Chapter 16
Inflation and the Price Level

物價水準與通貨膨脹
Learning Objectives

1. Explain how the consumer price index (CPI) is constructed and use it to calculate the inflation rate
2. Show how the CPI is used to adjust dollar amounts to eliminate the effects of inflation
3. Discuss the two most important biases in the CPI
4. Distinguish between inflation and relative price changes to find the true costs of inflation
5. The connections among inflation, nominal interest rates, and real interest rates: the Fisher Equation
如何計算消費者物價指數(CPI)?
如何用CPI計算通貨膨脹率?
Keeping up with Grandpa

• Prices of goods change over time
• Baseball salaries
  – Babe Ruth earned $80,000 in 1930
  – Barry Bonds earned $10.3 million in 2001
• Consider costs of inflation
• Inflation increases uncertainty when planning for the future
Measuring the Price Level

• The **Consumer Price Index** (CPI) is a measure of the **cost of living** during a particular period.

• The CPI measures (假設: 典型消費者)
  – The cost of a standard basket of goods and services in a given year (分子)
  – relative to the cost of the same basket of goods and services in the base year (分母)
  – 固定一籃子貨物(N種)，權重是基期年之商品數量\(Q_{b,i}\)

\[
\sum_{i=1}^{N} P_{t,i} * Q_{b,i} / \sum_{i=1}^{N} P_{b,i} * Q_{b,i}
\]

– Base year changes periodically.
## Calculating the CPI

<table>
<thead>
<tr>
<th>2010 Spending</th>
<th>Monthly Cost in 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent (2 bedroom apartment)</td>
<td>$500</td>
</tr>
<tr>
<td>Hamburgers (60 at $2 each)</td>
<td>120</td>
</tr>
<tr>
<td>Movie tickets (10 at $6 each)</td>
<td>60</td>
</tr>
<tr>
<td>Monthly expenditures</td>
<td>$680</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2015 Spending</th>
<th>Monthly Cost in 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent (2 bedroom apartment)</td>
<td>$630</td>
</tr>
<tr>
<td>Hamburgers (60 at $2.50 each)</td>
<td>150</td>
</tr>
<tr>
<td>Movie tickets (10 at $7 each)</td>
<td>70</td>
</tr>
<tr>
<td>Monthly expenditures</td>
<td>$850</td>
</tr>
</tbody>
</table>
Calculating the CPI

• CPI is the ratio of the cost of the basket of goods in the current year to the cost in the base year
  – Base year (2010) cost $680
  – 2015 cost $850

\[
\text{CPI} = \left( \frac{850}{680} \right) (100) = 1.25
\]

• Cost of living in 2015 is 25% higher than in 2010
  – CPI for the base year is always 1
  – CPI for a given period is the cost of living in that period relative to what it was in the base year
  – Most people uses CPI as a percentage – the ratio times 100
# Cost of Living (Example 16.1)

The Consumer Price Index (CPI) is a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services, weighted by the relative importance of each item in the basket. It is a key indicator of inflation and is calculated by comparing the cost of a fixed basket of goods and services in the current period to the cost in a base period.

## 2010 Spending

<table>
<thead>
<tr>
<th>Item</th>
<th>Monthly Cost in 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent (2 bedroom apartment)</td>
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</tr>
<tr>
<td>Hamburgers (60 at $2 each)</td>
<td>120</td>
</tr>
<tr>
<td>Movie tickets (10 at $6 each)</td>
<td>60</td>
</tr>
<tr>
<td>Sweaters (4 at $30)</td>
<td>120</td>
</tr>
<tr>
<td>Monthly expenditures</td>
<td>$800</td>
</tr>
</tbody>
</table>

## 2015 Spending

<table>
<thead>
<tr>
<th>Item</th>
<th>Monthly Cost in 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent (2 bedroom apartment)</td>
<td>$630</td>
</tr>
<tr>
<td>Hamburgers (60 at $2.50 each)</td>
<td>150</td>
</tr>
<tr>
<td>Movie tickets (10 at $7 each)</td>
<td>70</td>
</tr>
<tr>
<td>Sweaters (4 at $50)</td>
<td>200</td>
</tr>
<tr>
<td>Monthly expenditures</td>
<td>$1,050</td>
</tr>
</tbody>
</table>

The CPI in 2010 was calculated as follows:

\[
\text{CPI} = \frac{1050}{800} = 1.31
\]
Price Index

- A **price index** measures the average price of a given class of goods and services relative to the price of the same goods and services in a base year.
- CPI measures the change in consumer prices.
- Other indices:
  - Core inflation is CPI without energy and food.
  - Producer price index.
  - Import / export price index.
Inflation 通貨膨脹

