Numbers: Elasticities, GDP, and CPI

ECON201 - Winter, '24

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This Lecture

- First, we consider the slopes in our demand and supply diagrams. These elasticities allow us to answer more precise questions.

- Then, we learn about GDP, a measure of a nation's output. We also introduce the distinction between *real* and *nominal* variables.

- Finally, the consumer price index (CPI) is a measure of inflation. This index allows us to compare economic activity over time and guarantee stable government benefits.

What is...

1. Elasticity
2. Gross Domestic Product
3. Consumer Price Index

Elasticities

- In Lecture A, we considered how the quantity demanded/supplied changes with price qualitatively.
- Now, we want to be a little bit more precise and quantify how much these quantities change in response to changes in price and other variables.
- Measures of “responsiveness” like this are called “elasticities”.
- These measures will shape a more nuanced understanding about the effects of macroeconomic events, adding another layer to our demand and supply diagram.

What is...

1. Elasticity
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3. Consumer Price Index

1. Demand
2. Supply
3. Application

Own-Price Elasticity of Demand

$$\text{Price elasticity of demand} = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}}$$

- Measures how much quantity demanded of X responds to a change in the price of X.
- **Elastic** if the quantity demanded responds **more than proportionally** to a price change, that is, if the absolute value of the above fraction is greater than 1.
- **Inelastic** if the quantity demanded responds **less than proportionally** to a price change, that is, if absolute value less than 1.
- **Unit elastic** if the quantity demanded responds **proportionally** to a price change, that is, if absolute value equal to 1.

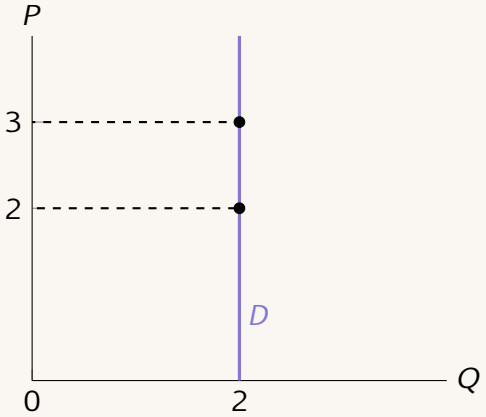
Examples: Perfectly Inelastic Demand

- Price decrease of 33.3%

$$100 * \frac{2-3}{3} = -\frac{100}{3} \approx -33.3$$

- Quantity increases by 0%
- **Price Elasticity of Demand:**

$$\frac{0\%}{33.3\%} = 0$$



Examples: Inelastic Demand

- Price decrease of 33.3%

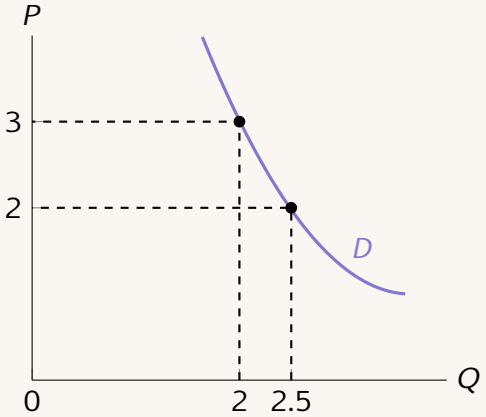
$$100 * \frac{2-3}{3} = -\frac{100}{3} \approx -33.3$$

- Quantity increases by 25%

$$100 * \frac{2.5-2}{2} = \frac{100}{4} = 25$$

- **Price Elasticity of Demand:**

$$\frac{25\%}{33.3\%} = 0.75 < 1$$



Examples: Unit Elastic Demand

- Price decrease of 33.3%

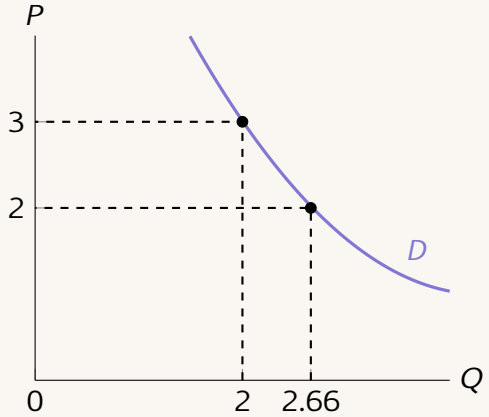
$$100 * \frac{2-3}{3} = -\frac{100}{3} \approx -33.3$$

