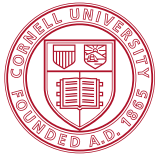
ECON 6130: Macroeconomics I

Mathieu Taschereau-Dumouchel



Organization

Organization

- Schedule: Monday and Wednesday, 10:10am to 11:25am in Rockefeller Hall 112
- Discussion: Friday, 8:40am to 9:55am in Uris 262 and Goldwin Smith 236
- Website: https://canvas.cornell.edu/courses/65178

Professor

- Mathieu Taschereau-Dumouchel (mt763@cornell.edu)
  - Office hours: Uris 480, M, 3-5pm or by appt. (email me)

Teaching assistants

- Zheyang Zhu (zz792@cornell.edu)
  - Office hours: Uris TBA, Th 5pm to 7pm
- Ekaterina Zubova (ez268@cornell.edu)
  - Office hours: Uris 451, Tu 5pm to 7pm

Ryan Chahrour will teach the second half of this class

Organization

There is no required textbook for the class.

Good references:

- Lars Ljunqvist and Thomas J. Sargent. Recursive Macroeconomic Theory, 4th edition, MIT Press, 2018.
- Nancy Stokey and Robert Lucas, with Edward Prescott, Recursive Methods in Economic Dynamics, Harvard University Press, 1989.

More general discussions:

- David Romer, Advanced Macroeconomics, 3rd edition, McGraw Hill, 2006.
- Olivier Blanchard and Stanley Fisher, Lectures on Macroeconomics, MIT Press, 1989.

For numerical methods:

- Kenneth Judd, Numerical Methods in Economics, MIT Press, 1998.
- Angel de la Fuente, Mathematical Methods and Models for Economists, Cambridge, 2000.

Topics

Subject to major changes and reshuffling...

1. Data and Introduction to Macroeconomics
2. Endowment Economy with Complete Markets
3. Asset Pricing
4. Math, Dynamic Programming and Numerical Methods
5. Production and Investment
6. Neoclassical Growth model

Tools of Economics

Mathematics

1. Modern economics is very math heavy
2. Big benefit from learning as much math as you can early on
3. Take advanced math classes
4. Great papers have been written by adapting math/engineering tools to econ

Tools of Economics

Mathematics

1. Modern economics is very math heavy
2. Big benefit from learning as much math as you can early on
3. Take advanced math classes
4. Great papers have been written by adapting math/engineering tools to econ

Quantitative methods

1. Modern economics is very quantitative/computational
2. Big benefit from learning these methods early on
3. Pick (at least) one language and master it
4. One great resource: https://quantecon.org

How to think about this class and the PhD

What doing an economics PhD is about

- You are now on a mission to improve human knowledge (illustration)
- If you are successful we will understand the economy better because of your work
- Better economic policies can increase the welfare of millions of people

How to think about this class and the PhD

What doing an economics PhD is about

- You are now on a mission to improve human knowledge (illustration)
- If you are successful we will understand the economy better because of your work
- Better economic policies can increase the welfare of millions of people

How to tackle this class

- Focus on *understanding* the material and build your *intuition*
- *Question* the material
  - Is there a problem with it? Does the model fit the data? Is there a better one?

How to think about this class and the PhD

What doing an economics PhD is about

- You are now on a mission to improve human knowledge (illustration)
- If you are successful we will understand the economy better because of your work
- Better economic policies can increase the welfare of millions of people

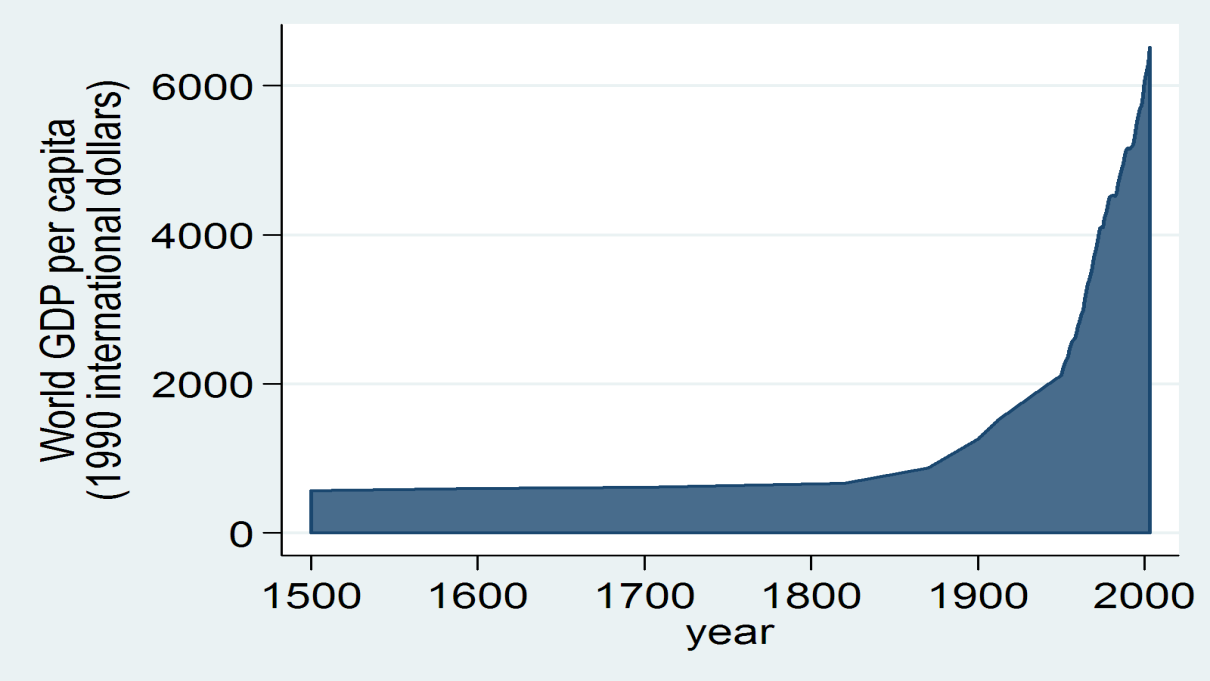
How to tackle this class

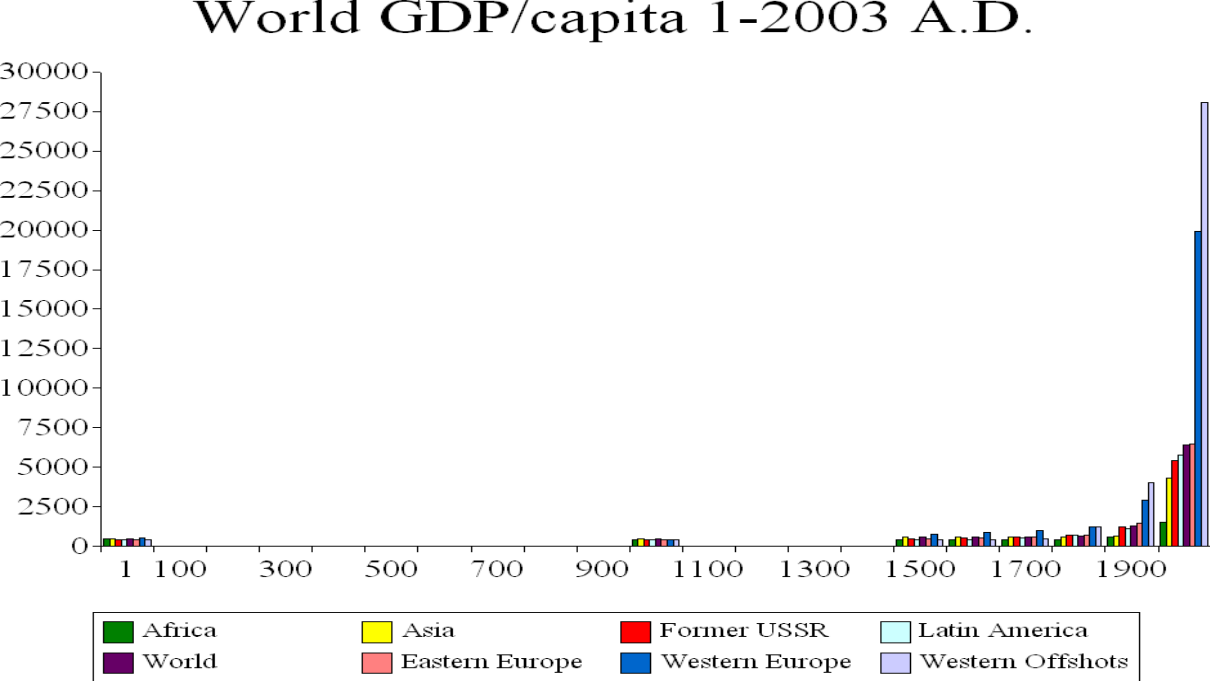
- Focus on *understanding* the material and build your *intuition*
- *Question* the material
  - Is there a problem with it? Does the model fit the data? Is there a better one?

