Measuring Income and Prices

Mark Huggett

Georgetown University

January 12, 2018
Income and Prices

1. These slides will review different ways to compute GDP. The Bureau of Economic Analysis (BEA) calculates GDP in different ways for the US.

2. These slides will also review different price indices and relate actual price indices to a “cost of living index”.
Nominal GDP is the value (in current-year prices) of all final goods and services produced domestically over a period of time.

Real GDP is the value (in base-year prices) of all final goods and services produced domestically over a period of time.

Some Key Issues:
- GDP Counts Final NOT Intermediate goods
- What are Goods vs Services
- GDP is a Geographical Concept
- Three Accounting Approaches for computing GDP
- GDP vs GNP
The Expenditure Approach:

- $Y_t = \sum_i p_{it}y_{it}$
- $p_{it}$ and $y_{it}$ - price and quantity of final good $i$ produced at time $t$
- we sum over ALL the different final goods which are indexed by $i$

NOTE: $Y_t = C_t + I_t + G_t + NX_t$ is commonly taught in introductory courses. This is consistent with the expenditure approach above. In this accounting equation expenditure is just being grouped by some major categories (e.g. $C$ is for consumption expenditures).
The Expenditure Approach:

- Conceptually this approach is very clean.
- For some final goods we can measure total expenditure but the price and quantity components are less clear (e.g. legal services).
- Many final goods expenditures are not included in GDP (e.g. the breakfast I prepared for myself today).
- GDP accountants impute a value for some goods even though no price, quantity or expenditure data are directly available (e.g. implicit rental value of owner-occupied housing).
Value Added Approach

- \[ Y = \sum_i VA_i \]
- \( VA_i \) - value added of firm \( i \)
- \( VA_i = Sales_i - Value \text{Intermediate Goods} Purchased_i \)
- The value added approach adds up the value added of each firm in the economy. Thus, the sum is over firms.
- It turns out that the value added approach is simply a tricky way to add up the expenditure on all final goods. Why is that?
Income Approach

- \( Y = \text{National Income} + \text{Indirect Tax} + \text{Depreciation} - \text{Net Foreign Factor Income} \)
- \( \text{National Income} = \text{Wages} + \text{Profit} + \text{Rent} + \text{Prop Income} + \text{Interest} \)
- The income approach starts from a simple idea (the plumbing diagram) but is ”ugly” to execute.
- Ugly Feature 1: Indirect Tax
- Ugly Feature 2: Depreciation
- Ugly Feature 3: Net Foreign Factor Income
The income approach and the expenditure approach should compute the same GDP, absent quite a few real world problems. The plumber’s diagram on the next slides helps us to understand why, absent several problems, the two approaches should compute the same GDP.

The logic for this claim is that all the expenditures on final goods received by firms are paid out by firms as income to various claimants on the firms income.

Two Real World Accounting Problems: Indirect Tax and Tax Treatment of Corporate Profits
Figure: Expenditure and Factor Income Method: A Plumber’s Diagram
Simple Example: 1

Farmer produces 10 units of wheat using labor
Miller produces 10 units of flour using 10 wheat and labor
Baker produces 10 units of bread using 10 flour and labor

What is GDP based on the price information below?

\[ p_b = 4, p_f = 2, p_w = 1 \]
Simple Example 1:

Expenditure Approach:

\[ Y = \sum_i p_i y_i = p_w y_w + p_f y_f + p_b y_b = 1 \cdot 0 + 2 \cdot 0 + 4 \cdot 10 = 40 \]

Value Added:

\[ Y = \sum_i V A_i = V A_1 + V A_2 + V A_3 \]
\[ Y = (10 - 0) + (20 - 10) + (40 - 20) = 40 \]

Firm 1 = Farmer, Firm 2 = Miller and Firm 3 = Baker
Simple Example: 2

Firm 1 produces $20 of consumption good and Firm 2 produces $20 of an investment good. Both firms are organized as corporations.

\[ \text{Profit}_1 = \text{Revenue}_1 - \text{Wages}_1 - \text{Dep}_1 = 20 - 20 - 0 = 0 \]
\[ \text{Profit}_2 = \text{Revenue}_2 - \text{Wages}_2 - \text{Dep}_2 = 20 - 10 - 5 = 5 \]

What is GDP?
Simple Example: 2

Income Approach:

\[ Y = Wages + CorpProfit + Depreciation \]
\[ Y = 30 + 5 + 5 = 40 \]

What would happen to GDP calculations if the corporate tax accounts decided to change their procedures and end up computing depreciation differently?