- Quantity increases by 33.3%

$$100 * \frac{2.66-2}{2} = \frac{100}{3} \approx 33.3$$

- **Price Elasticity of Demand:**

$$\frac{33.3\%}{33.3\%} = 1$$



Examples: Elastic Demand

- Price decrease of 33.3%

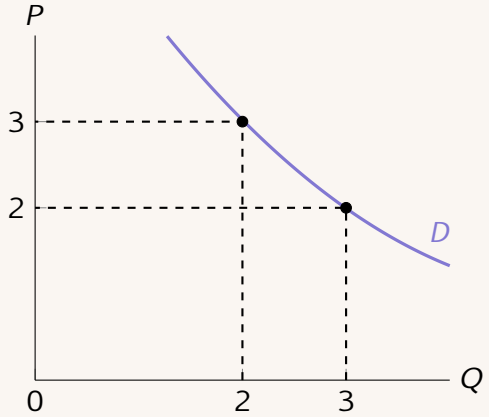
$$100 * \frac{2-3}{3} = -\frac{100}{3} \approx -33.3$$

- Quantity increases by 50%

$$100 * \frac{3-2}{2} = \frac{100}{2} = 50$$

- **Price Elasticity of Demand:**

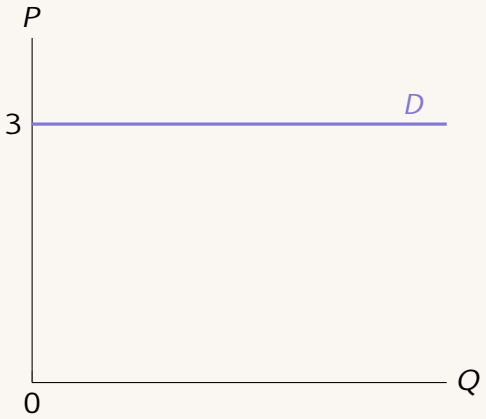
$$\frac{50\%}{33.3\%} = 1.5 > 1$$



Examples: Perfectly Elastic Demand

- Perfectly elastic demand is special:
  - Any price increase $\rightarrow Q^d = 0$.
  - Any price decrease $\rightarrow Q^d = \infty$.
- This is represented by a horizontal line at the price where Q^d is finite and strictly positive.
- **Price Elasticity of Demand:**

$$\infty$$



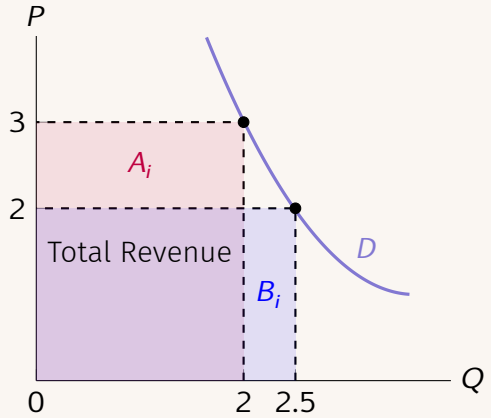
Determinants of Demand Elasticity

- The demand for a good is **more elastic if there are close substitutes.** This also depends on how we define the good. For instance, substitution for “iPhones” is easy (Android), substituting for “smartphones” is hard.

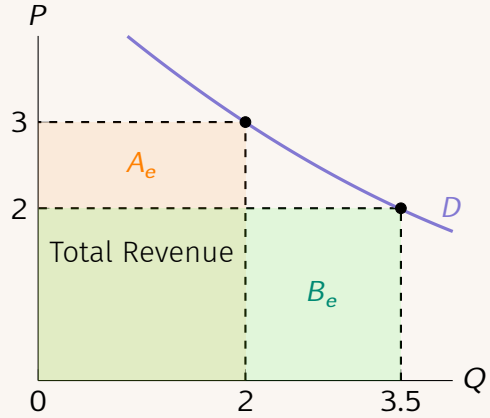
- The **demand for necessities is more inelastic** than that for luxury good. Necessity is in the eye of the beholder but examples are: food, shelter, heating,...

- Demand tends to be **least elastic in the short-run**. In the long-run, buyers will find a substitute and, thus, their long-run demand for any good is more elastic.

Total Revenue and Price Elasticity



$A_i > B_i$



$A_e < B_e$

→ Inelastic (elastic) demand = Price decrease causes revenue loss (gain).