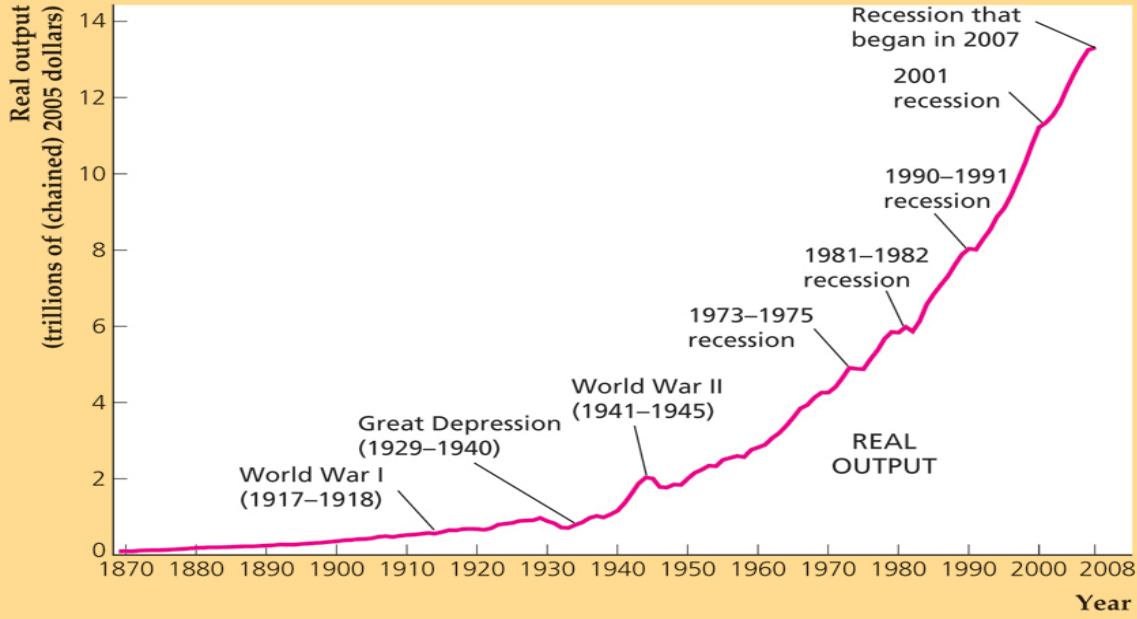
Economics is *hard*

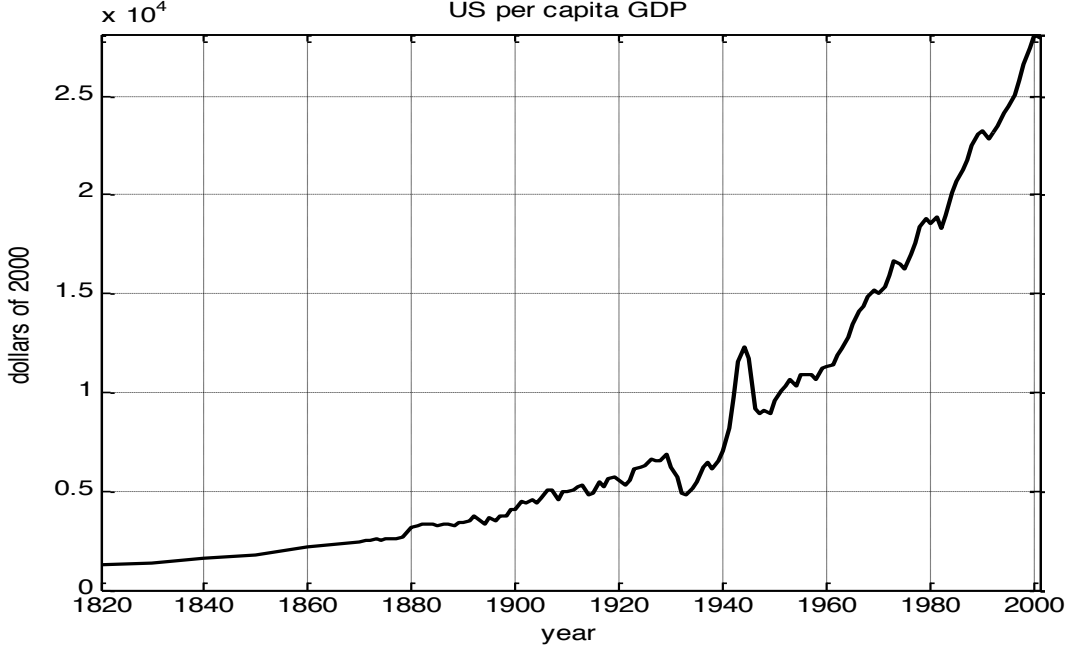
- Working hard is a necessary (but not sufficient) condition to do great work
- Be curious, think outside the box, and explore what interests you

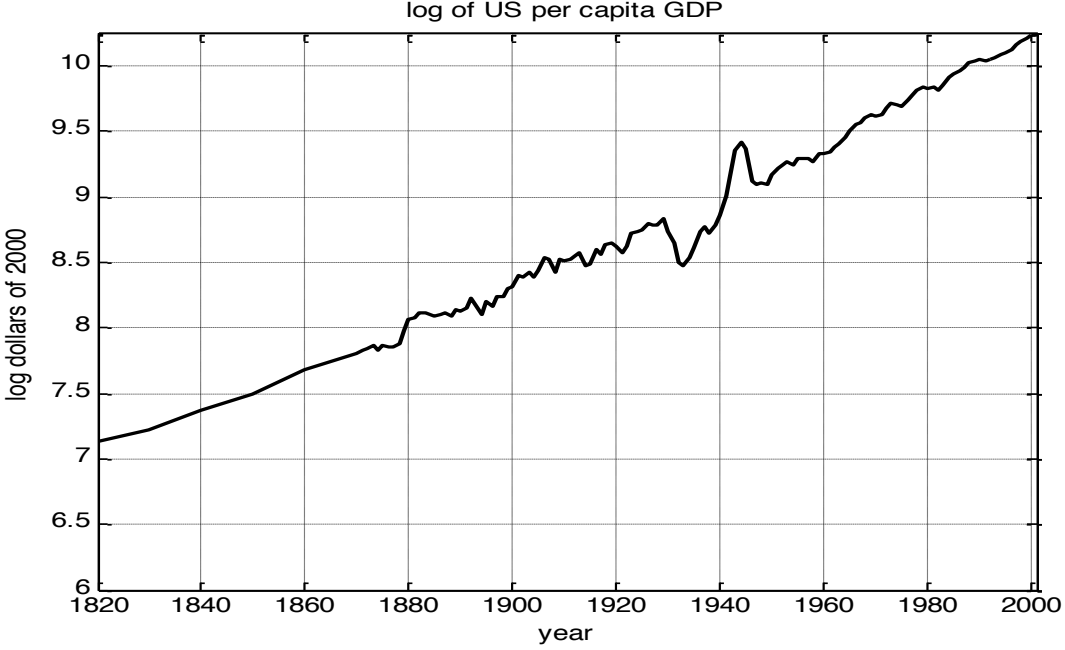
Quick look at the data


World GDP per capita
(1990 international dollars)
6000
4000
2000
0
1500
1600
1700
1800
1900
2000
year


World GDP/capita 1-2003 A.D.
30000
27500
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
1
100
300
500
700
900
1100
1300
1500
1700
1900
Africa
Asia
Former USSR
Latin America
World
Eastern Europe
Western Europe
Western Offshots

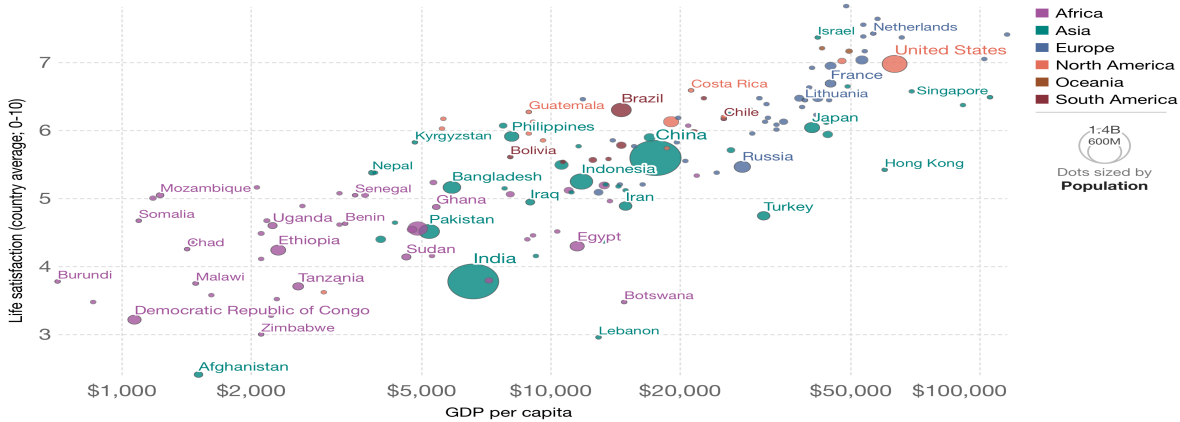

Real output
(trillions of (chained) 2005 dollars)
14
12
10
8
6
4
2
0
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2008
Year
Recession that began in 2007
2001 recession
1990–1991 recession
1981–1982 recession
1973–1975 recession
World War II (1941–1945)
Great Depression (1929–1940)
World War I (1917–1918)
REAL OUTPUT


US per capita GDP
x 10^4
2.5
2
1.5
1
0.5
0
dollars of 2000
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
year


log of US per capita GDP
log dollars of 2000
10
9.5
9
8.5
8
7.5
7
6.5
6
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
year

Self-reported life satisfaction vs. GDP per capita, 2022

Self-reported life satisfaction is measured on a scale ranging from 0-10, where 10 is the highest possible life satisfaction. GDP per capita is adjusted for inflation and differences in the cost of living between countries.

