The Data of Macroeconomics

Chapter 2

Econ 313 – Intermediate Macroeconomics

University of Tennessee, Knoxville

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In This Chapter, You Will Learn:

...the meaning and measurement of the most important macroeconomic statistics:

- gross domestic product (GDP)
- the consumer price index (CPI)
- the unemployment rate

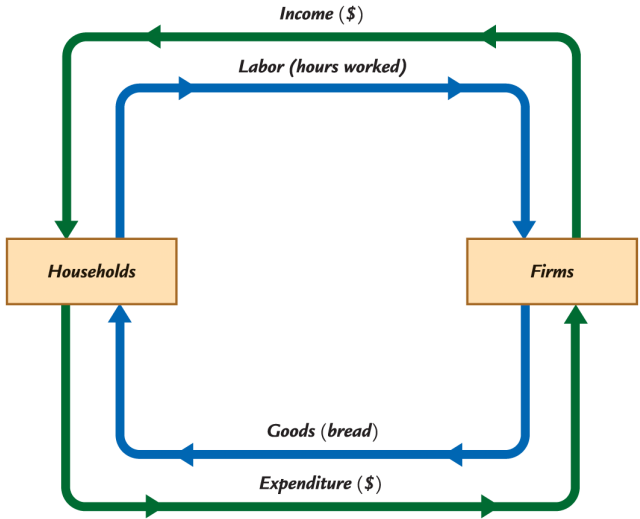
Gross domestic product: Expenditure and income

Two definitions:

- Total expenditure on domestically produced final goods and services
- Total income earned by domestically located factors of production

Expenditure equals income because
every dollar a buyer spends
becomes income to the seller.

The circular flow



Value added

Value added is the value of output minus the value of the intermediate goods used to produce that output.

It represents the increase in the value of a product or service at each stage of the production process.

It measures the contribution of a specific economic activity or sector to the overall economy.

NOW YOU TRY: Identifying value added

- A farmer grows a bushel of wheat and sells it to a miller for $1.00.
- The miller turns the wheat into flour and sells it to a baker for $3.00.
- The baker uses the flour to make a loaf of bread and sells it to an engineer for $6.00.
- The engineer eats the bread.

Compute the value added at each stage of production and GDP.

Final goods, value added, and GDP

- GDP = value of final goods produced
  = sum of value added at all stages of production
- The value of the final goods already includes the value of the intermediate goods, so including intermediate *and* final goods in GDP would be double counting.

The expenditure components of GDP

- consumption, C
- investment, I
- government spending, G
- net exports, NX

An important identity:

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

value of total output *aggregate expenditure*

Consumption (C)

Definition: The value of all goods and services bought by households, including:

- **Durable goods**
  last a long time. Examples: cars, home appliances
- **Nondurable goods**
  last a short time. Examples: food, clothing
- **Services**
  are intangible/non-physical items or activities, purchased by consumers.
  Examples: dry cleaning, air travel, concerts

U.S. consumption, 2022

	Total (billions of $)	Per Person ($)
Gross Domestic Product	25,461	76,324
Consumption	17,363	52,047
Nondurable goods	3,757	11,261
Durable goods	2,186	6,552
Services	11,420	34,234

Investment (I)

- Spending on capital, a physical asset used in future production
- Includes:
  - **Business fixed investment**—Spending on plant and equipment
  - **Residential fixed investment**—Spending by consumers and landlords on housing units
  - **Inventory investment**—The change in the value of all firms' inventories

U.S. investment, 2022

	Total (billions of $)	Per Person ($)
Gross Domestic Product	25,461	76,324
Investment	4,625	13,864
Nonresidential fixed investment	3,340	10,012
Residential fixed investment	1,127	3,377
Inventory investment	159	475

Government Spending (G)

- $\boldsymbol{G}$ includes all government spending on goods and services.
  - National defense
  - Purchases of trains and installation of subway rail
  - Services provided by a Park Ranger to visitors of national parks
- $\boldsymbol{G}$ excludes transfer payments (e.g., unemployment insurance payments) because they do not represent spending on goods and services.