Income Elasticities of Demand

$$\text{Income elasticity of demand} = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in income}}$$

- Measures how much quantity demanded of X responds to a change in income.
- *Normal goods:* Positive income elasticity of demand. The quantity demanded increases with income.
- *Inferior goods:* Negative income elasticity of demand. The quantity demanded decreases with income (e.g. public transit).
- **Engel's Law:** As household income increases, the percent of income spent on food declines.

Cross-Price Elasticities of Demand

$$\text{Cross-price elasticity of demand} = \frac{\text{Percentage change in quantity demanded of good X}}{\text{Percentage change in price of good Y}}$$

- Measures how much quantity demanded of X responds to a change in the price of good Y.
- *Substitutes:* Positive cross-price elasticity of demand. The quantity demanded of good X increases as the price of good Y rises.
- *Complements:* Negative cross-price elasticity of demand. The quantity demanded of good X decreases as the price of good Y rises.

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Own-Price Elasticity of Supply

$$\text{Price elasticity of supply} = \frac{\text{Percentage change in quantity supplied}}{\text{Percentage change in price}}$$

- Measures how much quantity supplied of X responds to a change in the price of X.
- The definitions of *elastic*, *inelastic*, and *unit elastic* are **analogous** to elasticities of demand.
- The main determinant of this elasticity is the **time horizon**:
  - In the short-run, supply is often inelastic, as firms have fixed capacity and take time to adjust.
  - In the long run, capacity and number of firms may adjust, making supply elastic.

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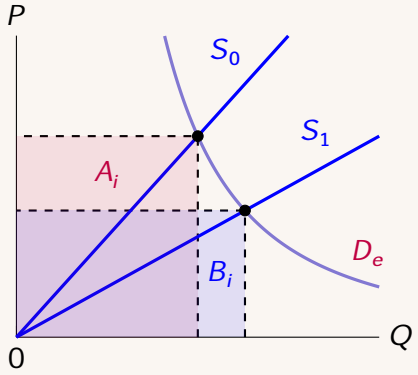
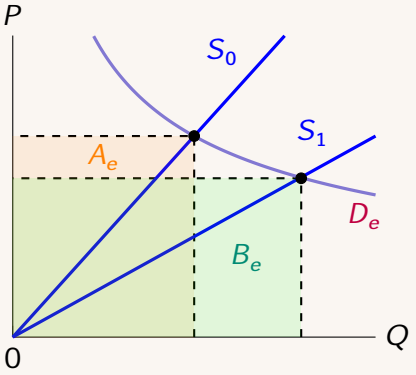
The Effect of Technology on Revenue

Inelastic Demand:



$A_i > B_i$

Elastic Demand:



$A_e < B_e$

$\longrightarrow$ Tech. improv. decreases (increases) revenue/employment/no. of firms

What is...

1. Elasticity

2. Gross Domestic Product

3. Consumer Price Index

What is...

1. Definition

2. The Four Components

3. The GDP Deflator

4. Measure of Well-Being?

1. Elasticity

2. Gross Domestic Product

3. Consumer Price Index

Definition

- For an economy, total income and total expenditure are the same. Why? Remember Circular-Flow Model!

- Gross domestic product is a measure of a country's output over a period. It can be calculated based on income or expenditure data by the Bureau of Economic Analysis.

- **Definition:**

  Gross domestic product (GDP) is the market value of all final goods and services produced within a country in a given period of time.

- Let's consider more carefully!

Market Value...

- To add up all output of an economy, we need a common unit.
- This is not trivial: How do you add up a bushel of wheat and an hour of legal services?
- GDP uses the market value: The amount of money people are actually willing to pay for a good.

...of All...

- GDP encompasses all items produced and sold **legally in markets**
- Items which are sold illegally are not included, mostly because their quantity is hard to measure.
- Home production is also not included because theses goods and services are not sold at market price.
- For example, childcare performed by parents is not included but professional daycare is. Feminist economics tries to address this (Nelson, 1995). Also, means what is counted may change (Bridgman, 2023).

...Final...

- **Intermediate goods** used in the production of other goods or services are **not included** in GDP.

- Including intermediate goods would lead to double counting.

- **Exception:**

  Intermediate goods are counted if they are not used in production in the same year they are produced (“inventory investment”).

...Goods and Services...

- Both tangible goods and intangible services are counted in GDP.