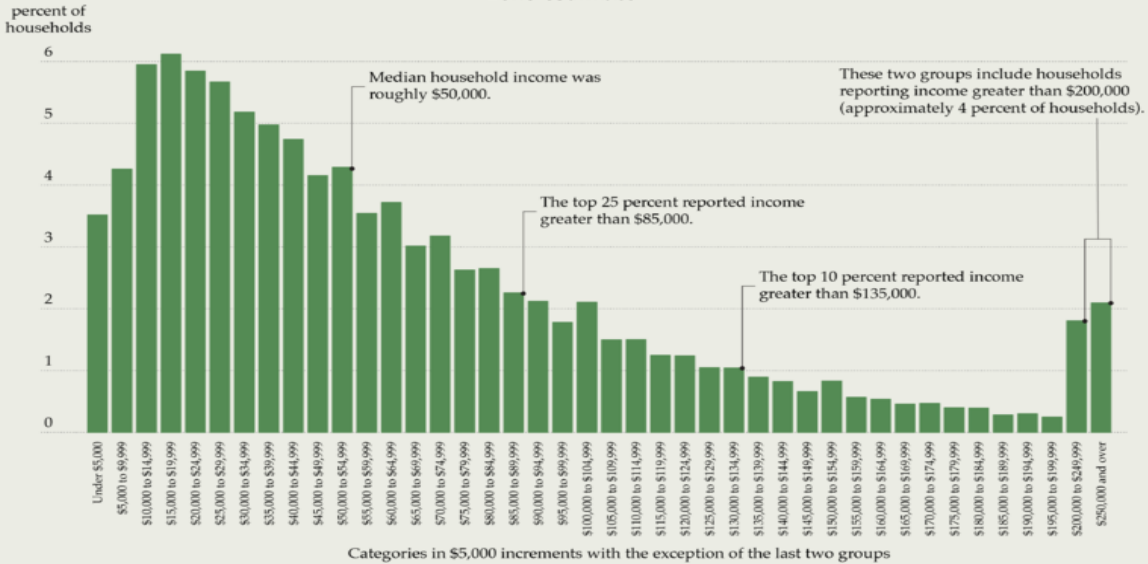


Source: World Happiness Report (2023), Data compiled from multiple sources by World Bank
Note: GDP per capita is expressed in international-$[1] at 2017 prices.
OurWorldInData.org/happiness-and-life-satisfaction/ • CC BY

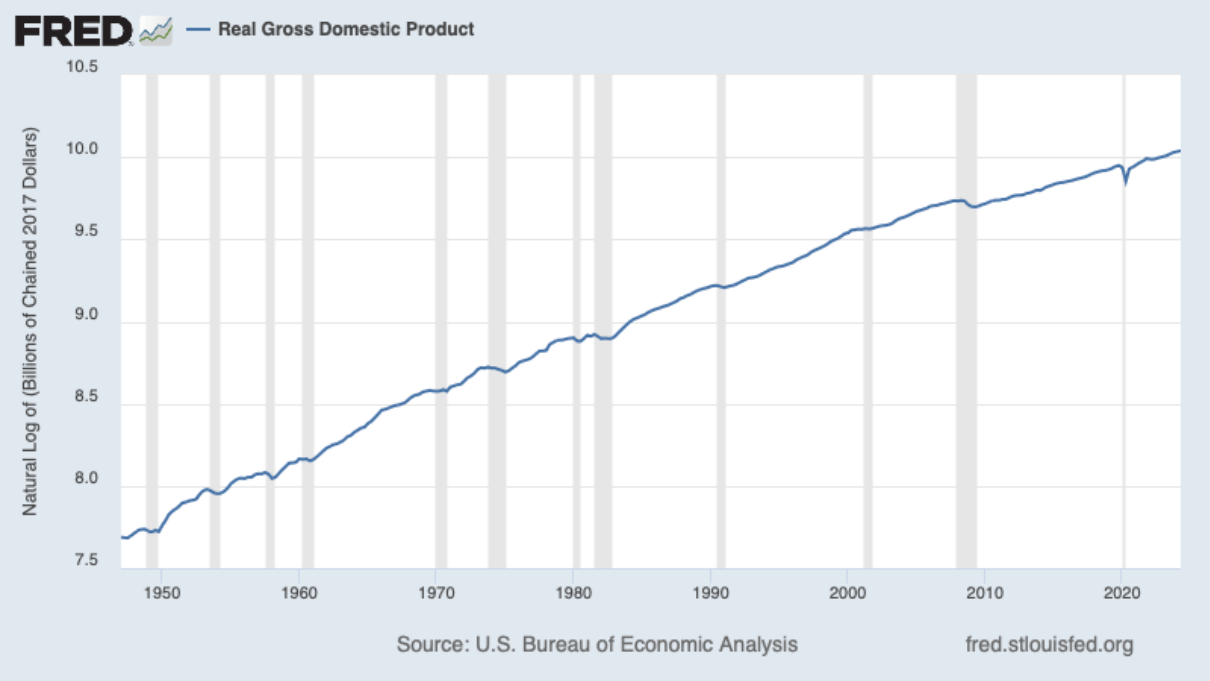
1. International dollars: International dollars are a hypothetical currency that is used to make meaningful comparisons of monetary indicators of living standards. Figures expressed in international dollars are adjusted for inflation within countries over time, and for differences in the cost of living between countries. The goal of such adjustments is to provide a unit whose purchasing power is held fixed over time and across countries, such that one international dollar can buy the same quantity and quality of goods and services no matter where or when it is spent. Read more in our article: What are Purchasing Power Parity adjustments and why do we need them?

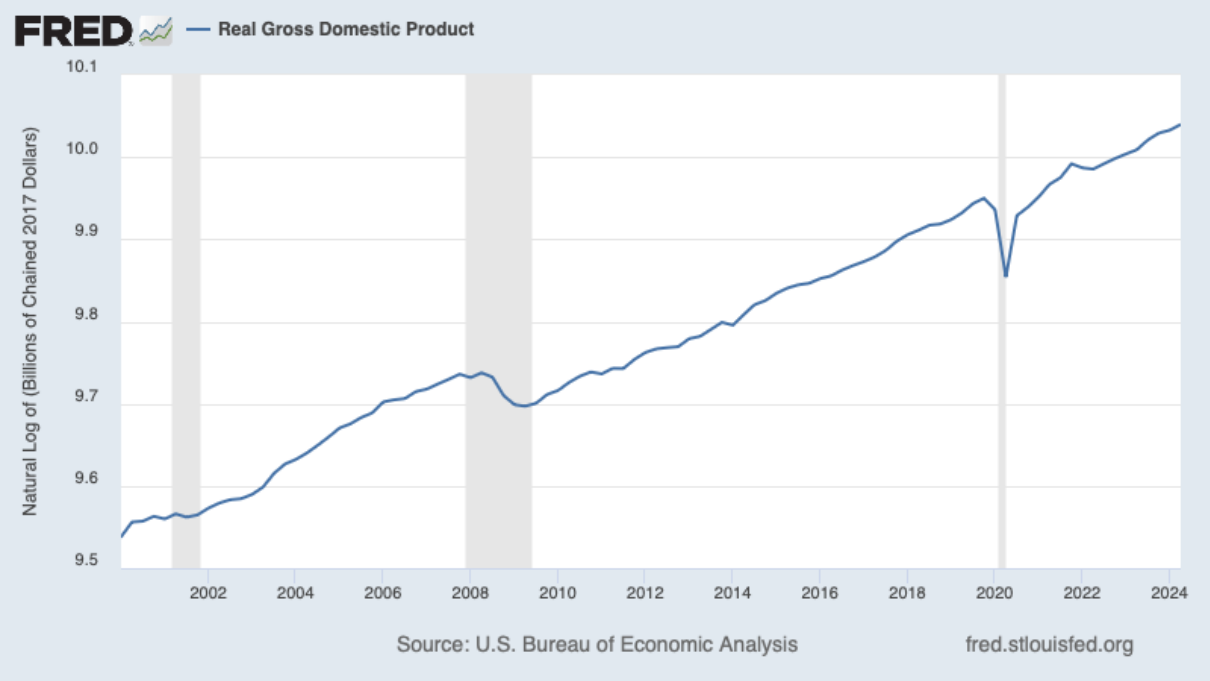
Distribution of annual household income in the United States