U.S. government spending, 2022

	Total (billions of $)	Per Person ($)
Gross Domestic Product	25,461	76,324
Government Purchases	4,446	13,328
Federal	1,647	4,936
Defense	925	2,773
Nondefense	722	2,163
State and local	2,800	8,392

Net Exports (NX)

- ***NX*** = exports – imports
  - **Exports**: The value of goods and services (g&s) sold to other countries.
  - **Imports**: The value of g&s purchased from other countries.
- Hence, NX equals net spending from abroad on our g&s.
- Notice: The trade deficit ($NX < 0$) does not reduce GDP. Instead, imports are subtracted to remove them from domestic spending.

U.S. net exports, 2022

	Total (billions of $)	Per Person ($)
Gross Domestic Product	25,461	76,324
Net Exports	−973	−2,916
Exports	2,981	8,935
Imports	3,953	11,851

NOW YOU TRY: An expenditure-output puzzle?

Suppose a firm:

- produces $10 million worth of final goods today and puts all 10 million in inventory.
- Then, tomorrow sells only $9 million worth.

- Does this violate the ***expenditure = output*** identity?

Why output = expenditure

- Unsold output goes into inventory and is counted as "inventory investment" ... whether or not the inventory buildup was intentional.
- In effect, we are assuming that firms purchase their unsold output.

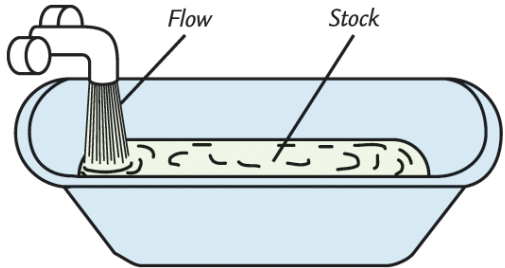
Stocks versus flows

A **stock** is a quantity measured at a point in time.

Example: The U.S. federal government debt was about $32 trillion in 2022.

A **flow** is a quantity measured per unit of time.

Example: "The U.S. federal government deficit was $1.7 trillion in 2022."



Stocks versus flows: examples

Stock	**Flow**
A person's wealth	A person's annual savings
Number of people with college degrees	Number of new college graduates this year
The government debt	The government budget deficit

Investment versus capital

Note: Investment is spending on new capital.

Example *(assuming no depreciation)*:

- 1/1/2023:
  Economy has \$40 trillion worth of capital.
- During 2023:
  investment = \$5 trillion.
- 1/1/2024:
  Economy will have \$45 trillion worth of capital.

NOW YOU TRY: Stock or flow?

- The balance on your credit card statement
- How much time you spend studying a day
- The length of a Spotify playlist
- The inflation rate
- The unemployment rate
- Human capital of a country
- Greenhouse gas emissions
- Birth rate

An important and versatile concept

We have now seen that GDP measures:

- total income
- total output
- total expenditure
- the sum of value added at all stages in the production of final goods

GNP versus GDP

- Gross **national** product (GNP):
  Total income earned by the nation's factors of production, regardless of where located.
- Gross **domestic** product (GDP):
  Total income earned by domestically located factors of production, regardless of nationality.
- GNP – GDP = factor payments from abroad
  minus factor payments to abroad
- Examples of factor payments: wages, profits, rent, interest and dividends on assets

Real versus nominal GDP

- GDP is the *value* of all final goods and services produced.
- **Nominal GDP** measures these values using current prices.
- **Real GDP** measures these values using the prices of a base year.

NOW YOU TRY: Real and nominal GDP

	2021: P	2021: Q	2022: P	2022: Q	2023: P	2023: Q
Good A	\$30	900	\$31	1,000	\$36	1,050
Good B	\$100	192	\$102	200	\$100	205

- Compute nominal GDP in each year.
- Compute real GDP in each year, using 2021 as the base year.

