Q went down) but prices (P) increased more than the decrease in Q. Thus, in the net P x Q increased in 2008.
You can see now that Real GDP is very useful when we compare between years.

Also, note that the **Real GDP = Nominal GDP for the base year**

\[
\text{Real GDP}_{2000} = \frac{\text{Nominal GDP}_{2000}}{\text{GDP Deflator}_{2000}}
\]

This is one the most important equations of the whole semester and you MUST know it!!!!

It is important because it tell us how to compute the Real GDP. It says that if you know the GDP Deflator and the nominal GDP all you have to do is to divide nominal GDP by the GDP deflator and you get Real GDP.
But, what is the GDP deflator?

From the previous slide we can solve the equation for the GDP Deflator and obtain the following:

\[
\text{GDP deflator}_{2000} = \frac{\text{Nominal GDP}_{2000}}{\text{Real GDP}_{2000}}
\]

Now, let's assume that the base year is 2003, then we write

\[
\text{GDP deflator}_{2000} = \frac{\text{Nominal GDP}_{2000}}{\text{Real GDP}_{2000(\text{base year 2003})}}
\]

Using our previous definitions of Real and Nominal GDP, we get:

\[
\text{GDP Deflator}_{2000} = \frac{\text{Nominal GDP}_{2000}}{\text{Real GDP}_{2000(\text{base year 2003})}} = \frac{P_{2000} \times Q_{2000}}{P_{2003} \times Q_{2000}} = \frac{P_{2000}}{P_{2003}} = \text{price ratio}
\]

This tells us something important: THE GDP DEFLATOR IS THE PRICE RATIO BETWEEN THE YEAR IN QUESTION (2000 in the example above) AND THE BASE YEAR (2003 in the example above).

This is important because if we know the price level for several years we can obtain the GDP deflator and then compute Real and Nominal GDP.
GDP Deflator

The GDP deflator is a very important concept. It is useful because it helps us to obtain Real GDP and we can also use it to get the inflation rate.

In the rest of these slides we will cover how to compute the GDP deflator.

Remember that: 
\[
\text{GDP Deflator}_{2000} = \frac{\text{Nominal GDP}_{2000}}{\text{Real GDP}_{2000 \text{ (base year 2003)}}} = \frac{P_{2000} \times Q_{2000}}{P_{2003} \times Q_{2000}} = \frac{P_{2000}}{P_{2003}}
\]

Therefore, in order to compute the GDP deflator I need to obtain the price level of each year. Once, I know the price level of each year then I can divide the current year \((P_{2003})\) by the base year price level \((P_{2003})\) to get the GDP deflator.

Thus, our next task is to figure out how to compute the P’s. The question is then how do we calculate the GDP deflator or the prices.

It is not as easy as you might think because the economy has millions of different prices: price of gasoline, price of chewing gum, price of beer, etc.
One possibility you might think is to add up all the prices in the economy for a particular year and that is the price level.

However, there is a big problem with this approach: it assumes that all goods have the same importance in the economy. That is, a one dollar increase in the price of food is the same as one dollar increase in the price of cars.

This is unrealistic, why should cars and food have the same importance if the total value of the production of cars and food are different?

For instance, imagine that the price of chewing gum goes up by one dollar and the price of gasoline goes up by one dollar.

I am sure that for most people the increase in the price of gasoline is more important than the increase in the price of chewing gum. This is a result of the fact that people spend a bigger proportion of their income in gasoline than in chewing gum.

Hence, this approach is not good!!!!!!!!
**Weighted approach**

We are going to solve this problem calculating the P’s by weighting the price of each good according to their contribution to total expenditures.

These are the steps we are going to follow:

1) Find the basket of goods: figure out which goods actually matter for the consumer and include them.

2) Find the price of the goods: one you know which goods you are included obtain the price of each individual goods.

3) Choose a base year: pick one year the will be the base, no science on this whatever year you want is ok.

4) Find the share of each good in total expenditures of the base year: in this step you get how important is each good on total consumption.