- The rate of inflation is the annual percentage change in the price level
- Inflation in 2007
  \[ \frac{2.07 - 2.02}{2.02} = 0.0247 = 2.5\% \]
- The Great Depression
  - Period of falling output and prices
  - When inflation rates are negative there is deflation

<table>
<thead>
<tr>
<th>Year</th>
<th>CPI</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>2.02</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>2.07</td>
<td>2.5%</td>
</tr>
<tr>
<td>2008</td>
<td>2.15</td>
<td>3.9%</td>
</tr>
<tr>
<td>2009</td>
<td>2.15</td>
<td>0%</td>
</tr>
<tr>
<td>2010</td>
<td>2.18</td>
<td>1.4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>CPI</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1929</td>
<td>0.171</td>
<td></td>
</tr>
<tr>
<td>1930</td>
<td>0.167</td>
<td>−2.3%</td>
</tr>
<tr>
<td>1931</td>
<td>0.152</td>
<td>−9.0%</td>
</tr>
<tr>
<td>1932</td>
<td>0.137</td>
<td>−9.9%</td>
</tr>
<tr>
<td>1933</td>
<td>0.130</td>
<td>−5.1%</td>
</tr>
</tbody>
</table>
U.S. Inflation Rates
Learning Objective 2

如何用CPI調整名目變數以消除通貨膨脹的影響？
Deflating – 將名目轉換成實質變數

• A nominal quantity is measured in terms of its dollar value (未經物價調整)
• A real quantity is measured in physical terms
  – Quantities of goods and services
• To compare values over time, use real quantities
  – 比較不同年份的名目薪資無意義，要用實質薪資
  – Deflating a nominal quantity converts it to a real quantity
    • Divide a nominal quantity by its price index to express the quantity in real terms, e.g. Nominal wage/Price (≡W/P)
Family Income in 2010 and 2015

Can a family buy more with $40,000 in income in 2010 or with $44,000 in 2015?

- 2010 is the base year for the CPI
- Deflate nominal income in both years to get real income
- Compare real income
- $40,000 in 2010 has the greater purchasing power

<table>
<thead>
<tr>
<th>Year</th>
<th>Nominal Income</th>
<th>CPI</th>
<th>Real Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>$40,000</td>
<td>1.00</td>
<td>$40,000/1.00 = $40,000</td>
</tr>
<tr>
<td>2015</td>
<td>$44,000</td>
<td>1.25</td>
<td>$44,000/1.25 = $35,200</td>
</tr>
</tbody>
</table>
Baseball Stars

• Compare Babe Ruth's salary with Barry Bonds'
  – Requires a CPI series that includes 1930
    • CPI using 1982 – 1984 as base year
    – Bonds had higher real salary
• Does not convey information about relative incomes
  – 1930 was Great Depression
  – Multi-million dollar salaries common for sports stars in 2001

<table>
<thead>
<tr>
<th>Player</th>
<th>Year</th>
<th>Nominal Salary</th>
<th>CPI</th>
<th>Real Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babe Ruth</td>
<td>1930</td>
<td>$80,000</td>
<td>0.167</td>
<td>$479,042</td>
</tr>
<tr>
<td>Barry Bonds</td>
<td>2001</td>
<td>$10,300,000</td>
<td>1.780</td>
<td>$5,786,517</td>
</tr>
</tbody>
</table>
Real Wages

- The **real wage** is the wage paid to the worker measured in terms of **purchasing power**
  - The real wage for any given period is calculated by dividing the nominal wage by the CPI for that period

- **US production worker wages**
  - CPI uses 1982 – 1984 as base year
  - Real wages stayed the same between 1970 and 2010 despite the fact that the nominal wage in 2010 was 5.5 times the nominal wage in 1970

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Wage</th>
<th>CPI</th>
<th>Real Average Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>$3.40</td>
<td>0.39</td>
<td>$3.40 / 0.39 = $8.72</td>
</tr>
<tr>
<td>2010</td>
<td>$19.00</td>
<td>2.18</td>
<td>$19.00 / 2.18 = $8.72</td>
</tr>
</tbody>
</table>
Production Workers’ Wages, 1960 - 2010

The graph shows the nominal wage and real wage for production workers from 1970 to 2010. The nominal wage line (red) indicates a steady increase over the years, while the real wage line (blue) remains relatively flat. The nominal wage has risen significantly from 1970 to 2010, whereas the real wage has remained constant, suggesting that inflation has had a significant impact on the purchasing power of wages.
Indexing (名目變數的指數化)

• **Indexing** increases a nominal quantity each period by the percentage increase in a specified price index (透過指數化使名目變數保持固定的購買力)
  – Indexing prevents the purchasing power of the nominal quantity from being eroded by inflation