NOW YOU TRY: Real and nominal GDP, answers

Nominal GDP: *multiply Ps and Qs from the same year*

2021: \$46,200 = \$30 × 900 + \$100 × 192

2022: \$51,400

2023: \$58,300

Real GDP: *multiply each year's Qs by 2021 Ps*

2021: \$46,200

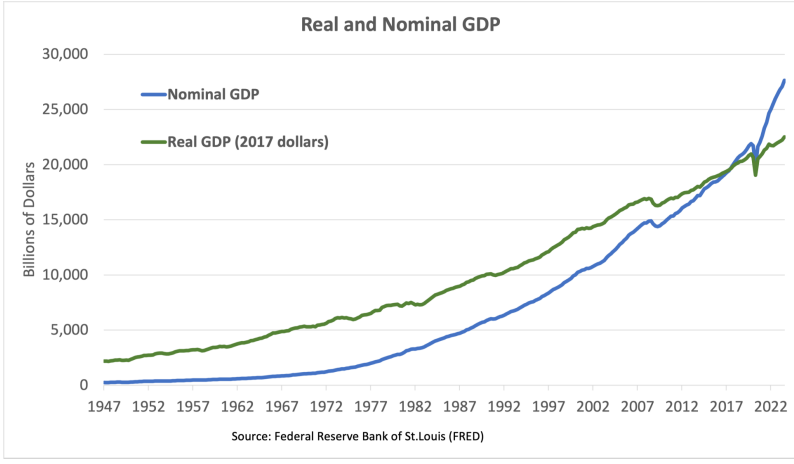
2022: \$50,000

2023: \$52,000 = \$30 × 1,050 + \$100 × 205

Real GDP controls for inflation

- Changes in nominal GDP can be due to:
  - changes in prices
  - changes in quantities of output produced
- Changes in real GDP can only be due to changes in quantities because real GDP is constructed using constant base-year prices.

U.S. nominal and real GDP, 1947–2023



GDP deflator

- **Inflation rate**: the percentage increase in the overall level of prices
- One measure of the price level: **GDP deflator**

Definition:

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

NOW YOU TRY: GDP deflator and the inflation rate

	Nominal GDP	Real GDP	GDP Deflator	Inflation Rate
2021	$46,200	$46,200		n.a.
2022	51,400	50,000		
2023	58,300	52,000		

- Use your previous answers to compute the GDP deflator in each year.
- Use the GDP deflator to compute the inflation rate from 2021 to 2022 and from 2022 to 2023.

NOW YOU TRY: GDP deflator and the inflation rate, answers

	Nominal GDP	Real GDP	GDP Deflator	Inflation Rate
2021	\$46,200	\$46,200	100	n.a.
2022	51,400	50,000	102.8	2.8%
2023	58,300	52,000	112.1	9.0%

$$\text{2022 inflation rate} = \left(\frac{102.8 - 100}{100}\right) \times 100 = 2.8\%$$

Understanding the GDP deflator, part 1

Example with three goods

For good $i = 1, 2, 3$

P_{it} = the market price of good i in month t

Q_{it} = the quantity of good i produced in month t

NGDP_t = nominal GDP in month t

RGDP_t = real GDP in month t

Understanding the GDP deflator, part 2

$$\text{GDP Deflator}_t = \frac{\text{NGDP}_t}{\text{RGDP}_t} = \frac{P_{1t}Q_{1t} + P_{2t}Q_{2t} + P_{3t}Q_{3t}}{\text{RGDP}_t}$$

$$= \left(\frac{Q_{1t}}{\text{RGDP}_t}\right) P_{1t} + \left(\frac{Q_{2t}}{\text{RGDP}_t}\right) P_{2t} + \left(\frac{Q_{3t}}{\text{RGDP}_t}\right) P_{3t}$$

The GDP deflator is a weighted average of prices.
The weight on each price reflects that good's relative importance in GDP.
Note that the weights change over time.

Two helpful facts for working with percentage changes, part 1

1. For any variables $\boldsymbol{X}$ and $\boldsymbol{Y}$,

percentage change in $(\boldsymbol{X} \times \boldsymbol{Y})$
$\approx$ percentage change in $\boldsymbol{X}$
$+$ percentage change in $\boldsymbol{Y}$

Example: If your hourly wage rises 5 percent and you work 7 percent more hours, then your wage income rises approximately 12 percent.

Two helpful facts for working with percentage changes, part 2

2. Percentage change in (X/Y)

$\approx$ percentage change in X
$-$ percentage change in Y

Example: GDP Deflator $= 100 \times$ NGDP / RGDP

If NGDP rises 9 percent and RGDP rises 4 percent, then the inflation rate is approximately 5 percent.

Chain-weighted real GDP

- Over time, relative prices change, so the base year should be updated periodically.
- In essence, **chain-weighted real GDP** updates the base year every year, so it is more accurate than constant-price GDP.
- Your textbook usually uses constant-price real GDP because:
  - the two measures are highly correlated.
  - constant-price real GDP is easier to compute.