5) Compute P’s : multiply the price change between the year in question and the base year, multiply it by the share of the price and add them up.
Let's work out an example to show you how it is done:

**Step 1. Find the basket of goods:** I will assume that this economy has only two goods I care about Food and Cars.

**Step 2. Find the prices:** imagine that I do a survey and I find that the prices are the following:

<table>
<thead>
<tr>
<th>Good</th>
<th>Year 2000</th>
<th>Year 2001</th>
<th>Year 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>23</td>
<td>27</td>
<td>39</td>
</tr>
<tr>
<td>Cars</td>
<td>120</td>
<td>125</td>
<td>130</td>
</tr>
</tbody>
</table>

**Step 3. Choose the base year:** I will choose the year 2001 as the base year but this is completely arbitrary.

**Step 4. Find the share of each good in total expenditures of the base year:** in order to get this I need to know the amount of cars and food purchased in the base year.
<table>
<thead>
<tr>
<th>Good</th>
<th>Year 2000</th>
<th>Year 2001</th>
<th>Year 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>30</td>
<td>36</td>
<td>40</td>
</tr>
<tr>
<td>Cars</td>
<td>2</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Obtain the total expenditure in 2001:

\[
\text{Expenditure}_{2001} = (36 \times 27) + (5 \times 125) = 972 + 625 = $1,597
\]

Share of Food in Expenditure 2001 = \( \frac{972}{1597} = 0.60 \) (or 60%)

Share of Cars in Expenditure 2001 = \( \frac{625}{1597} = 0.40 \) (or 40%)
Step 5. Compute P’s: multiply the price change between the year in question and the base year, multiply it by the share of the price and add them up.

\[
P_{2000} = \frac{P_{food,2000}}{P_{food,2001}} \times Weight_{food,2001} + \frac{P_{cars,2000}}{P_{cars,2001}} \times Weight_{cars,2001} = (0.85)0.60 + (0.96)0.40 = 0.51 + 0.384 = 0.894
\]

\[
P_{2001} = \frac{P_{food,2001}}{P_{food,2001}} \times Weight_{food,2001} + \frac{P_{cars,2001}}{P_{cars,2001}} \times Weight_{cars,2001} = 1(0.60) + 1(0.40) = 0.60 + 0.4 = 1
\]

\[
P_{2002} = \frac{P_{food,2002}}{P_{food,2001}} \times Weight_{food,2001} + \frac{P_{cars,2002}}{P_{cars,2001}} \times Weight_{cars,2001} = (1.444)0.60 + (1.04)0.40 = 0.866 + 0.416 = 1.282
\]

Notice that the P for the base year P2001 is equal to 1. We have obtained the P’s necessary to compute the GDP Deflator. Using our previous finding:

\[
GDP \text{ Deflator}_{2000} \text{ (base 2001)} = \frac{P_{2000}}{P_{2001}} = \frac{0.894}{1} = 0.894
\]

\[
GDP \text{ Deflator}_{2001} \text{ (base 2001)} = \frac{P_{2001}}{P_{2001}} = \frac{1}{1} = 1
\]

\[
GDP \text{ Deflator}_{2002} \text{ (base 2001)} = \frac{P_{2002}}{P_{2001}} = \frac{1.282}{1} = 1.282
\]
Let's get a little bit more specific now.

When we use the GDP deflator we consider ALL the goods in the economy. That is in Step 1 we choose every single good in the economy.

Sometimes we use another measure of prices called the Consumer Price Index (CPI). The CPI is like the GDP deflator and it is also used to convert nominal values into real values.

The main difference between the GDP deflator and the CPI is that the CPI uses a different basket of goods. The CPI uses a basket of good that is representative of the typical American consumer.

To clarify:

**GDP deflator uses the prices of all goods in the economy**

**CPI uses the prices for a basket of goods that are representative of the typical consumer.**

**BOTH OF THEM ARE MEASURES OF PRICES IN THE ECONOMY BUT ARE USED FOR DIFFERENT PURPOSES.**
Before, we look at when we use GDP deflator and when we use the CPI. Let's work out an example to practice. Consider the following information:

<table>
<thead>
<tr>
<th>Year</th>
<th>Nominal GDP</th>
<th>Price Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>120</td>
<td>78</td>
</tr>
<tr>
<td>2004</td>
<td>145</td>
<td>90</td>
</tr>
<tr>
<td>2005</td>
<td>155</td>
<td>120</td>
</tr>
<tr>
<td>2006</td>
<td>158</td>
<td>121</td>
</tr>
<tr>
<td>2007</td>
<td>167</td>
<td>127</td>
</tr>
<tr>
<td>2008</td>
<td>170</td>
<td>140</td>
</tr>
</tbody>
</table>

Given this information obtain: the GDP deflator and the Real GDP using 2003 as the base year.