• Indexing automatically adjusts certain values, such as Social Security payments, by the amount of inflation
  – If prices increase 3% in a given year, the Social Security recipients receive 3% more
  – Indexing is sometimes included in labor contracts
Adjusting for Inflation

- An indexed labor contract
  - First year wage is $12 per hour
    - Real wages rise by 2% per year for next 2 years
      - Relevant price index is 1.00 in first year, 1.05 in the second, and 1.10 in the third
- Nominal wage is real wage times the price index

<table>
<thead>
<tr>
<th>Year</th>
<th>Real Wage</th>
<th>Price Index</th>
<th>Nominal Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$12.00</td>
<td>1.00</td>
<td>$12.00</td>
</tr>
<tr>
<td>2</td>
<td>$12.24</td>
<td>1.05</td>
<td>$12.85</td>
</tr>
<tr>
<td>3</td>
<td>$12.48</td>
<td>1.10</td>
<td>$13.73</td>
</tr>
</tbody>
</table>
CPI 反應了真實的物價或生活成本變動嗎？CPI 的兩種衡量誤差
CPI quality adjustment bias (誤差一)

- One important bias in the CPI is its measurement of price changes but not quality changes
  - PC with 20% more memory has 20% higher price
    - Not the same PC as the one with less memory
    - If no adjustment is made for quality, PC's contribution to the CPI will be 20%
- Adjusting for quality is difficult
  - Large numbers of goods
  - Subjective differences
- Incorporating new goods is difficult
  - No base year price for this year's new goods
CPI substitution bias (誤差二)

- CPI uses a **fixed** basket of goods and services
  - When the price of a good increases, consumers buy less and substitute other goods
  - Failing to account for substitution overstates inflation

- Example: base year cost of market basket

<table>
<thead>
<tr>
<th>Item</th>
<th>2010 Price</th>
<th>2010 Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee (50 cups)</td>
<td>$1.00</td>
<td>$50.00</td>
</tr>
<tr>
<td>Tea (50 cups)</td>
<td>$1.00</td>
<td>$50.00</td>
</tr>
<tr>
<td>Scones (100)</td>
<td>$1.00</td>
<td>$100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$200.00</strong></td>
</tr>
</tbody>
</table>
CPI substitution bias

- In 2015, coffee and scones are more expensive
  - Buying exactly the same basket of goods costs $300, compared to $200 in 2005
  - \( \text{CPI} = \frac{300}{200} = 1.50 \)

<table>
<thead>
<tr>
<th>Item</th>
<th>2015 price</th>
<th>2015 Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee (50 cups)</td>
<td>$2.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>Tea (50 cups)</td>
<td>$1.00</td>
<td>$50.00</td>
</tr>
<tr>
<td>Scones (100)</td>
<td>$1.50</td>
<td>$150.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$300.00</td>
</tr>
</tbody>
</table>
CPI substitution bias

- Actually, consumer substitutes tea for coffee
  - Scone purchases constant
- True CPI for consumer is $\frac{250}{200} = 1.25$
- CPI estimate of 1.50 is 20% higher than the consumer's experience

<table>
<thead>
<tr>
<th>Item</th>
<th>2015 price</th>
<th>2015 Spending</th>
</tr>
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<tbody>
<tr>
<td>Coffee (00 cups)</td>
<td>$2.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>Tea (100 cups)</td>
<td>$1.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>Scones (100)</td>
<td>$1.50</td>
<td>$150.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$250.00</strong></td>
</tr>
</tbody>
</table>
Learning Objective 4

如何分辨一般物價與相對物價的變動？通貨膨脹對經濟體帶來哪些成本？
Changes in price level or relative price?

• The **price level** is a measure of the overall level of prices at a particular point in time
  – Measured by a price index such as the CPI

• The **relative price** of a specific good is a comparison of its price to the prices of other goods and services (實質變數)
  – Calculated as a ratio: $P_x/P_y$ (一單位$X$換多少單位$Y$)
  – 回想$W/P$
Changes in price level or relative price?

