Comparing GDP Across Countries

In these notes we discuss the comparison of GDP across countries. Recall that the GDP is the market value of the final goods and services produced by labor and property located in the country during one year. Thus the U.S. GDP is measured in dollars while India’s GDP is measured in Indian Rupee. It seems reasonable that in order to compare the U.S. GDP with India’s GDP we need to convert them into a common currency. For example, we can convert India’s GDP into dollars or the U.S. GDP into Indian Rupee. The straightforward way of converting one currency into another is using the market exchange rate. We will show however, that using the market exchange rates tends to undervalue the GDP of developing countries. We will demonstrate that using an alternative exchange rate, the so-called Purchasing Power Parity (PPP) exchange rate eliminates some of that bias.

1 Using Market Exchange Rates

Suppose that the exchange rate between the dollar ($) and the Indian Rupee (INR) is 40 Indian Rupees per 1 dollar. This means that the price of one dollar is 40 Indian Rupees. We denote the above exchange rate by

\[ e = 40 \frac{INR}{\$} \]

Note that the above exchange rate can be expressed as the price of one Indian Rupee in the dollars, i.e. \( \frac{1}{40} \frac{\$}{INR} \).

**Example 1** Suppose that I have $100, and I want to know how many INR I can get for that at the foreign exchange. The exchange rate tells me that each dollar is worth 40 INR, so $100 is worth 4000 INR. That is,

\[ 100\$ \cdot 40 \frac{INR}{\$} = 4000INR \]

To make sure that we did not make a mistake, and multiplied by the exchange rate instead of dividing, notice that the $ “cancels out” and we are left with INR.

**Example 2** Now suppose that I have 80 INR, and I want to see how many dollars I can get for that at the foreign exchange. If 40 INR are traded for 1 dollar, then 80 INR will give me 2 dollars. That is,

\[ 80INR \cdot \frac{1}{40} \frac{\$}{INR} = 2\$ \]

In this example we used the exchange rate as the price of one Indian Rupee in dollars, so the INR will “cancel out” and we are left with dollar amount.

The next section provides a theory of how the market exchange rates are determined.
2 The Law of One Price

The Law of One Price states that the price of traded goods has to be the same in two countries, when converted into a common currency.

**Example 3** Suppose that televisions are traded good and the price of a TV set in U.S. is $100 while the price of the same TV set in India is 8000 INR. What should be the exchange rate between the $ and INR? Since the TV’s are traded, the price of a TV, when converted to the same currency, must be the same. Therefore,

\[
100\textdollar \cdot \frac{\text{INR}}{\textdollar} = 8000\text{INR}
\]

\[
\Rightarrow \frac{\text{INR}}{\textdollar} = \frac{8000\text{INR}}{100\textdollar} = 80\frac{\text{INR}}{\textdollar}
\]

Thus, the exchange rate has to be such that when the price of the U.S. TV is converted to Indian currency, we get the same price at which this TV is traded in India, provided that TVs are traded between these countries. If the above inequality did not hold, there was a possibility for arbitrage (either buy TVs in India and sell in the U.S., or the other way around). The above equality is called the “Law of One Price”, which states that the price of traded goods has to be the same in two countries, when converted into a common currency. The last example is in fact a basic theory of market exchange rates determination.

3 Comparing GDP in Two Countries Using Market Exchange Rate

In the last section we have seen that prices of traded goods determine the value of exchange rates between two currencies. In this section we illustrate that using the market exchange rates tends to undervalue the GDP of developing countries. Suppose that two countries, the U.S. and India, can produce two goods: TV’s that are traded, and restaurant meals that are not traded internationally. The following table contains data on quantities produced and local prices of both goods in the two countries. The quantities produced are per capita.

<table>
<thead>
<tr>
<th>Production</th>
<th>Price</th>
<th>GDP in local currency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TVs</td>
<td>Meals</td>
</tr>
<tr>
<td>U.S.</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>India</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Of course we cannot compare 40$ with 43INR unless we convert them to a common currency. What should be the market exchange rate under the assumption of the law of one price? The price of the traded good (TVs) has to be the same when converted to common currency. The law of one price requires that the price of TV be the same in both countries, when converted to common currency:

\[
4\textdollar \cdot \frac{\text{INR}}{\textdollar} = 40\text{INR}
\]
which implies that the exchange rate is

\[ e = 10 \frac{INR}{\$} \]

Now we can compare the GDP in the two countries, in the same currency (e.g. INR), using the market exchange rate.