▸ Worked example (appendix)

Consumer price index (CPI)

- A measure of the overall level of prices
- Published by the Bureau of Labor Statistics (BLS)
- Uses:
  - tracking changes in the typical household's cost of living
  - adjusting many contracts for inflation ("COLAs")
  - allowing comparisons of dollar amounts over time

How the BLS constructs the CPI

1. It surveys consumers to determine the composition of the typical consumer's "basket" of goods.
2. Every month, it collects data on the prices of all items in the basket and computes the cost of the basket.
3. CPI in any month equals

$$100 \times \frac{\text{Cost of basket in that month}}{\text{Cost of basket in base period}}$$

NOW YOU TRY: Compute the CPI

Basket: 20 pizzas, 10 records

Prices:

	Pizza	**Records**
2020	10	15
2021	11	15
2022	12	16
2023	13	15

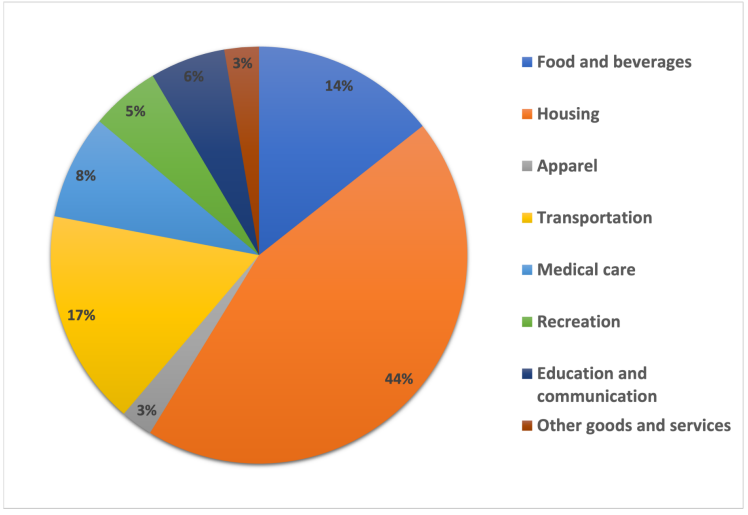
For each year, compute:

- the cost of the basket
- the CPI (using 2020 as the base year)
- the inflation rate from the preceding year

NOW YOU TRY: Compute the CPI, answers

	Cost of Basket	CPI	Inflation Rate
2020	$350	100	n.a.
2021	370	105.7	5.7%
2022	400	114.3	8.1%
2023	410	117.1	2.5%

The composition of the CPI's "basket"



Understanding the CPI, part 1

Example with three goods

For good $i = 1, 2, 3$

C_i = amount of good i in the CPI's basket

P_{it} = price of good i in month t

E_t = cost of the CPI basket in month t

E_b = cost of the basket in the base period

Understanding the CPI, part 2

$$\text{CPI in month } t = \frac{E_t}{E_b} = \frac{P_{1t}C_1 + P_{2t}C_2 + P_{3t}C_3}{E_b}$$

$$= \left(\frac{C_1}{E_b}\right) P_{1t} + \left(\frac{C_2}{E_b}\right) P_{2t} + \left(\frac{C_3}{E_b}\right) P_{3t}$$

The CPI is a weighted average of prices.
The weight on each price reflects that good's relative importance in the CPI's basket.
Note that the weights remain fixed over time.

Why the CPI may overstate inflation

- **Substitution bias**:
  The CPI uses fixed weights, so it cannot reflect consumers' ability to substitute toward goods whose relative prices have fallen.
- **Introduction of new goods**:
  The introduction of new goods makes consumers better off and, in effect, increases the real value of the dollar. But it does not reduce the CPI because the CPI uses fixed weights.
- **Unmeasured changes in quality**:
  Quality improvements increase the value of the dollar but are often not fully measured.

The size of the CPI's bias

- In 1995, a Senate-appointed panel of experts estimated that the CPI overstates inflation by 1.1–1.3 percent per year due to factors such as substitution bias, quality change bias, and new product bias.
- The BLS therefore made adjustments to reduce the bias.
- Now, the CPI's bias is probably under 1 percent per year and remains significant.