- **Examples of Goods:**

  Food, clothing, cars, computers,...

- **Examples of Services:**

  Haircuts, professional house cleaning, doctor visits, software subscriptions,...

...Produced...

- Only goods and services produced in this period are in GDP.

- GDP is a measure of income/expenditure, **not** wealth.
  (However, if a country has high income over a long period, it will also build wealth.)

- **Example:**

  A house built in 2023 is included in GDP for 2023, but *any* house built in 2022 or earlier is *not* included, even if it were re-sold in 2023.

...Within a Country...

- GDP is geographically defined. Who produces the goods or services is irrelevant, as long as they produce on U.S. territory.

- Reversely, if an American firm produces in Mexico, this adds to Mexico's GDP, not U.S. GDP.

- **Example:**

  This lecture counts towards U.S. GDP because, even though I am a German citizen, I (must) reside in the U.S. for the duration of the course.

...In a Given Period of Time.

- GDP is the value of output within a specific interval of time. Often, a year or a quarter.

- Conventionally, the govt reports quarterly GDP growth “at an annual rate” (e.g. multiplied by 4).

- Seasonal adjustments are commonly applied to quarterly GDP data, to ease comparison.

Gross Domestic Income

- For an economy, total income and total expenditure are the same.

- **Definitions:**

  Gross domestic product (GDP) is the *market value of* all final goods and services produced within a country in a given period of time.

  Gross domestic income (GDI) is the *income generated by* all final goods and services produced within a country in a given period of time.

- In practice, these two numbers are not exactly equal $\longrightarrow$ *statistical discrepancy*.

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1. Definition

2. The Four Components

3. The GDP Deflator

4. Measure of Well-Being?

Expenditure Approach

Economists study the different components of GDP, i.e. spending on different types of goods/services.

Gross Domestic Product (Y):

$$Y = C + I + G + NX.$$

- C = Consumption,
- I = Investment,
- G = Government Purchases, and
- NX = Net Exports.

Consumption, C

- Any spending by households on new final goods/services.
- Includes food, durable consumption goods (e.g. cars), and intangible services (e.g. haircuts, education).
- **Exception:** New housing is part of investment (I).

Investment, I

- Spending on **capital goods** used for (future) production, **inventory**, and **new housing**.

- **Capital goods:**
  Machinery, office buildings, equipment, software,...

- **Inventory:**
  Final goods which have not been sold yet. Subtracted from inventory when sold in future periods.

- Investment here is **not** financial investment (e.g. stock, bonds, mutual funds).

Government Purchases, G

- Spending on goods and services **by local, state, and federal governments**.

- **Included:**

  Salaries of employees, infrastructure expenditure, ...

- **Excluded:**

  Transfer payments, e.g. unemployment benefits or Social Security.
  - Transfers do not reflect production, just redistribution.

Net Exports, NX

$$\underbrace{NX}_{\text{Net exports}} = \underbrace{X}_{\text{Exports}} - \underbrace{M}_{\text{Imports}}$$

- **Exports (X):**

  All foreign spending on domestically produced goods.

- **Imports (M):**

  All domestic spending on foreign goods.

  - Imports are subtracted because the other components (C, I, G) include foreign-produced goods which do not count towards our production/GDP.

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Nominal vs. Real GDP

- **Problem:** Suppose economy produces the same amount in two years. But, in one year, prices are 10% higher. GDP will be 10% greater, even though production is the same!

- **Solution:** Use the same prices in both years.

- *Nominal GDP:* GDP measured using current prices in each period.

- *Real GDP:* GDP measured using **base-year prices** in every period.

Example

Year	Price of Tea	Quantity of Tea	Price of Coffee	Quantity of Coffee
2020	$1	100	$2	50
2021	2	150	3	100
2022	3	200	4	150

Year	Nominal GDP		Real GDP (base year 2021)	
2020	($1 × 100 tea) + ($2 × 50 coffee) =	$200	($2 × 100 tea) + ($3 × 50 coffee) =	$350
2021	($2 × 150 tea) + ($3 × 100 coffee) =	$600	($2 × 150 tea) + ($3 × 100 coffee) =	$600
2022	($3 × 200 tea) + ($4 × 150 coffee) =	$1,200	($2 × 200 tea) + ($3 × 150 coffee) =	$950

The GDP Deflator

$$\text{GDP deflator} = 100 \times \frac{\text{Nominal GDP}}{\text{Real GDP}}$$

- Measures how much prices have changed, not quantities.

