1.1 Macroeconomics: Data and Models
- **Data**: GDP, Unemployment, Inflation, etc. (Do you have a ‘big’ picture of various economic data in US? Where to obtain them?)
- **Model**: IS-LM, Growth, Business Cycle, etc. (Mapping: data $\leftrightarrow$ models)
- **Types of data**: Time series, Cross-sectional, Pooled/Panel.
- **Model specification**: Exogenous Variables versus Endogenous Variables.

1.2 Demand/Supply Analysis (Microeconomic Foundation of Macroeconomics)
- **Derive** the demand curve/function: Utility Maximization (constrained problem)
  \[ \max_{c} U(c) \]
  \[ \text{s.t. budget constraint holds (typically, } P \cdot c \leq Y) \]
  \[ \Rightarrow c^*(P,Y) \]
  \[ \text{e.g.1 } U(c) = \ln(c), \text{ what is } c^*(P,Y) \text{? (generally, } c \text{ & } P \text{ is not one-dimensional)} \]
  Check if the above-derived curve looks reasonable?
- **Derive** the supply curve/function: Profit Maximization
  \[ \max_{l,w} P \cdot f(l) - w \cdot l \]
  \[ \Rightarrow l^*(P,w) \Rightarrow Q^S(P,w) \]
  \[ \text{e.g.2 } f(l) = l^{0.5}, \text{ what is } Q^S \text{?} \]
- **Putting together**: Equilibrium
  \[ Q^S(P,w) = c^*(P,Y) \Rightarrow P^* \]
  \[ Q: \text{what is the equilibrium price, combining e.g.1 and e.g.2?} \]

2.1 Measurement of Real GDP and Nominal GDP
- **Example**: Real GDP and Nominal GDP (based on mid-term 2008)

<table>
<thead>
<tr>
<th>Year</th>
<th>Footballs</th>
<th>Grapes</th>
<th>Dresses</th>
<th>Wine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P$</td>
<td>$Q$</td>
<td>$P$</td>
<td>$Q$</td>
</tr>
<tr>
<td>2000</td>
<td>$5$</td>
<td>3</td>
<td>$1$</td>
<td>15</td>
</tr>
<tr>
<td>2001</td>
<td>$6$</td>
<td>4</td>
<td>$2$</td>
<td>20</td>
</tr>
</tbody>
</table>

1. Assuming all grapes are used to produce wine, calculate 2000/2001 Nominal GDP and Real GDP using year 2000 as the base year, respectively.
2. Report the GDP Deflator.

**Notes**: CPI versus GDP Deflator; Equivalence between three approaches.

3.1 Economic Growth
- **Production Function**: \[ Y = A \cdot F(K,L) \]
  Shows how output ($Y$) the economy can produce with $K$ units of capital and $L$ units of labor. The level of technology $A$ is taken as given.
Cobb-Douglas production function and Constant Return to Scale (CRS)

**CRS property:** \( F(\alpha K, \alpha L) = \alpha F(K, L) \), also called 'homogeneous of degree one'

**Cobb-Douglas:** \( F(K, L) = K^\alpha L^\beta \), where \( \alpha + \beta = 1 \) and \( 0 \leq \alpha \leq 1 \)

*Note:* Throughout this course, we will focus on CRS technology.

- **Marginal Product of Labor (MPL):** The extra output the firm can produce using an additional unit of labor (holding other inputs fixed): \( \text{MPL} \approx \frac{AF(K, L + 1) - AF(K, L)}{L} \)

  © **Definition:** \( MPL = \frac{\partial Y}{\partial L} = \frac{\partial A \cdot F(K, L)}{\partial L} \equiv A \cdot F_1(K, L) \)

- **Marginal Product of Capital (MPK):** \( A \cdot F_K(K, L) \)

- **Diminishing Marginal Returns:** MPK & MPL

- **Growth Accounting formula:**

  \[
  \frac{\Delta Y}{A} = \frac{\Delta A}{A} + \alpha \cdot \frac{\Delta K}{K} + (1 - \alpha) \cdot \frac{\Delta L}{L}
  \]

  \( \frac{\Delta A}{A} \): Solow Residual, Total Factor Productivity (TFP)

### 3.2 Neoclassical Growth Theory: Solow Growth Model

- **Assume constant saving rate:** abstract household decision from consideration, i.e. no optimization problem involved.

  \( I - \delta K = s(Y - \delta K), \quad \Delta K = I - \delta K \), CRS Production Function.

- **Growth Rate:**

  \[
  \frac{\Delta Y}{Y} \approx \Delta \ln(Y), \quad \frac{\Delta K}{K} \approx \Delta \ln(K), \text{etc.}
  \]

- **Approximation:** \( \Delta \ln(Y) = \Delta \ln(A \cdot F(K, L)) = \Delta \ln(A) + \alpha \cdot \Delta \ln(K) + (1 - \alpha) \cdot \Delta \ln(L) \)

  \[
  \Rightarrow \frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha \cdot \frac{\Delta K}{K} + (1 - \alpha) \cdot \frac{\Delta L}{L}
  \]

  - **Assuming A constant, per capita variables:** \( y = \frac{Y}{L}; k = \frac{K}{L} \)

    \[
    \frac{\Delta Y}{Y} \approx \Delta \ln \left( \frac{Y}{L} \right) = \Delta \ln(Y) - \Delta \ln(L) \approx \frac{\Delta Y}{Y} - \frac{\Delta L}{L}, \text{ i.e. } \frac{\Delta y}{y} = \frac{\Delta Y}{Y} - \frac{\Delta L}{L}
    \]

- **Y = A \cdot F(K, L) \rightarrow y = A \cdot F(k, 1) \equiv A \cdot f(k), \quad f(k) = k^\alpha \)**

- **\( \frac{\Delta k}{k} = \frac{\Delta K}{K} \cdot \frac{\Delta L}{L} = s \cdot \frac{Y}{K} - s \delta - n \Rightarrow \frac{\Delta k}{k} = s \cdot \frac{y}{k} - s \delta - n \Rightarrow \frac{\Delta y}{y} = \alpha \cdot \frac{\Delta k}{k} \)**

*Example 4* What happens to the GDP level, growth rate, per capita growth rate, if the depreciation rate, \( \delta \), decreases/increases? How about \( n, s, \alpha \)?