NOW YOU TRY: Questions for discussion

1. If your grandmother receives Social Security, how is she affected by the CPI's bias?
2. Where does the government get the money to pay COLAs to Social Security recipients?
3. If you pay income and Social Security taxes, how does the CPI's bias affect you?
4. Is the government giving your grandmother too much of a COLA?
5. How does your grandmother's "basket" differ from the CPI's? Does this affect your answer to Q4?

▸ Answers (appendix)

CPI versus GDP deflator

Prices of capital goods:

- included in GDP deflator (if produced domestically)
- excluded from CPI

Prices of imported consumer goods:

- included in CPI
- excluded from GDP deflator

The basket of goods:

- CPI: fixed
- GDP deflator: changes every year

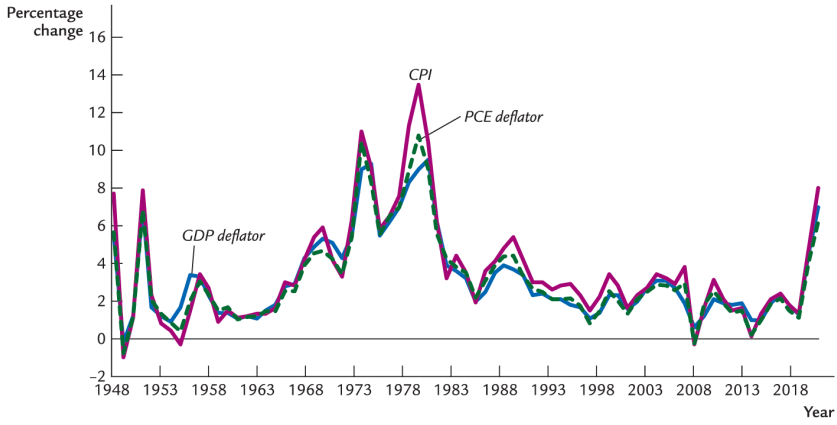
The PCE deflator

- Another measure of the price level: personal consumption expenditures (PCE) deflator, the ratio of nominal to real consumer spending
- How the PCE is like the CPI:
  - only includes consumer spending
  - includes imported consumer goods
- How the PCE is like the GDP deflator:
  - the "basket" changes over time
- The Federal Reserve prefers PCE.

Core Inflation

- Another measure of inflation that excludes food and energy prices.
- Food and energy prices have been volatile in the short-run.
- Sometimes viewed as a better gauge of underlying inflation trends.
- There exists both Core CPI and Core PCE.

The GDP deflator, CPI, and PCE deflator



Categories of the population

- **Employed**
  working at a paid job
- **Unemployed**
  not employed but looking for a job
- **Labor force**
  the amount of labor available for producing goods and services; all employed plus unemployed persons
- **Not in the labor force**
  not employed, not looking for work

Two important labor-force concepts

- **Unemployment rate**
  percentage of the labor force that is unemployed
- **Labor-force participation rate**
  fraction of the adult population that "participates" in the labor force—that is, is working or looking for work

NOW YOU TRY: Computing labor statistics

U.S. adult population by group, January 2023

Number employed = 160.1 million
Number unemployed = 5.7 million
Adult population = 264 million

Calculate

- the labor force
- the unemployment rate
- the labor force participation rate

NOW YOU TRY: Computing labor statistics, answers

Data: $E = 160.1$, $U = 5.7$, $POP = 264$

Labor force
$L = E + U = 160.1 + 5.7 = \underline{165.8}$

Unemployment rate
$U/L \times 100\% = (5.7/165.8) \times 100\% = \underline{3.4\%}$

Labor-force participation rate
$L/POP \times 100\% = (165.8/264) \times 100\% = \underline{62.8\%}$

NOW YOU TRY: Computing percentage changes

Suppose

- population increases by 1 percent
- labor force increases by 3 percent
- the number of unemployed persons increases by 2 percent

Compute the percentage changes in the labor-force participation and unemployment rates.

NOW YOU TRY: Computing percentage changes, answers

LFPR = L/POP

L increases 3%, POP increases 1%,
so LFPR increases $3\% - 1\% = 2\%$.