Answer: Nothing as corporate profit and depreciation would simply move in opposite directions but by the same magnitude. GDP would be unaffected.
### Table: US Nominal GDP in 2016: Expenditure Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP (Y)</td>
<td>18,569.1 billion</td>
</tr>
<tr>
<td>Consumption (C)</td>
<td>12,757.9 billion</td>
</tr>
<tr>
<td>Investment (I)</td>
<td>3,035.7 billion</td>
</tr>
<tr>
<td>Government (G)</td>
<td>3,276.7 billion</td>
</tr>
<tr>
<td>Net Exports (NX)</td>
<td>-501.3 billion</td>
</tr>
</tbody>
</table>

Source: BEA Table 1.1.5
### Table: US Nominal GDP in 2016: Factor Income Components

<table>
<thead>
<tr>
<th>GDP (Y)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensation of Employees</td>
<td>10,101.3 billion</td>
</tr>
<tr>
<td>Proprietor’s Income</td>
<td>1,417.5 billion</td>
</tr>
<tr>
<td>Rent</td>
<td>704.7 billion</td>
</tr>
<tr>
<td>Corporate Profit</td>
<td>2,088.1 billion</td>
</tr>
<tr>
<td>Net Interest</td>
<td>524.1 billion</td>
</tr>
<tr>
<td>Tax on Production</td>
<td>1,237.6 billion</td>
</tr>
<tr>
<td>Depreciation</td>
<td>2,910.4 billion</td>
</tr>
</tbody>
</table>

Source: BEA Table 1.12 and Table 1.7.5

Note: Tax on Production above is the term Indirect Tax used earlier.
US Real GDP Time Series

The next slide plots GDP and its components. The vertical scale is in log units because all aggregates grow over time. The log scale helps to spot changes in growth rates.

US GDP is nearly a straight line with a positive slope. Over the last 100 years GDP in the US has displayed a positive growth rate. Growth theory offers theories of why (many) countries over the last century have grown.
Figure: Real GDP and Components

US Real GDP and Components

Log Scale (2009 Dollars)
**Labor’s Share of Income**

What share of income is paid to labor and what share is paid to capital?

How capital and labor’s share varies over time is an issue of great importance. This can be answered by GDP accounting, at least in principle, using the factor incomes approach. One possible calculation (US 2016 Data):

\[
\text{Labor’s Share} = \frac{\text{Comp. Employees}}{\text{GDP}} = \frac{10.10}{18.56} = .54
\]

Problem: Proprietor’s Income and Tax on Production are an unclear mix of labor and capital income, but both are excluded from this calculation.
Labor’s Share of Income

A better calculation (US 2016 Data):

\[
\text{Labor's Share} = \frac{\text{Comp. Employees}}{\text{GDP} - \text{Tax on Prod} - \text{Prop. Income}}
\]

\[
\frac{\text{Comp. Employees}}{\text{GDP} - \text{Tax on Prod} - \text{Prop. Income}} = \frac{10.10}{15.915} = .634
\]
Labor’s Share of Income: England and UK
Changes in the Wealth of Nations
Authors: Parente and Prescott

Goal: Document facts about the distribution of GDP per capita across countries at a point in time and over time. Measure GDP using PPP approach.

Price Indicies

- \( CPI_t = \frac{\sum_i p_{it} x_i}{\sum_i p_{i}^* x_i} \) - fixed weight index
- \( Deflator_t = \frac{\sum_i p_{it} y_{it}}{\sum_i p_{i}^* y_{it}} \) - variable weight index
- \( x_i \) - quantity of good \( i \) in the basket
- \( y_{it} \) - quantity of final good \( i \) produced in year \( t \)
- \( p_{it} \) and \( p_{i}^* \) - price good \( i \) at time \( t \) and in the base year
How is the CPI used?

- It indexes old-age payments in the US Social Security program.
- It indexes the income level where US federal income tax brackets begin. Absent new legislation, the income level where a higher income tax rate applies shifts up over time proportional to the CPI.
- It has been used to index salary levels for some union workers.
- The Federal Reserve uses “core CPI” to inform monetary policy decisions.
Bias in the CPI

A Cost-of-Living Index measures the minimum cost of obtaining a fixed level of utility or welfare over time as market prices change. The CPI measures the cost of a fixed basket over time. Thus, there may be a bias in the CPI when it is used as a ”Cost-of-Living Index”.

▶ Moulton (1996) discusses CPI construction and sources of bias
▶ Substitution Bias
▶ Quality Adjustment Bias
▶ New Goods Bias
Moulton (1996): Two Stages of CPI Construction

- Construct Strata Indexes
  - 44 Geographical stats (e.g. Denver metro area)
  - 207 item strata (e.g. women’s shoes)
  - $44 \times 207 = 9108$ strata indexes
- Combine Stata Indexes into CPI using weights
  - CEX weights (e.g. expenditure on women’s shoes in Denver/total exp)
  - weights changed (historically) every 10 years

Note:
1. Strata indexes estimated using sample of prices at specified outlets.
2. Broad housing category has 41 percent of expenditure in 1995.
3. CPI constructed monthly. Many different versions of CPI are constructed.
Bias in the CPI: Substitution Bias

In theory, when both item (i)-(ii) below hold and the CPI indexes income, then the CPI overcompensates for changes in the cost of living. This is called substitution bias.

(i) There is a change in the relative prices of some goods. 
(ii) The indifference curve is smooth about the current consumption allocation.

The Figure on the next slide shows that the new budget line cuts through the original indifference curve when (i)-(ii) both hold. The base year choice \((x_1^*, x_2^*)\) is tangent to the budget line as agents in theory make best choices.
Figure: Consumer Choice with a Relative Price Change