• Suppose we have a one-time doubling of the gas price
  – Overall price level and inflation increase by a small amount
  – The increase in the relative price of gasoline is large
Relative Prices

- Relative prices can change markedly without corresponding changes in inflation
- Summer prices

**Higher**
- Beach hotels
- Cruises
- Gas prices

**Lower**
- Fresh fruit and vegetables
- Heating oil
“Noise” in the price system

• Prices transmit information about
  – The cost of production and
  – The value buyers place on buying an additional unit

• Inflation creates noise in the communication
  – Buyers and sellers can't easily tell whether
    • The relative price of this good is increasing OR
    • Inflation is increasing the price of this good and all others
  – Deciding these issues requires market participants gather information – at a cost
  – Response to changing prices is tentative and slow
“Shoe-Leather” Cost 皮鞋成本

• If there is no inflation, cash holds its value over time
  – Some cash will be held for convenience
• When inflation is high, cash loses value over time
• Manage cash balances to limit losses (通膨增加了持有現金的成本)
  – More frequent, smaller withdrawals cost consumers and businesses time, travel – a real cost of inflation
  – Banks process more transactions, increasing costs – another real cost of inflation
  – Costs of managing cash holding are called “shoe leather” costs, referring to the cost of frequent trips to the bank
Unexpected Redistribution of Wealth

• **Unexpected inflation redistributes wealth** (未預期通膨有利期末現金流出的一方，如雇主與還款者)

• Suppose workers' salaries are not indexed and inflation is higher than anticipated
  – Salaries lose purchasing power
  – Employers gain at the expense of workers

• Similarly, unexpectedly high inflation benefits borrowers at the expense of lenders
  – Borrowers repay with dollars worth less than anticipated

• 未預期通膨減少人們努力工作與儲蓄的動機
Interference with Long-Term Planning

• Some decisions have a long time horizon
  – Erratic inflation makes planning risky
• Retirement planning requires an estimated cost for your desired life-style
  – Save too little and you live less well in the future
  – Save too much and you live less well now
• Given the costs of inflation, most economists agree that low and stable inflation promotes a healthy economy (但不是零通胀)
Hyperinflation 惡性通貨膨脹

• **Hyperinflation** is an extremely high rate of inflation
  – In 1923, German employers paid workers twice a day
  – Magnifies the costs of inflation
  – Minimize your cash holding

• A study of market economies, 1960 – 1996 showed 45 episodes of high inflation (100%+) in 25 countries
  – Real GDP/person fell by an average of 1.6% per year
  – Real consumption/person fell by an average of 1.3% per year
  – Real investment per person fell by an average of 3.3% per year
Learning Objective 5

通貨膨脹、名目利率與實質利率的關係: 費雪方程式 (Fisher Equation)
Inflation and Interest Rates

- Unanticipated inflation helps borrowers and hurts lenders.
- The **real interest rate** is the annual percentage increase in the purchasing power of financial assets.

實質利率是(金融資產)”實質購買力”的變動
Inflation and Interest Rates

- The **nominal interest rate** is the annual percentage increase in the dollar value of an asset.
  - Nominal interest rates are the most commonly stated rates.

- 事後的費雪方程式
  
  Real interest rate = nominal interest rate – inflation

  \[ r_t = i_t - \pi_t \]

- 事前的費雪方程式：
  
  \[ r_t = i_t - \pi^e \]
Inflation and (Nominal) Interest Rates

- Nominal interest rates and inflation vary
  - Nominal interest rate range is 3.2% to 11.4%
  - Inflation rate range is 1.6% to 13.5%
  - Real interest rate is nominal interest rate minus inflation
    - Real interest rate was highest in 1985, 7.0%
    - Real interest rate was lowest in 1980, – 2.1%

<table>
<thead>
<tr>
<th>Year</th>
<th>Interest Rate (%)</th>
<th>Inflation Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>8.0%</td>
<td>9.1</td>
</tr>
<tr>
<td>1980</td>
<td>11.4</td>
<td>13.5</td>
</tr>
<tr>
<td>1985</td>
<td>10.6</td>
<td>3.6</td>
</tr>
<tr>
<td>1990</td>
<td>8.6</td>
<td>5.4</td>
</tr>
<tr>
<td>1995</td>
<td>6.6</td>
<td>2.8</td>
</tr>
<tr>
<td>2000</td>
<td>6.0</td>
<td>3.4</td>
</tr>
<tr>
<td>2005</td>
<td>4.3</td>
<td>3.4</td>
</tr>
<tr>
<td>2010</td>
<td>3.2</td>
<td>1.6</td>
</tr>
</tbody>
</table>
U.S. Real Interest Rates, 1960 - 2010
Inflation and Interest Rates

- For a given nominal interest rate, the higher the inflation rate, the lower the real interest rate
  - Expected inflation may not hurt lenders if they can adjust the nominal interest rates
  - Inflation-protected bonds pay a real rate of interest plus the inflation rate \( (i = r + \pi^e) \)

- The **Fisher effect** is the tendency for nominal interest rates to be high when inflation is high and low when inflation is low (在長期，當預期的通膨上升，名目利率也會上升，以維持實質利率不變)
US Inflation and Interest Rates, 1960 - 2010