U rate = U/L

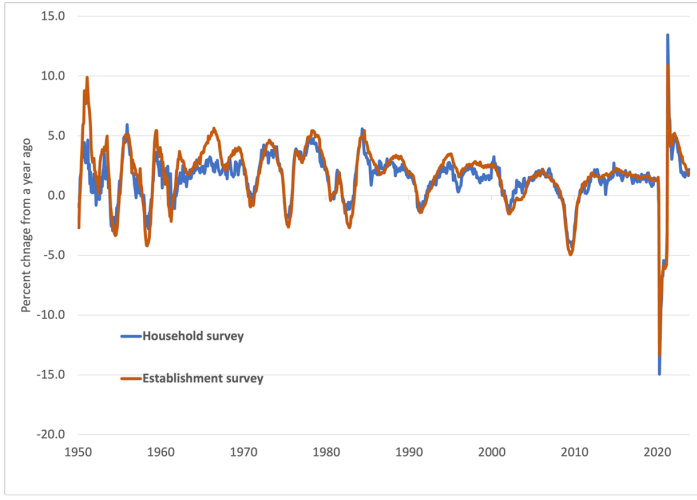
U increases 2%, L increases 3%,
so U-rate increases $2\% - 3\% = -1\%$.

Note: The changes in LFPR and U-rate are shown as a percentage of their initial values, not in percentage points! Example: If the initial value of LFPR is 60.0 percent, a 2 percent increase would bring it to 61.2 percent because 2 percent of 60 equals 1.2.

The establishment survey

- The BLS obtains a second measure of employment by surveying businesses, asking how many workers are on their payrolls.
- Neither measure is perfect, and they occasionally diverge due to:
  - treatment of self-employed persons
  - new firms not counted in establishment survey
  - technical issues involving population inferences from sample data

The measures of employment growth



Source: Federal Reserve Bank of St. Louis

Chapter Summary, Part 1

- Gross domestic product (GDP) measures both total income and total expenditure on the economy's output of goods and services.
- Nominal GDP values output at current prices; real GDP values output at constant prices. Changes in output affect both measures, but changes in prices affect only nominal GDP.
- GDP is the sum of consumption, investment, government purchases, and net exports.

Chapter Summary

- The overall level of prices can be measured by either:
  - the consumer price index (CPI), the price of a fixed basket of goods purchased by the typical consumer, or
  - the GDP deflator, the ratio of nominal to real GDP.
  - the PCE deflator
- The unemployment rate is the fraction of the labor force that is not employed.

Appendix: Chain-weighted real GDP — a worked example

Setup: an economy that produces only **computers** and **food**.

Year	Computers Q	Computer price	Food Q	Food price
2024	100	10	50	20
2025	120	9	55	22
2026	150	8	58	24

Nominal GDP = current-year prices × current-year quantities:

$$\begin{aligned}
\text{NGDP}_{2024} &= 100(10) + 50(20) = 2000, \\
\text{NGDP}_{2025} &= 120(9) + 55(22) = 2290, \\
\text{NGDP}_{2026} &= 150(8) + 58(24) = 2592.
\end{aligned}$$

back

Appendix — 2024 → 2025: Laspeyres, Paasche, Fisher

Laspeyres (base-year 2024 prices as weights):

$$g_L = \frac{120(10) + 55(20)}{100(10) + 50(20)} = \frac{2300}{2000} = 1.150.$$

Paasche (current-year 2025 prices as weights):

$$g_P = \frac{120(9) + 55(22)}{100(9) + 50(22)} = \frac{2290}{2000} = 1.145.$$

Fisher (geometric mean of the two):

$$g_F = \sqrt{g_L\, g_P} = \sqrt{1.150 \times 1.145} \approx 1.1475.$$

Real growth 2024 → 2025 $\approx 14.75\%$.

back

Appendix — 2025 → 2026: Laspeyres, Paasche, Fisher

Laspeyres (2025 prices as weights):

$$g_L = \frac{150(9) + 58(22)}{120(9) + 55(22)} = \frac{2626}{2290} \approx 1.1467.$$

Paasche (2026 prices as weights):

$$g_P = \frac{150(8) + 58(24)}{120(8) + 55(24)} = \frac{2592}{2280} \approx 1.1368.$$

Fisher:

$$g_F = \sqrt{1.1467 \times 1.1368} \approx 1.1418.$$

Real growth 2025 → 2026 $\approx 14.18\%$.