- *Inflation:* An increase in the economy's overall price level.

$$\text{Inflation in year } t = 100 \times \frac{\text{GDP deflator in } t - \text{GDP deflator in } (t-1)}{\text{GDP deflator in } (t-1)}$$

Example

Year	Nominal GDP	Real GDP (base year 2021)	GDP deflator	
2020	200	350	200/350 × 100 =	66.6
2021	600	600	600/600 × 100 =	100
2022	1,200	950	1,200/900 × 100 =	133.3

Year	Inflation rate
2020	*unknown*
2021	100 × (100 - 66.6)/66.6 = 50%
2022	100 × (133.3 - 100)/100 = 33.3%

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Does GDP Measure Well-Being?

- **Contra:**
  - GDP only measures economic output. Does not account for e.g. health outcomes, human rights, crime, inequality,...
  - Non-market output is not even included, e.g. home production.
  - Market value may not correspond to value of output in a market without distortions/externalities, e.g. coal mining.
- **Pro:**
  - More marketable economic output means more resources which could (!) be used to improve welfare.
  - Strong, albeit imperfect, positive correlation between GDP and other measures of well-being, e.g. life expectancy, schooling, subjective life satisfaction.

$\rightarrow$ GDP is not a perfect summary of welfare, but one of many useful indicators.

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Motivation

- From 1931 to 2022, annual GDP per capita has **increased by 122x** ($624.12 to $76,395.81).[1] Are living standards more than 100x higher than in 1931?

- At the same time, an ice cream cone cost $0.05 in 1931. In 2023, an ice cream cone is $2.39 at McDonald's. That's a **47x increase** in prices!

- *In terms of ice cream cones*, mean income has thus **grown nearly 3x** from 1931 to 2022 (12,482 cones to 31,965 cones).

- Obviously, ice cream may not be the best *unit of measurement*....

→ **Lesson:** Need to adjust $-values if we want to compare across time.

[1] BEA and Census data.

What is...

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1. Calculation

2. Issues

3. Comparison to GDP Deflator

4. Comparisons Across Time

5. Indexation

CPI Formula

- **Idea:**
  To determine how much a $ amount in year t is worth to the average consumer, express the amount in terms of a representative *basket of goods*.
- In practice, Burea of Labor Statistics (BLS):
  i. chooses **one** basket of goods and services,
  ii. collects prices of these goods and services in each year,
  iii. calculates the cost of the basket in each year,
  iv. chooses a base year as a benchmark (index = 100),
  v. compares cost in other years to the cost in base year.
- The result is the Consumer Price Index (CPI):

$$\text{Consumer price index} = \frac{\text{Price of representative basket in current year}}{\text{Price of basket in base year}} \times 100.$$

An Example

Year	Price of Tea	Quantity of Tea	Price of Coffee	Quantity of Coffee
2020	\$1	100	\$2	50
2021	2	150	3	100
2022	3	200	4	150

Choose 2021 as base year and basket of 150 tea and 100 coffee. Then:

Year	Price of basket	CPI	
2020	$\$1 \times 150 + \$2 \times 100 = \$350$	$100 \times \frac{350}{600} =$	58.33
2021	$\$2 \times 150 + \$3 \times 100 = \$600$		100
2022	$\$3 \times 150 + \$4 \times 100 = \$850$	$100 \times \frac{850}{600} =$	141.67

Inflation

- The *inflation rate* is measured as the percentage change in the CPI from period to period:

$$\text{Inflation rate in year } t = \frac{\text{CPI in } t - \text{CPI in } (t-1)}{\text{CPI in } (t-1)} \times 100$$

Year	CPI	Inflation rate
2020	58.33	*unknown*
2021	100	$\frac{100-58.33}{58.33} \times 100 = 71.44\%$
2022	141.67	$\frac{141.67-100}{100} \times 100 = 41.67\ \%$

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Substitution Bias

Compare inflation rates from CPI and GDP deflator:

Year	GDP deflator inflation rate	CPI inflation rate
2021	50%	71.44%
2022	33.3%	41.67%

Year	Price of Tea	Quantity of Tea	Price of Coffee	Quantity of Coffee
2020	\$1	100	\$2	50
2021	2	150	3	100
2022	3	200	4	150

Consumers substitute away from goods as their **relative price** increases! CPI does not account for this substitution because *basket is fixed*.