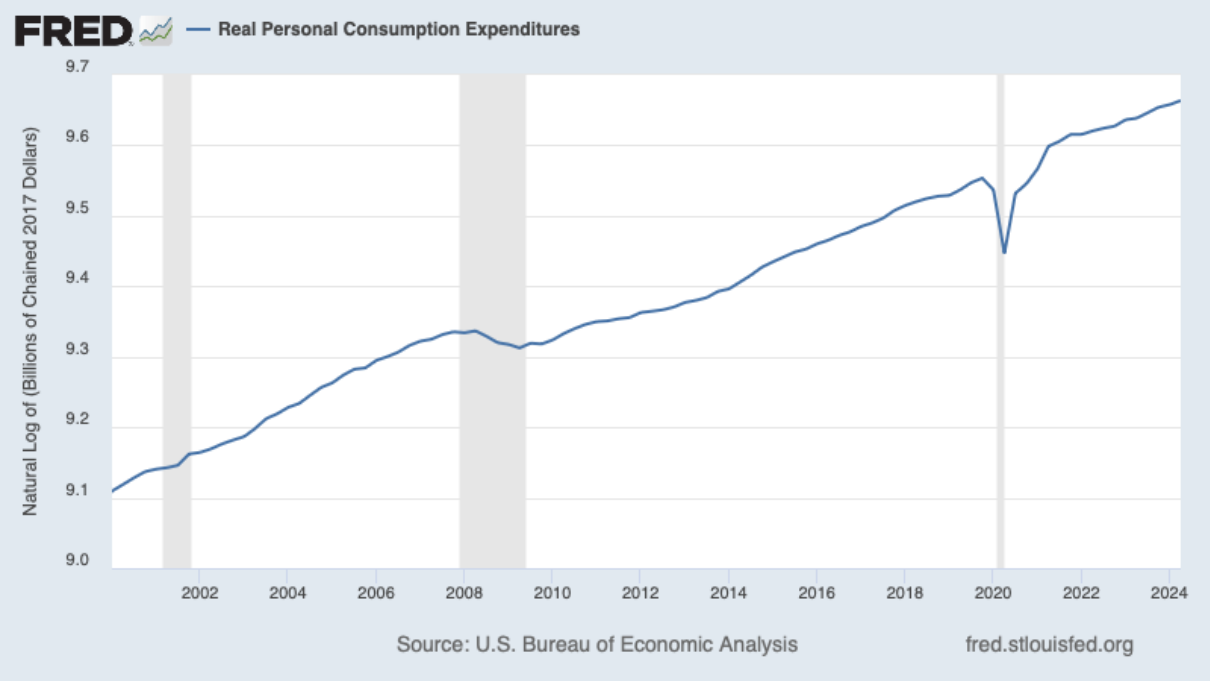
2010 estimate

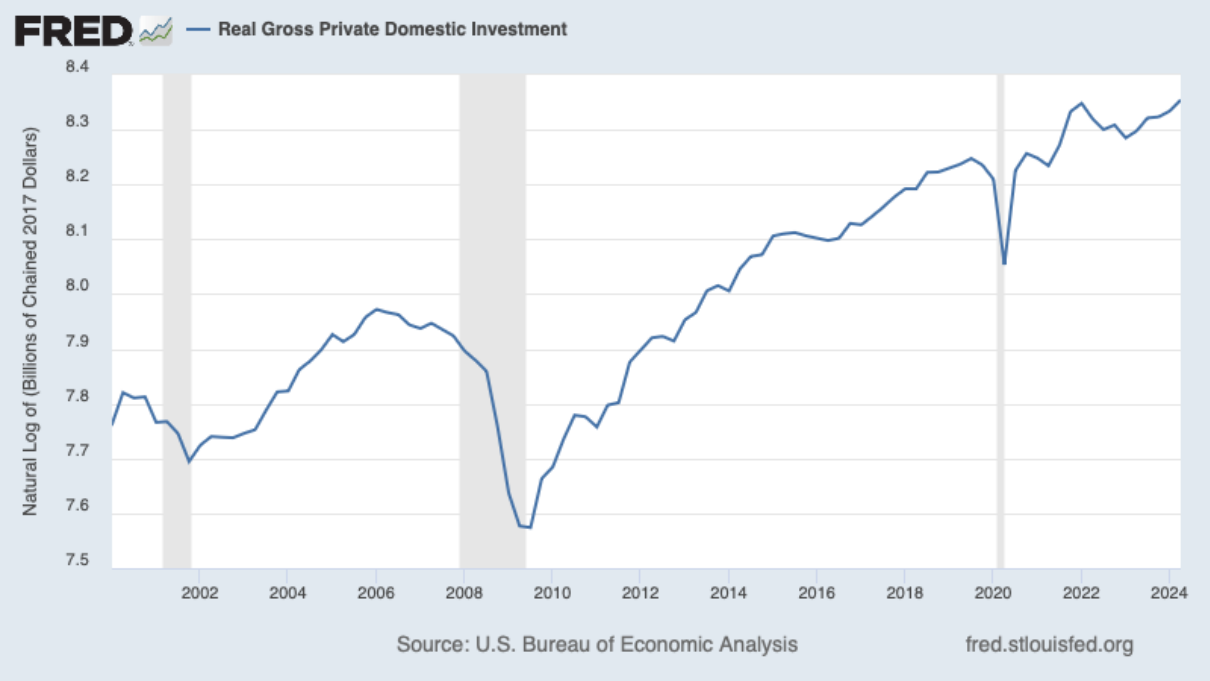


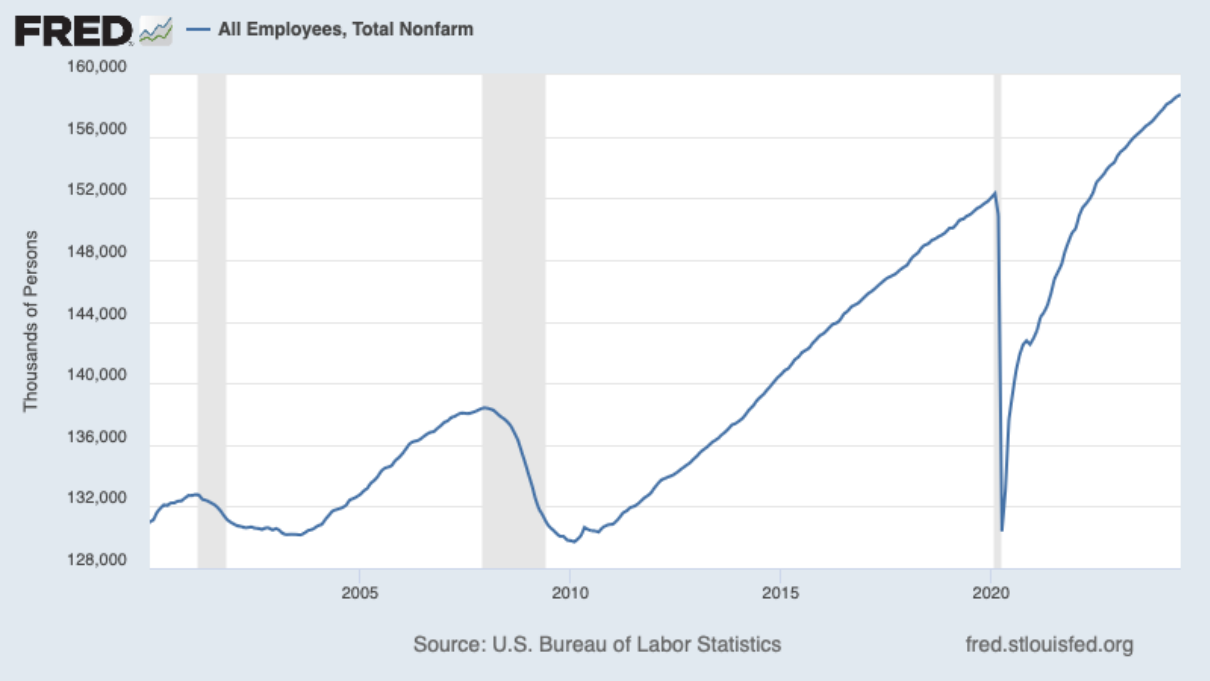
Source: U.S. Census Bureau, Current Population Survey, 2011 Annual Social and Economic Supplement

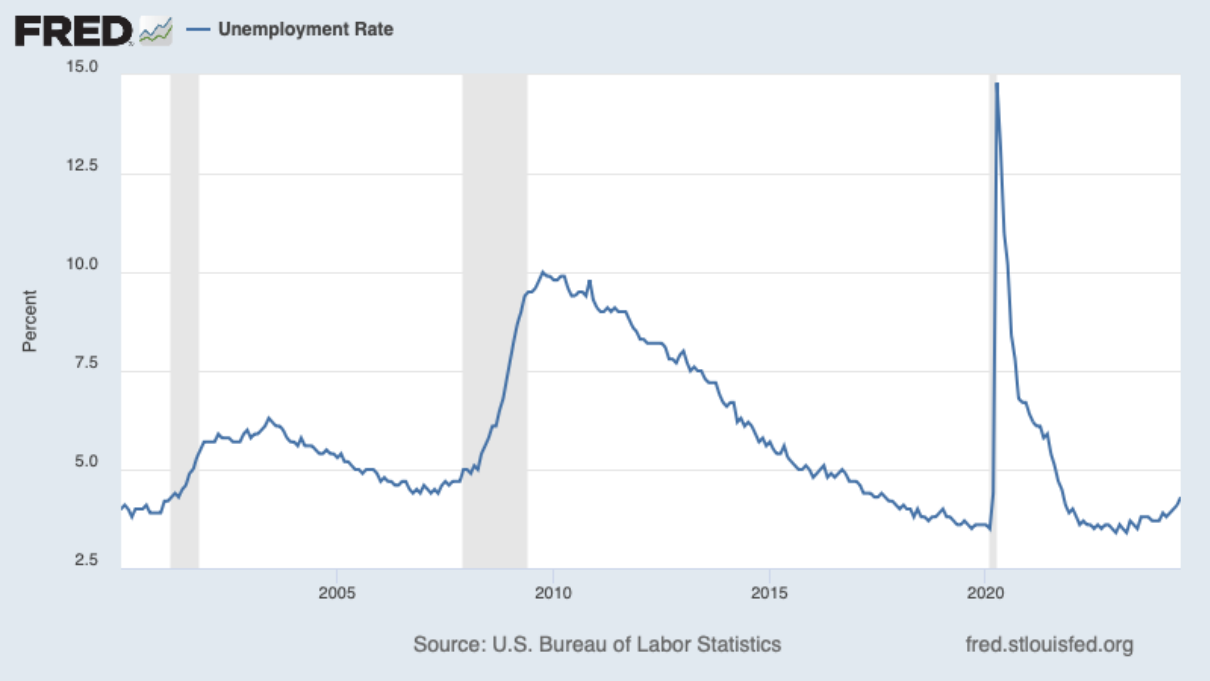

FRED
Real Gross Domestic Product
Natural Log of (Billions of Chained 2017 Dollars)
10.5
10.0
9.5
9.0
8.5
8.0
7.5
1950
1960
1970
1980
1990
2000
2010
2020
Source: U.S. Bureau of Economic Analysis
fred.stlouisfed.org

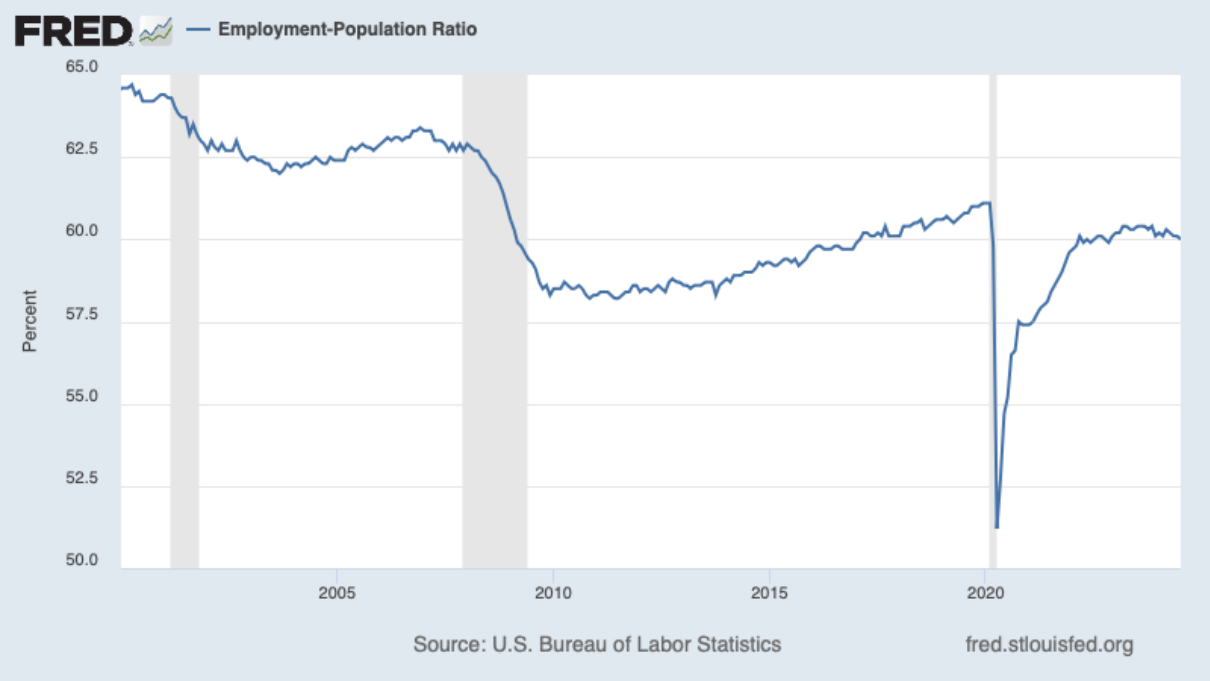

FRED
Real Gross Domestic Product
Natural Log of (Billions of Chained 2017 Dollars)
10.1
10.0
9.9
9.8
9.7
9.6
9.5
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Source: U.S. Bureau of Economic Analysis
fred.stlouisfed.org