back

Appendix — Chain the growth rates into a real GDP series

Anchor $\text{RGDP}_{2024} = \text{NGDP}_{2024} = 2000$. Then:

$$\text{RGDP}_{2025} = 2000 \times 1.1475 \approx 2295.0,$$
$$\text{RGDP}_{2026} = 2295.0 \times 1.1418 \approx 2620.4.$$

Year	Nominal GDP	Chain-weighted Real GDP
2024	2000	2000.0
2025	2290	2295.0
2026	2592	2620.4

back

Appendix — Why chain-weighting is more accurate

Using **constant 2024 prices** throughout would give

$$\text{RGDP}_{2025}^{\text{2024-price}} = 120(10) + 55(20) = 2300,$$
$$\text{RGDP}_{2026}^{\text{2024-price}} = 150(10) + 58(20) = 2660.$$

Year	Constant-2024-price real GDP	Chain-weighted real GDP
2025	2300	2295.0
2026	2660	2620.4

Computer prices *fell* from 10 to 8 while computer output grew fast. Sticking with the old 2024 prices keeps computers "expensive" in the calculation and overstates real growth. Chain-weighting refreshes the weights every year, so it tracks the true growth of output more faithfully.

Appendix: What is a COLA?

COLA = *Cost-Of-Living Adjustment*. It is an automatic increase in a nominal payment tied to a price index (usually the CPI), designed to keep the recipient's real purchasing power roughly constant when prices rise.

Common examples in the U.S.:

- **Social Security** benefits — adjusted every January based on the CPI-W (a version of the CPI for wage earners).
- **Federal civil-service and military pensions.**
- Some **union wage contracts** and long-term **lease/rent agreements**.
- **Federal income tax brackets** are indexed to inflation — a form of automatic COLA.

Formula. If the reference CPI rose by π percent this year, next year's payment is

$$\text{Benefit}_{t+1} = \text{Benefit}_t \times (1 + \pi).$$

Appendix — COLA worked example

Grandma receives \$2,000 per month in Social Security in 2024.
Between Q3 2023 and Q3 2024, the CPI-W rose from 300 to 309 — a 3% increase.

Her 2025 monthly benefit is automatically raised to

$$\$2{,}000 \times \frac{309}{300} = \$2{,}000 \times 1.03 = \$2{,}060.$$

The extra \$60 is not a real raise — it just keeps her check's purchasing power constant.
If the CPI *overstates* true inflation (substitution bias, quality bias, new-goods bias, outlet bias), the COLA over-compensates and her real income slowly drifts upward.
That is exactly the CPI-bias question raised later in the chapter.

back

Appendix: Answers to the discussion questions (Q1–Q3)

Q1. How is grandma affected by the CPI's bias?
The CPI overstates true inflation (substitution, quality, new-goods, and outlet biases). Because her Social Security COLA is tied to the CPI-W, her nominal benefit grows *faster* than her true cost of living — her real purchasing power drifts slowly upward.

Q2. Where does the money for those COLAs come from?
From current workers' payroll (FICA) taxes and, when the trust fund is drawn down, from general federal revenue. In effect, today's taxpayers finance today's retiree COLAs.

Q3. If you pay income and payroll taxes, how does the bias affect you?
Two channels with opposite signs:

- \+ Income-tax brackets are also indexed to the CPI, so they widen *too fast* $\Rightarrow$ you pay less real income tax.
- − Your payroll taxes fund an over-generous Social Security COLA $\Rightarrow$ you effectively pay more.

Net effect depends on your income and stage of life.

back

Appendix: Answers to the discussion questions (Q4–Q5)

Q4. Is the government giving grandma too much of a COLA?
On the CPI-bias argument alone: **yes**. The Boskin Commission (1996) estimated the CPI overstated true inflation by about **1.1% per year**. Compounded over decades, that is a large real over-adjustment.

Q5. How does grandma's "basket" differ from the CPI's?
Elderly households spend a much larger share on **medical care** and **housing**, and medical prices have risen faster than the overall CPI. The BLS publishes an experimental **CPI-E** (for the elderly), which typically shows *higher* inflation than the CPI-W actually used for Social Security.

Two effects pushing opposite ways: CPI *bias* $\Rightarrow$ grandma is over-compensated; her elderly *basket* $\Rightarrow$ she is under-compensated. Whether the net COLA is "too much" is empirically ambiguous.