\[
\begin{align*}
GDP_{U.S.} &= 40\$ \cdot 10 \frac{INR}{\$} = 400INR \\
GDP_{India} &= 43INR
\end{align*}
\]

The ratio of GDP in the two countries is:

\[
\frac{GDP_{U.S.}}{GDP_{India}} = \frac{400}{43} = 9.3
\]

This result means that the U.S. GDP is more than 9 times larger than the Indian GDP. A closer look however reveals that U.S. produces 4 times as much as India of both goods, so it seems that the right ratio of U.S. GDP over Indian GDP should be 4:1. Why did we get such a big difference in GDP of two countries when we used the market exchange rate? Notice that the price of meals is much lower in India then in the U.S.: 2\$ is equivalent to 20INR using the market exchange rate, i.e. meals in the U.S. are 20 times more expensive than in India. But meals are not traded, so the law of one price does not force the exchange rate to adjust. Instead, the market exchange rate is affected by traded goods (TVs), which are relatively more expensive in India. The next section demonstrates how we can resolve the problem of undervalued GDP in India, using the so called Purchasing Power Parity exchange rate.

4 Comparing GDP in Two Countries Using PPP Exchange Rate

The PPP (Purchasing Power Parity) exchange rate is constructed using traded as well as non-traded goods. Suppose that you live in the U.S. and you have 4\$. You can buy 1 TV or 2 meals. Now suppose that you trade your 4\$ for 40INR (the market exchange rate is 10 INR/\$) and move to India. In India you are able to buy 1 TV or 40 meals. This means that the purchasing power of 4\$ is much greater in India than in the U.S. The “regular” market exchange rate does not take into account that meals are so much cheaper in India than in the U.S. The PPP exchange rate attempts to account for the much cheaper non-traded goods in India. When we construct the PPP exchange rate, we pretend that all goods are traded. We choose a common consumption bundle that will include traded and non-traded goods and the PPP exchange rate is set such that this bundle costs the same in both countries, when converted into a common currency. What bundle should we choose for our example? It seems reasonable to choose 1 TV and 3 meals because this is the ratio at which those goods are produced in both countries.
<table>
<thead>
<tr>
<th></th>
<th>Price of the bundle</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>$1 \cdot 4 + 3 \cdot 2 = 10$</td>
</tr>
<tr>
<td>India</td>
<td>$1 \cdot 40 + 3 \cdot 1 = 43\text{INR}$</td>
</tr>
</tbody>
</table>

Pretend that the Law of One Price applies to the above consumption bundle, consisting of 1 TV and 3 meals. Then, the PPP exchange rate is determined by

$$10\$, \ \varepsilon_{PPP} = 43\text{INR}$$

$$\Rightarrow \varepsilon_{PPP} = 4.3 \frac{\text{INR}}{\$}$$

The name "Purchasing Power Parity" comes from the fact that the above exchange rate makes the purchasing power of 1\$ the same in both countries. The purchasing power of 1\$ in the U.S. is $\frac{1}{10}$, i.e. 1\$ buys $\frac{1}{10}$ of the consumption bundle. The purchasing power if 1\$ in India, after converting to INR is:

$$\frac{1 \cdot \varepsilon_{PPP}}{43}$$

Purchasing Power Parity requires that

$$\frac{1}{10} = \frac{1 \cdot \varepsilon_{PPP}}{43}$$

$$\Rightarrow \varepsilon_{PPP} = 4.3 \frac{\text{INR}}{\$}$$

Notice that when we take into account the cheaper meals in India, the value of the Indian currency goes up relative to the dollar.

Let’s use the PPP exchange rate, to compare the GDP in the two countries:

$$GDP_{U.S.} = 40\$ \cdot 4.3 \frac{\text{INR}}{\$} = 172\text{INR}$$

$$GDP_{India} = 43\text{INR}$$

The ratio of GDP in the two countries is:

$$\frac{GDP_{U.S.}}{GDP_{India}} = \frac{172}{43} = 4$$

Thus, the PPP exchange rate gives us a more realistic measure of the relative GDP in both countries.

5 Summary

Our goal was to compare standard of living in the two countries. The market exchange rate is determined by traded goods (here TVs) only, which are relatively more expensive in developing countries such as India. When we neglect to take into account the cheap non-traded goods (here meals) in India, we undervalue India’s standard of living. Comparing bundles which include both traded and non-traded goods, gives us a better estimate of the relative differences in the standard of living. The PPP exchange rate is determined in such a way that the purchasing power of 1\$, in terms of the consumption bundle, is the same in both countries. Thus, when comparing standard of living across countries, economists use the PPP exchange rate, instead of the market exchange rate.