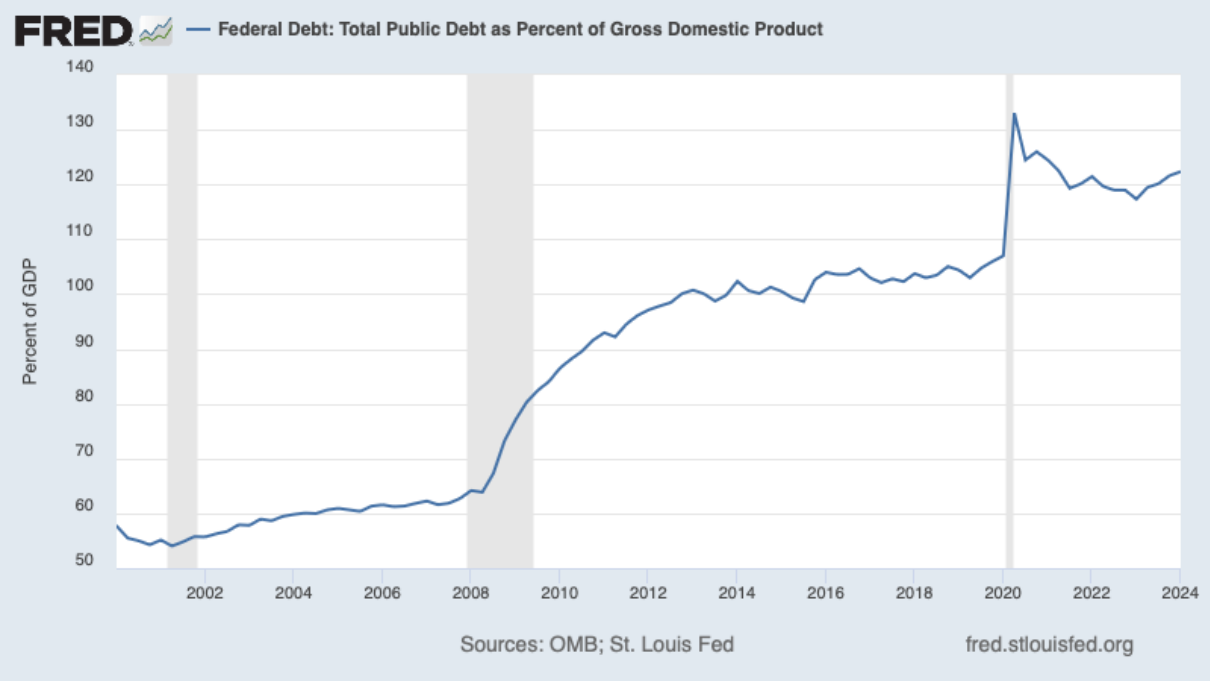

FRED
Real Personal Consumption Expenditures
Natural Log of (Billions of Chained 2017 Dollars)
9.7
9.6
9.5
9.4
9.3
9.2
9.1
9.0
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Source: U.S. Bureau of Economic Analysis
fred.stlouisfed.org

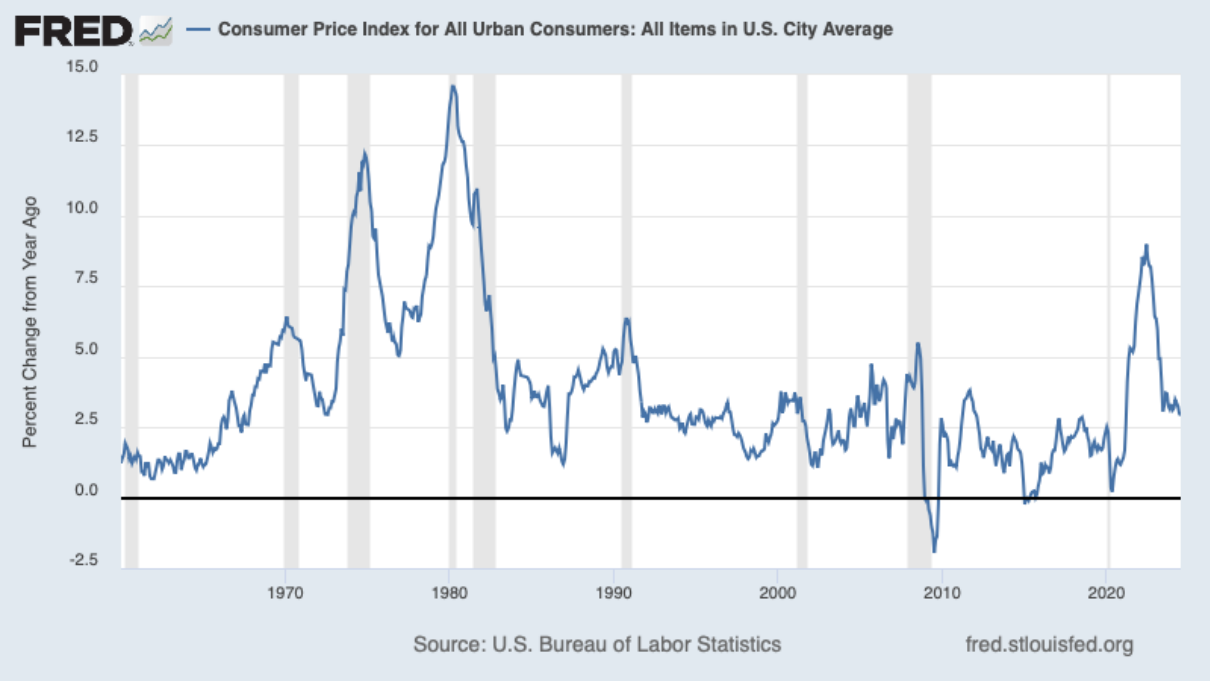

FRED
Real Gross Private Domestic Investment
Natural Log of (Billions of Chained 2017 Dollars)
8.4
8.3
8.2
8.1
8.0
7.9
7.8
7.7
7.6
7.5
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Source: U.S. Bureau of Economic Analysis
fred.stlouisfed.org

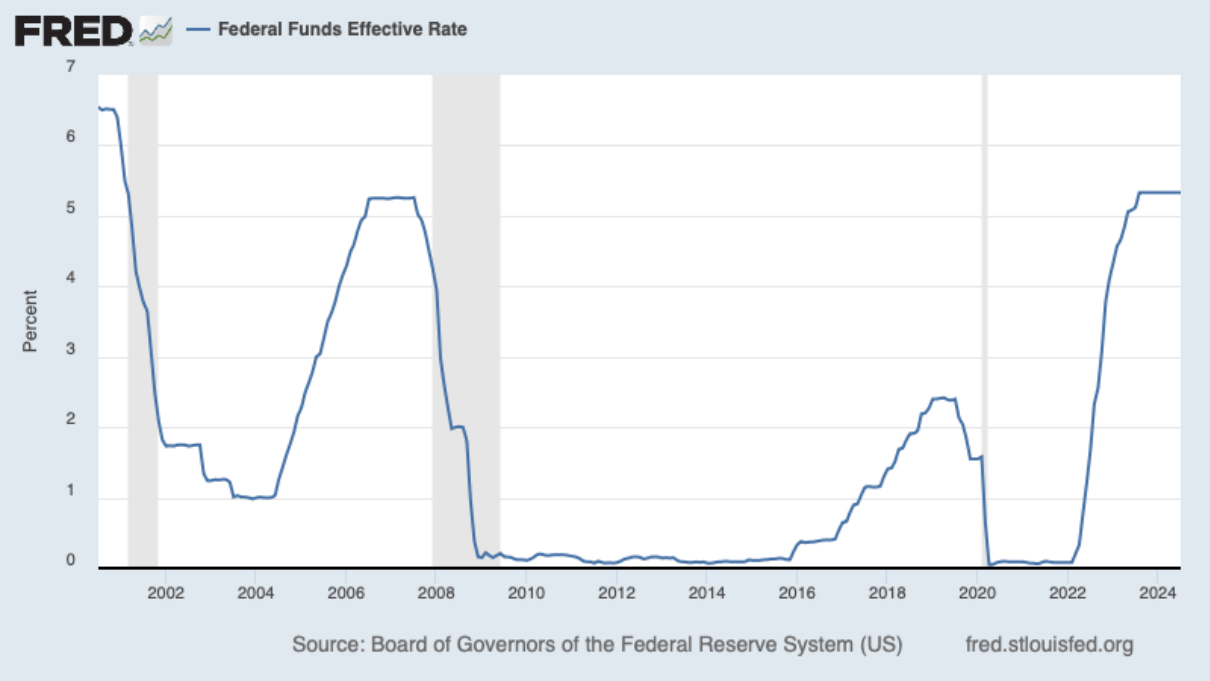

FRED
All Employees, Total Nonfarm
160,000
156,000
152,000
148,000
144,000
140,000
136,000
132,000
128,000
Thousands of Persons
2005
2010
2015
2020
Source: U.S. Bureau of Labor Statistics
fred.stlouisfed.org


FRED
Unemployment Rate
15.0
12.5
10.0
7.5
5.0
2.5
Percent
2005
2010
2015
2020
Source: U.S. Bureau of Labor Statistics
fred.stlouisfed.org


FRED
Employment-Population Ratio
65.0
62.5
60.0
57.5
55.0
52.5
50.0
Percent
2005
2010
2015
2020
Source: U.S. Bureau of Labor Statistics
fred.stlouisfed.org


FRED
Federal Debt: Total Public Debt as Percent of Gross Domestic Product
Percent of GDP
140
130
120
110
100
90
80
70
60
50
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Sources: OMB; St. Louis Fed
fred.stlouisfed.org


FRED
Consumer Price Index for All Urban Consumers: All Items in U.S. City Average
Percent Change from Year Ago
15.0
12.5
10.0
7.5
5.0
2.5
0.0
-2.5
1970
1980
1990
2000
2010
2020
Source: U.S. Bureau of Labor Statistics
fred.stlouisfed.org


FRED
Federal Funds Effective Rate
Percent
7
6
5
4
3
2
1
0
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Source: Board of Governors of the Federal Reserve System (US)
fred.stlouisfed.org

What are we trying to do?