Lesson: CPI overstates inflation because of *substitution bias*!

CPI and Innovation

Other problems:

- **New Products:**
  - When new products enter the market, they do not automatically enter the BLS's CPI basket. It takes time.
  - For example, introduction of the smartphone (2007 vs. 2018).
- **Quality Improvements:**
  - The quality of goods changes over time. For instance, personal computer in 1977 vs. in 2023.
  - BLS tries to gradually adjust basket for quality but this is difficult...

Both of these issues lead to *upward bias* (same money pays better goods).

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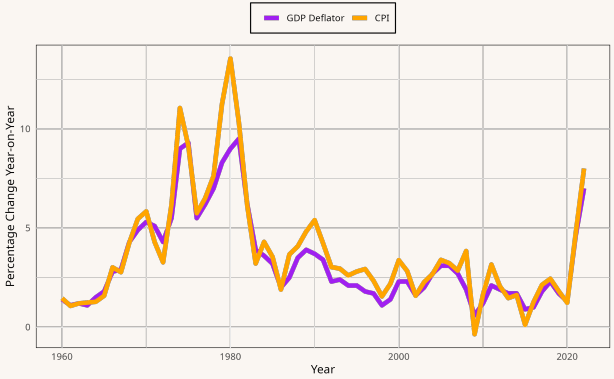
CPI vs GDP Deflator

- CPI includes *imported goods*. GDP deflator does not.
- CPI does not include price changes in "*I*- and *G*-goods." GDP deflator does. Example: Military equipment.
- CPI is a *fixed* basket of good. GDP deflator accounts for changing composition.



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One Dollar, Two Values

– To convert $-amounts from a past year t to current $ amount:

$$\text{Amount in today's \$} = \text{Amount in year } t\text{'s\$} \times \frac{\text{Price level today}}{\text{Price level in year } t},$$

where the price level is measured by an index, e.g. the CPI.

Example: 1931 ice cone in today's $

$$\underbrace{0.05}_{\text{1931 ice cone in 1931's \$}} \times \frac{\overbrace{303.8}^{\text{CPI in June 2023}}}{\underbrace{15.2}_{\text{CPI in 1931}}}$$

$$\underbrace{0.05}_{\text{1931 ice cone in 1931's \$}} \times \frac{\overbrace{303.8}^{\text{CPI in June 2023}}}{\underbrace{15.2}_{\text{CPI in 1931}}} \approx 0.05 \times 20$$

$$\underbrace{0.05}_{} \times \frac{\overbrace{303.8}^{\text{CPI in June 2023}}}{15.2} = 1$$

Real and Nominal Interest Rates

- This is also relevant for savings and financial investments.
- If you save $10,000 at 5% annual interest, you gain $50 over 1 year.
- However, how much this interest is worth *in real terms* depends on how much prices have changes:

$$\text{Real interest rate} \approx \text{Nominal interest rate} - \text{Inflation rate}$$

Example: If the interest rate is 5% and inflation is also 5%, then the final $10,050 is worth the same as the initial $10,000, i.e. real interest rate is 0.

$$0\% \approx 5\% - 5\%$$

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Indexation

- Does any of this matter in normal life?
- Yes! Many wage contracts include *cost-of-living adjustment* (COLA) clauses, automatically adjusting wages to increases in the CPI.
- Many government transfers, e.g. Social Security benefits, are adjusted using the CPI every year.
- It also matters when no adjustment takes place:
  If the federal minimum wage had been increased by CPI since it was last raised in July 2009, it would be $10.26, not $7.25.

Conclusion

- Understanding the elasticities of different goods allows us to answer more specific questions, e.g. whether technological improvement in an industry will lead to more or less employment.
- The Gross Domestic Product (GDP) measures the output and income of an economy. It sums up the market value of all final goods and services produced within a country in a given period of time. $Y = C + I + G + NX$.
- Inflation can be measured by the change in GDP deflator or CPI:
  - **GDP deflator:** Use base year's prices in every year.
  - **CPI:** Fixed quantity basket of consumption goods and services.
- CPI suffers from substitution bias and difficult accounting for innovation.
- Real interest rate = Nominal interest rate - Inflation rate
- **Next:** How do we measure unemployment? It's harder than you may think.

References I

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Nelson, Julie A. (1995). 'Feminism and Economics'. *Journal of Economic Perspectives* 9.2, pp. 131–148.