Using the definition of GDP deflator:

\[
\text{GDP Deflator}_{2003} = \frac{P_{2003}}{P_{2003}} = \frac{78}{78} = 1
\]

\[
\text{GDP Deflator}_{2004} = \frac{P_{2004}}{P_{2003}} = \frac{90}{78} = 1.154
\]

\[
\text{GDP Deflator}_{2005} = \frac{P_{2005}}{P_{2003}} = \frac{120}{78} = 1.54
\]

and so on
Hence, we obtain the GDP deflator at 2003 prices

<table>
<thead>
<tr>
<th>Year</th>
<th>Nominal GDP</th>
<th>Price Level</th>
<th>Base 2003 GDP deflator</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>120</td>
<td>78</td>
<td>1.0000</td>
</tr>
<tr>
<td>2004</td>
<td>145</td>
<td>90</td>
<td>1.1538</td>
</tr>
<tr>
<td>2005</td>
<td>155</td>
<td>120</td>
<td>1.5385</td>
</tr>
<tr>
<td>2006</td>
<td>158</td>
<td>121</td>
<td>1.5513</td>
</tr>
<tr>
<td>2007</td>
<td>167</td>
<td>127</td>
<td>1.6282</td>
</tr>
<tr>
<td>2008</td>
<td>170</td>
<td>140</td>
<td>1.7949</td>
</tr>
</tbody>
</table>

Now, obtain the nominal GDP by the GDP deflator.

\[
\text{Real GDP}_{2003} = \frac{\text{Nominal GDP}_{2003}}{\text{GDP Deflator}_{2003}} = \frac{120}{1} = 120
\]

\[
\text{Real GDP}_{2004} = \frac{\text{Nominal GDP}_{2004}}{\text{GDP Deflator}_{2004}} = \frac{145}{1.154} = 125.7
\]

\[
\text{Real GDP}_{2005} = \frac{\text{Nominal GDP}_{2005}}{\text{GDP Deflator}_{2005}} = \frac{155}{1.54} = 100.8
\]

and so on.
Hence, we obtain the Real GDP at 2003 prices

<table>
<thead>
<tr>
<th></th>
<th>Nominal GDP</th>
<th>Base 2003 GDP deflator</th>
<th>Real GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>120</td>
<td>1.0000</td>
<td>120.0</td>
</tr>
<tr>
<td>2004</td>
<td>145</td>
<td>1.1538</td>
<td>125.7</td>
</tr>
<tr>
<td>2005</td>
<td>155</td>
<td>1.5385</td>
<td>100.8</td>
</tr>
<tr>
<td>2006</td>
<td>158</td>
<td>1.5513</td>
<td>101.9</td>
</tr>
<tr>
<td>2007</td>
<td>167</td>
<td>1.6282</td>
<td>102.6</td>
</tr>
<tr>
<td>2008</td>
<td>170</td>
<td>1.7949</td>
<td>94.7</td>
</tr>
</tbody>
</table>

This process of turning a nominal value (in this case GDP) into a real value is called “deflating”.
Deflating is also useful when we want to know the real value of a past monetary value.
For example, we know if your Dad made 30,000 dollars a year in 1985 we may want to know how much is that today. In other words, we have to put it in 2008 prices.
This is done using the following formula:

\[
\text{Monetary Value today} = \frac{\text{Monetary Value in the past} \times \text{Price level today}}{\text{Price level in the past}}
\]

Example:
Babe Ruth the famous baseball player got paid $80,000 in 1931. How much is that in 2001 prices?
First, we obtain the prices and we find that \( P_{1931} = 15.2 \)
Second, we obtain the prices and we find that \( P_{2001} = 177 \)
Now use the formula above:

\[
\text{Babe Ruth's wage in 1931 at 2001 prices} = \frac{80,000 \times 177}{15.2} = \$931,579
\]

This means that the 80,000 dollars that Babe Ruth earned in 1931 is the equivalent to $931,579 in 2001.
Another measure of prices (P’s) is the Consumer Price Index (CPI). The CPI is produced by Bureau of Labor Statistics and its main intention is to compute the cost of living for the average household.