How can we make sense of that data?

- What drives long-run growth? Why are some countries much richer than others?
- What drives business cycles?
- What drives income/wealth inequality?

What are we trying to do?

How can we make sense of that data?

- What drives long-run growth? Why are some countries much richer than others?
- What drives business cycles?
- What drives income/wealth inequality?

Make policy recommendations

- What should a government do to foster growth?
- What are the best policy to avoid/alleviate recessions?
- Should we redistribute income? What's the best way to do that?

Let's learn from the data!

Philipps Curve

Negative relationship between inflation and unemployment

- Discovered by Bill Phillips in 1958
- The relationship held in many countries during many periods

Philipps Curve

Negative relationship between inflation and unemployment

- Discovered by Bill Phillips in 1958
- The relationship held in many countries during many periods

This is great news!

- We know how to create inflation (print more money)
- Central Banks can now reduce unemployment helping millions
- Inflation is unfortunate but remember money neutrality

Philipps Curve

Negative relationship between inflation and unemployment

- Discovered by Bill Phillips in 1958
- The relationship held in many countries during many periods

This is great news!

- We know how to create inflation (print more money)
- Central Banks can now reduce unemployment helping millions
- Inflation is unfortunate but remember money neutrality

But once Central Banks tried to exploit the curve it disappeared!

Philipps Curve

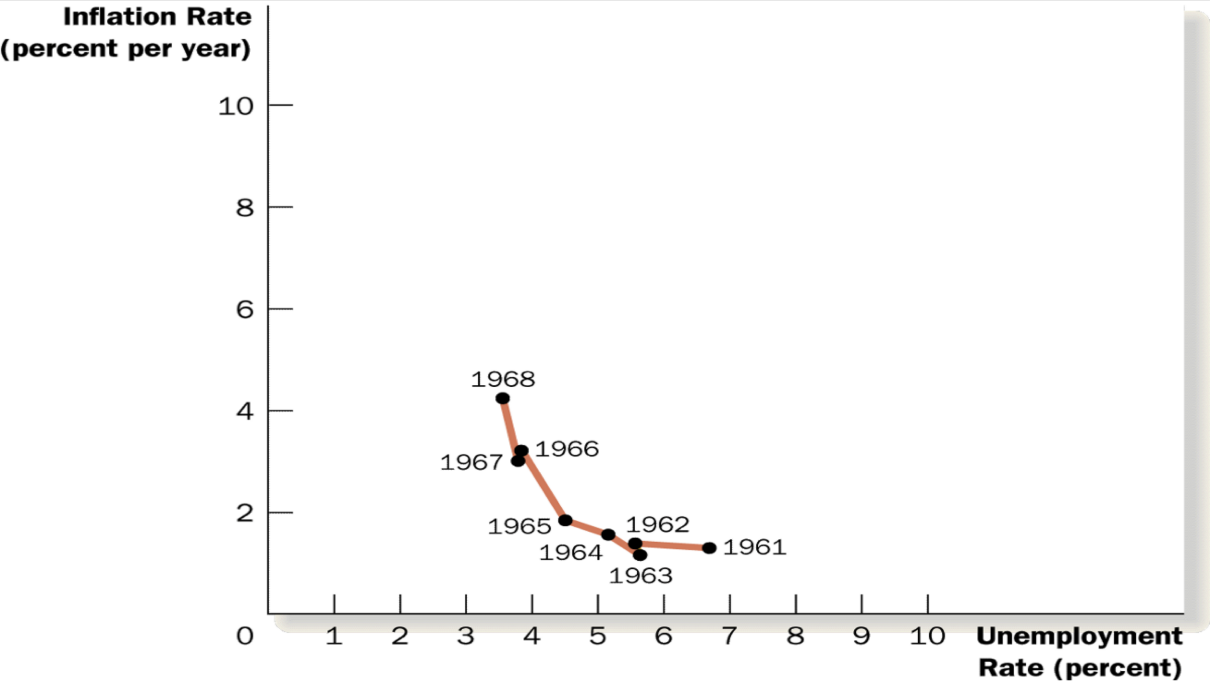
Negative relationship between inflation and unemployment

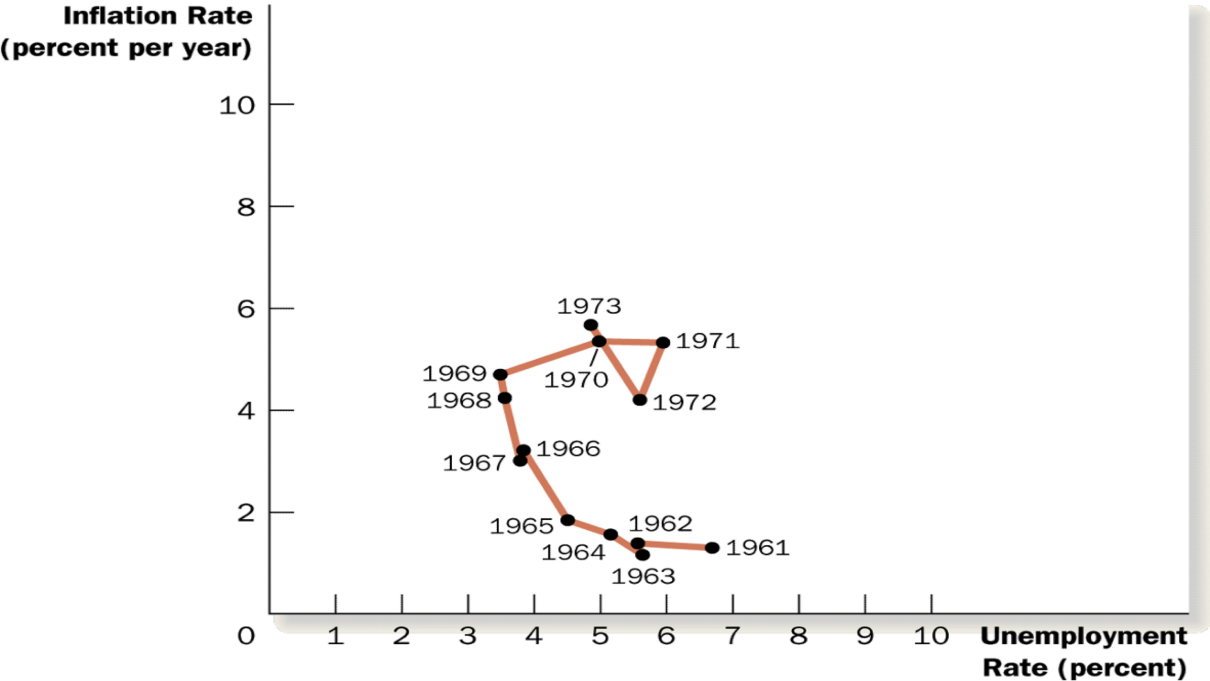
- Discovered by Bill Phillips in 1958
- The relationship held in many countries during many periods

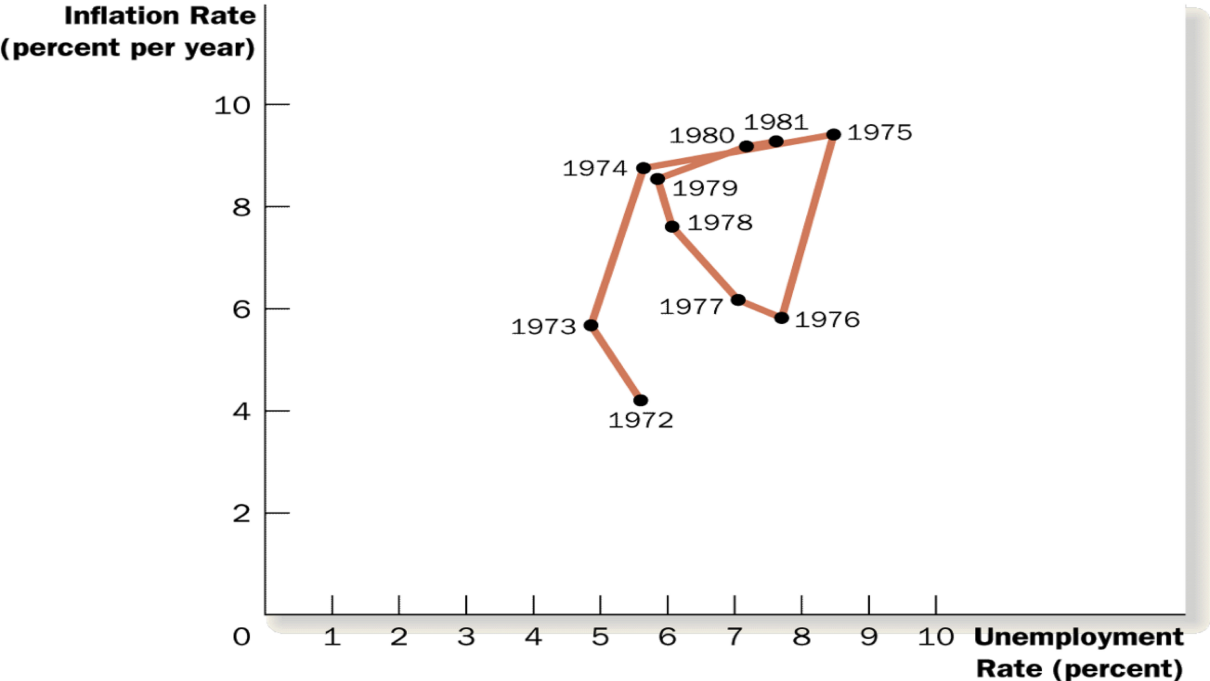
This is great news!

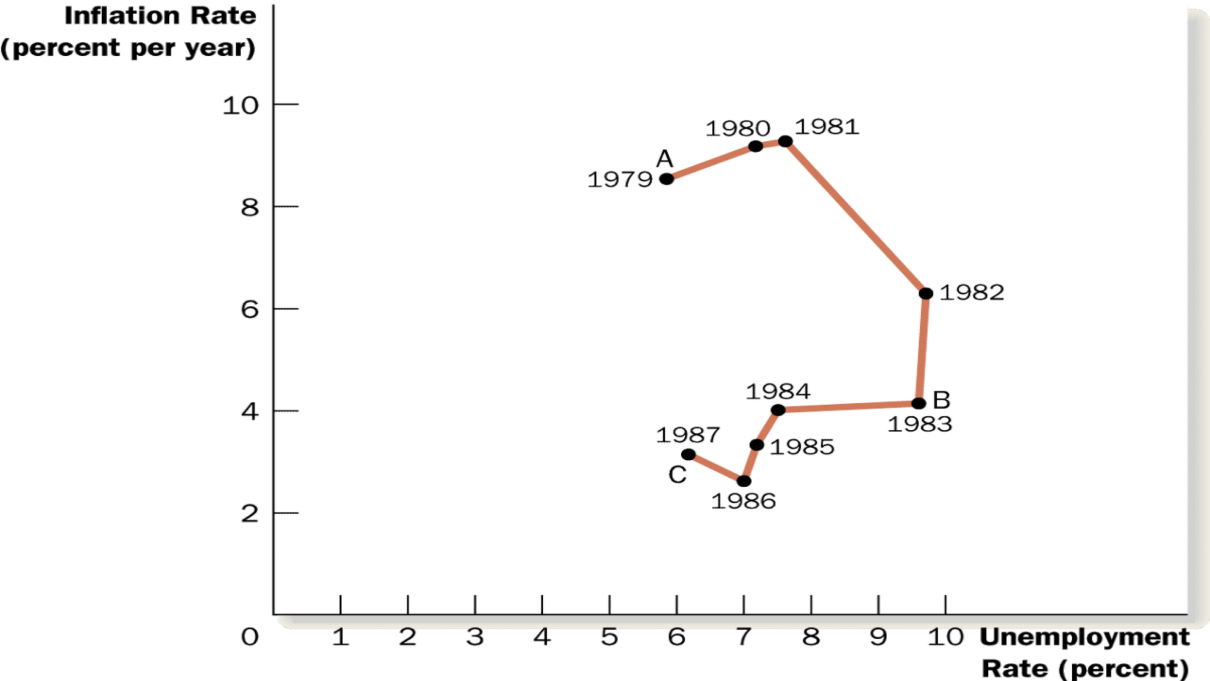
- We know how to create inflation (print more money)
- Central Banks can now reduce unemployment helping millions
- Inflation is unfortunate but remember money neutrality

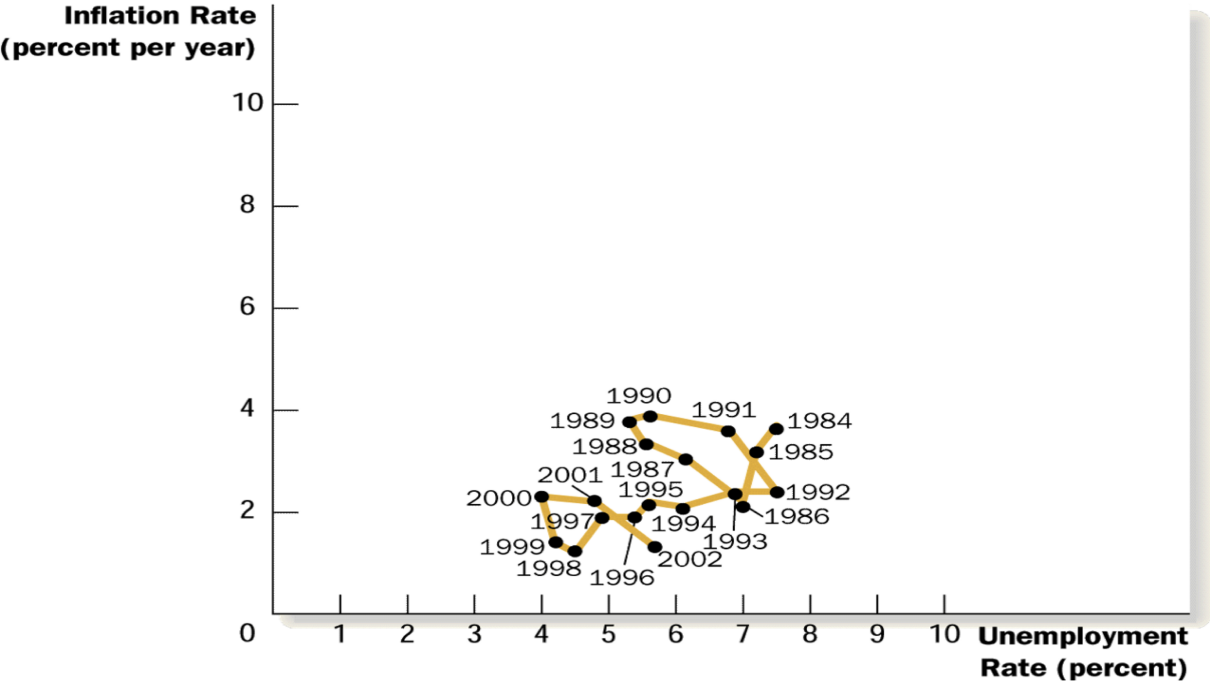
But once Central Banks tried to exploit the curve it disappeared! Why?

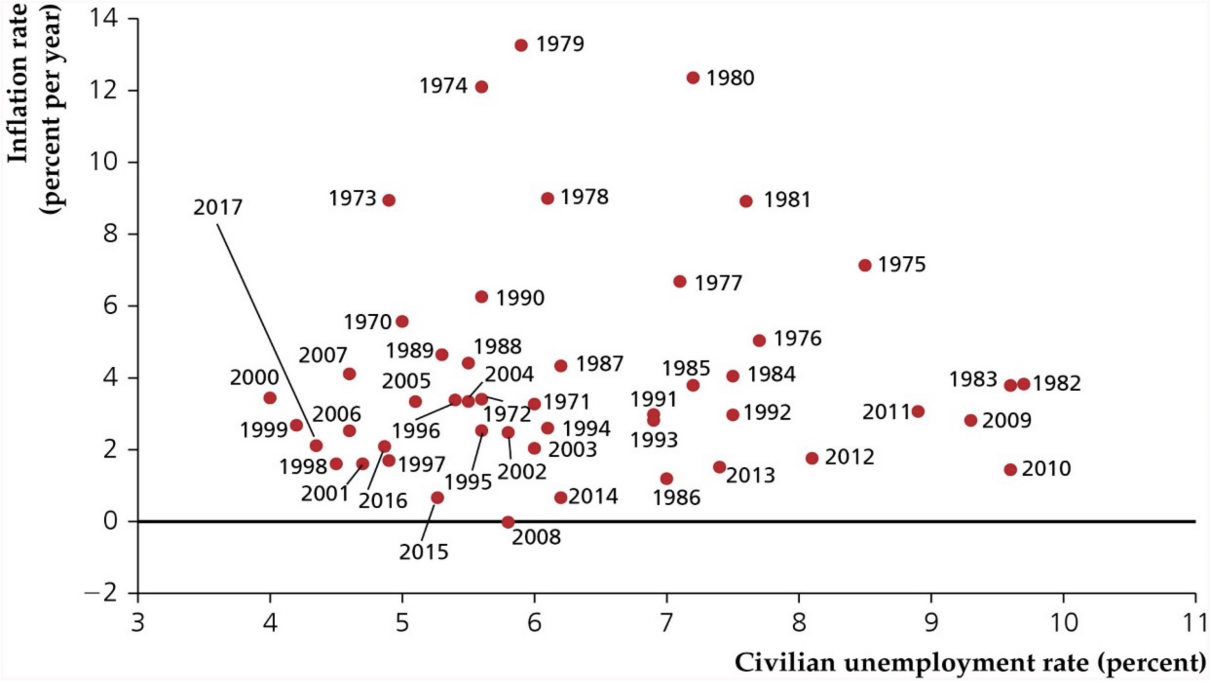

Inflation Rate
(percent per year)
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Unemployment
Rate (percent)
1968
1967
1966
1965
1964
1963
1962
1961


Inflation Rate
(percent per year)
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Unemployment
Rate (percent)
1973
1971
1969
1970
1972
1968
1966
1967
1965
1962
1964
1961
1963


Inflation Rate
(percent per year)
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Unemployment
Rate (percent)
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981


Inflation Rate
(percent per year)
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Unemployment
Rate (percent)
1979
A
1980
1981
1982
1983
B
1984
1985
1986
C
1987


Inflation Rate
(percent per year)
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Unemployment
Rate (percent)
1990
1989
1991
1984
1988
1985
2001
1987
2000
1995
1992
1997
1994
1986
1999
1993
1998
1996
2002


Inflation rate
(percent per year)
14
12
10
8
6
4
2
0
−2
3
4
5
6
7
8
9
10
11
Civilian unemployment rate (percent)
1979
1974
1980
1973
1978
1981
2017
1975
1977
1990
1970
1976
2007
1989
1988
1987
2000
2005
2004
1985
1984
1983
1982
1991
1971
2006
1972
1992
2011
1999
1996
1994
2009
1993
2003
1998
1997
2012
2002
1995
2013
2001
2016
2014
1986
2010
2015
2008

The data can be misleading...