This is different from the GDP deflator because the GDP deflator tries to measure the prices in the economy.

However, the GDP deflator and the CPI are similar in that they both use a fixed basket of goods. In the case of the GDP deflator the basket of goods includes all the goods and services in the economy and in the case of the CPI includes only some of the consumption goods.

Using our previous formula for GDP deflator we get that:

\[
\text{Real GDP} = \frac{\text{Nominal GDP}}{\text{GDP deflator}} \quad \text{but since GDP deflator} = P \quad \text{(see the previous slides)}
\]

then

\[
\text{Real GDP} = \frac{\text{Nominal GDP}}{P}
\]

Since Nominal GDP = C + I + G + NX then

\[
\text{Real GDP} = \frac{C + I + G + NX}{P}
\]
**Consumer Price Index**

This last equation tells us that the P of the GDP deflator includes prices for all the components of GDP: consumption (C), investment (I), government spending (G) and net exports (NX).

On the other hand, the CPI includes only goods in C.

**So, when do we use CPI and when do we use GDP deflator?**

If we want to know what has happened to the cost of living for the average household we use the CPI. In fact, inflation is usually measure by computing the percentage change in CPI.

If we want to compute Real GDP the first choice should be GDP deflator. If we want to know what has happened to the prices of all the goods and services in the economy, then we use GDP deflator.
Consumer Price Index

As mentioned before the CPI is also computed by using a fixed basket of goods. However these are all consumption goods and services. These are the weights of the different types of goods and services in the CPI:

1) Food and Beverages are 16% of CPI
2) Housing is 42% of CPI
3) Transportation is 17% of CPI
4) Education and Communication is 6% of CPI
5) Medical care is 6% of CPI
6) Recreation is 6% of CPI
7) Apparel is 4% of CPI
8) Other goods and services 4% of CPI

Once we know these shares we follow Step 5 in slide 7 to get CPI. (Again the only difference between computing P’s using GDP deflator and CPI is the type of goods considered)
The CPI and GDP deflator have some problems that are important to keep in mind:

1) They do not account for the introduction of new goods: since the shares are fixed then new goods will not be considered.

2) Unmeasured quality changes: we can compute the prices of TVs in 2008 and 1968 but the TVs are very different because the quality of the 2008 TV is probably better. Well, in these case the GDP deflator or CPI will not account for quality changes.

3) Substitution bias: the fixed basket is not always fixed specially when households change their consumption patterns as a result to changes in prices. Since the share of the goods is fixed then when prices change in different proportions consumers will buy more of the cheaper goods and less of the expensive goods. For example, if food becomes cheaper and housing more expensive consumers will spend 18% of their consumption on food (instead of 16%) and 39% in housing (instead of 41%). Because the consumer will do this type of substitution as a response to all the prices changes the original basket is not longer completely representative of the consumption pattern of the consumer.
Consumer Price Index

Substitution bias is important because some wages and particularly social security are indexed to the CPI.

Indexation means that a value (wage or social security check) will change in the same proportion as the CPI. If CPI goes up by 5% then social security payment will also go up by 5%.

The purpose of this is to keep the purchasing power of social security or wages.

However, because of substitution bias consumers will be better off if their income increases in the same proportion as inflation. This is due because the consumer is not longer buying the old basket. The change in the prices of the goods produces a different basket (more affordable) so that at the end of the day the consumer buys even more than before.

The only exception is when ALL prices in the CPI increase in the same proportion. In that case no good is becoming cheaper or more expensive relative to the other goods and there is not substitution. However, this does not really happen in the real world. Usually, there is substitution bias so the CPI overstates the cost of living (in about 1 percentage point per year).