If we only look at the data we make mistakes

- Observed relationships (Philipps Curve) are the outcome of agent decisions
- When the environment changes (policy), agents change their behavior
- The observed relationships can disappear...

The data can be misleading...

If we only look at the data we make mistakes

- Observed relationships (Philipps Curve) are the outcome of agent decisions
- When the environment changes (policy), agents change their behavior
- The observed relationships can disappear...
- Lesson: never do policy by only looking at the data!

The data can be misleading...

If we only look at the data we make mistakes

- Observed relationships (Philipps Curve) are the outcome of agent decisions
- When the environment changes (policy), agents change their behavior
- The observed relationships can disappear...
- Lesson: never do policy by only looking at the data!

But then how do we learn anything about the macroeconomy?

The data can be misleading...

If we only look at the data we make mistakes

- Observed relationships (Philipps Curve) are the outcome of agent decisions
- When the environment changes (policy), agents change their behavior
- The observed relationships can disappear...
- Lesson: never do policy by only looking at the data!

But then how do we learn anything about the macroeconomy?

- If we *could* run experiments that would help
- If we had a *lot* of data that could help
- But *macro* data is sparse and democracies (thankfully) frown on experimentations

Instead we build *models*

Models are little laboratories to make sense of the economy

- We specify how the world works and agents behave
- We anchor these objects with policy-independent foundations
- We use data to discipline the model (i.e. pick parameter values)
- We can use the model to test different policies and make prediction

Instead we build *models*

Models are little laboratories to make sense of the economy

- We specify how the world works and agents behave
- We anchor these objects with policy-independent foundations
- We use data to discipline the model (i.e. pick parameter values)
- We can use the model to test different policies and make prediction

There is an art to building a good model...

Instead we build *models*

Models are little laboratories to make sense of the economy

- We specify how the world works and agents behave
- We anchor these objects with policy-independent foundations
- We use data to discipline the model (i.e. pick parameter values)
- We can use the model to test different policies and make prediction

There is an art to building a good model...

- Descriptive realism is not the objective
- The world is too complicated to tackle everything at once
- We look for regularities in the data and use models to understand them
- Focus on essential ingredients to explain data

What is a macroeconomic model?

Different entities making decisions under constraints and interacting with each other

The entities in a typical model:

- **Households** maximize their utility under budget constraint
- **Firms** use a technology to transform inputs into output
- **Government** uses policies (normative vs positive)

also need to specify:

- Set of commodities being traded (labor, consumption good, etc)
- Information structure
- Market structure

Example in *Partial equilibrium*

Consumption-saving problem of a household:

$$\max_{\{c_t\},\{b_{t+1}\}} \sum_{t=0}^{\infty} \beta^t u(c_t) \qquad \text{(utility function)}$$

$$\text{s.t. } \underbrace{c_t + b_{t+1}}_{\text{uses}} \leq \underbrace{y_t + R_t b_t}_{\text{sources}} \qquad \text{(budget constraint)}$$

$$b_{t+1} \geq -A \qquad \text{(borrowing constraint)}$$

$$c_t \geq 0 \qquad \text{(non-negativity constraint)}$$

$$b_0 \text{ given} \qquad \text{(initial condition)}$$

$$y_t \text{ and } R_t \text{ given}$$

where $u' > 0, u'' < 0, \lim_{c \to 0} u'(c) = \infty$, $0 < \beta < 1$, A is large.

Example in *Partial equilibrium*

Consumption-saving problem of a household:

$$\max_{\{c_t\},\{b_{t+1}\}} \sum_{t=0}^{\infty} \beta^t u(c_t) \qquad \text{(utility function)}$$

$$\text{s.t. } \underbrace{c_t + b_{t+1}}_{\text{uses}} \leq \underbrace{y_t + R_t b_t}_{\text{sources}} \qquad \text{(budget constraint)}$$

$$b_{t+1} \geq -A \qquad \text{(borrowing constraint)}$$

$$c_t \geq 0 \qquad \text{(non-negativity constraint)}$$

$$b_0 \text{ given} \qquad \text{(initial condition)}$$

$$y_t \text{ and } R_t \text{ given}$$

where $u' > 0, u'' < 0, \lim_{c \to 0} u'(c) = \infty$, $0 < \beta < 1$, A is large.

- What do these equations mean? What's the story behind them?
- What does *partial* equilibrium mean?
- Why $u' > 0, u'' < 0, \lim_{c \to 0} u'(c) = \infty$? Why $0 < \beta < 1$?
- Why $b_{t+1} \geq -A$? What does large mean?

Example in *Partial equilibrium*

The First Order Conditions

$$\boxed{u'(c_t) = \beta R_{t+1} u'(c_{t+1})}$$

- How many such conditions do we have?
- Are these conditions necessary for an optimum? Are they sufficient?
- What about Second Order Conditions?
- Intuitive interpretation as an optimality condition?
- Growth path of c_t. What about its level?
- What do we need for $c_t = c$ for all $t \geq 0$?

Example in *Partial equilibrium*

We need to solve for c_t. Suppose that $R_t = R = 1/\beta$ for all t (so that $c_t = c$). We can iterate the budget constraint forward:

$$b_t = \frac{1}{R}(c + b_{t+1} - y_t)$$

So that

$$b_0 = \frac{c - y_0}{R} + \frac{c - y_1}{R^2} + \frac{c - y_2}{R^3} + \frac{b_3}{R^3} = \sum_{t=0}^{\infty} \frac{c - y_t}{R^{t+1}} + \lim_{t \to \infty} \frac{b_{t+1}}{R^{t+1}}$$

Example in *Partial equilibrium*

We need to solve for c_t. Suppose that $R_t = R = 1/\beta$ for all t (so that $c_t = c$). We can iterate the budget constraint forward:

$$b_t = \frac{1}{R}(c + b_{t+1} - y_t)$$

So that

$$b_0 = \frac{c - y_0}{R} + \frac{c - y_1}{R^2} + \frac{c - y_2}{R^3} + \frac{b_3}{R^3} = \sum_{t=0}^{\infty} \frac{c - y_t}{R^{t+1}} + \lim_{t\to\infty} \frac{b_{t+1}}{R^{t+1}}$$

and therefore

$$c = \underbrace{(1-\beta)}_{\text{Propensity to consume}} \times \underbrace{\left(Rb_0 + \sum_{t=0}^{\infty} \frac{y_t}{R^t} \right)}_{\text{Lifetime income}}$$

- What if y_0 goes up by one unit?
- Is b_t constant over time?
- Does this results depend on the utility function? Why?

Example in *General equilibirum*

A simple economy:

- Pure exchange economy (no firms)
- Two agents who live forever
- Time is discrete $t = 0, 1, 2, ...$
- Each period, agents can trade the unique good (nonstorable). How many commodities are there?

Agent $i \in \{1, 2\}$ has the utility function $(0 < \beta < 1)$:

$$u(c^i) = \sum_{t=0}^{\infty} \beta^t \log(c_t^i)$$

Endowments are given by

$$e_t^1 = \begin{cases} 2 & \text{if } t \text{ is even} \\ 0 & \text{if } t \text{ is odd} \end{cases}$$

$$e_t^2 = \begin{cases} 0 & \text{if } t \text{ is even} \\ 2 & \text{if } t \text{ is odd} \end{cases}$$

Equilibrium

Definition: A competitive (?) Arrow-Debreu (?) equilibrium (?) is a set of prices $\{\hat{p}_t\}_{t=0}^{\infty}$ and allocations $(\{\hat{c}_i^t\}_{t=0}^{\infty})_{i=1,2}$ such that

1. Given $\{\hat{p}_t\}_{t=0}^{\infty}$, for $i = 1, 2$, $\{\hat{c}_i^t\}_{t=0}^{\infty}$ solves

$$\max_{\{c_t^i\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \log(c_t^i)$$

subject to

$$\sum_{t=0}^{\infty} \hat{p}_t c_t^i \leq \sum_{t=0}^{\infty} \hat{p}_t e_t^i$$
$$c_t^i \geq 0 \text{ for all } t$$

2. Market clearing

$$\hat{c}_t^1 + \hat{c}_t^2 = e_t^1 + e_t^2 \text{ for all } t$$

How to solve this model?

First, solve each agent's problem for any prices:

$$\beta^t = p_t c_t^i \lambda \text{ for all } t$$

combining with the budget constraint gives us $c_t^i(\{p_t\}_{t=0}^{\infty}, \{e_t^i\}_{t=0}^{\infty})$.
To find the prices, we use market clearing. In our simple case, the FOC gives

$$p_{t+1}(c_{t+1}^1 + c_{t+1}^2) = \beta p_t (c_t^1 + c_t^2)$$

and, with market clearing:

$$p_{t+1}(e_{t+1}^1 + e_{t+1}^2) = \beta p_t (e_t^1 + e_t^2)$$

So $p_{t+1} = \beta p_t$ and then $p_t = \beta^t p_0$. We can set $p_0 = 1$ (why?).
Therefore the equilibrium prices are $\hat{p}_t = \beta^t$.

How to solve this model?

Since the FOCs gave us $p_{t+1}c^i_{t+1} = \beta p_t c^i_t$ we have that $c^i_{t+1} = c^i_t = c^i_0$.
The values of the endowments are

$$\sum_{t=0}^{\infty} \hat{p}_t e^1_t = 2\sum_{t=0}^{\infty} \beta^{2t} = \frac{2}{1-\beta^2}$$

$$\sum_{t=0}^{\infty} \hat{p}_t e^2_t = 2\beta\sum_{t=0}^{\infty} \beta^{2t} = \frac{2\beta}{1-\beta^2}$$

The equilibrium consumptions are

$$\hat{c}^1_t = \frac{2}{1+\beta} \text{ and } \hat{c}^2_t = \frac{2\beta}{1+\beta}$$

- Who is better off? Why?
- Is trade welfare improving?
- Is the allocation socially optimal?
- What if trade was sequential instead of Arrow-Debreu?