Lecture 3: Macroeconomic Aggregates

See Barro Ch. 2

Trevor Gallen

Spring, 2015

Motivation-I

- We want to know how *everyone* is doing
- This is a *highly* multidimensional object:
  - How is Brendan's happiness? his income? mental health? employment?
  - How is Lakisha's? her income? mental health? employment?
  - ⋮
  - How is Emily's? her income? mental health? employment?
- Want to encode this information concisely.
  - (With some loss of information!)

Motivation-II

- The macroeconomic aggregates are how collapse information
  - GDP: how is the "local" economy doing?
  - GNP: how well are nationals in a country doing?
  - Unemployment: is the labor market functioning well?
  - Inflation: how much money do you have to have in 2015 to be just as happy as in 1985?
  - Before we start, it's natural to ask...are they any good?
  - Maybe you put stock in happiness surveys (N.B.: A priori, this is a terrible idea from my perspective!)

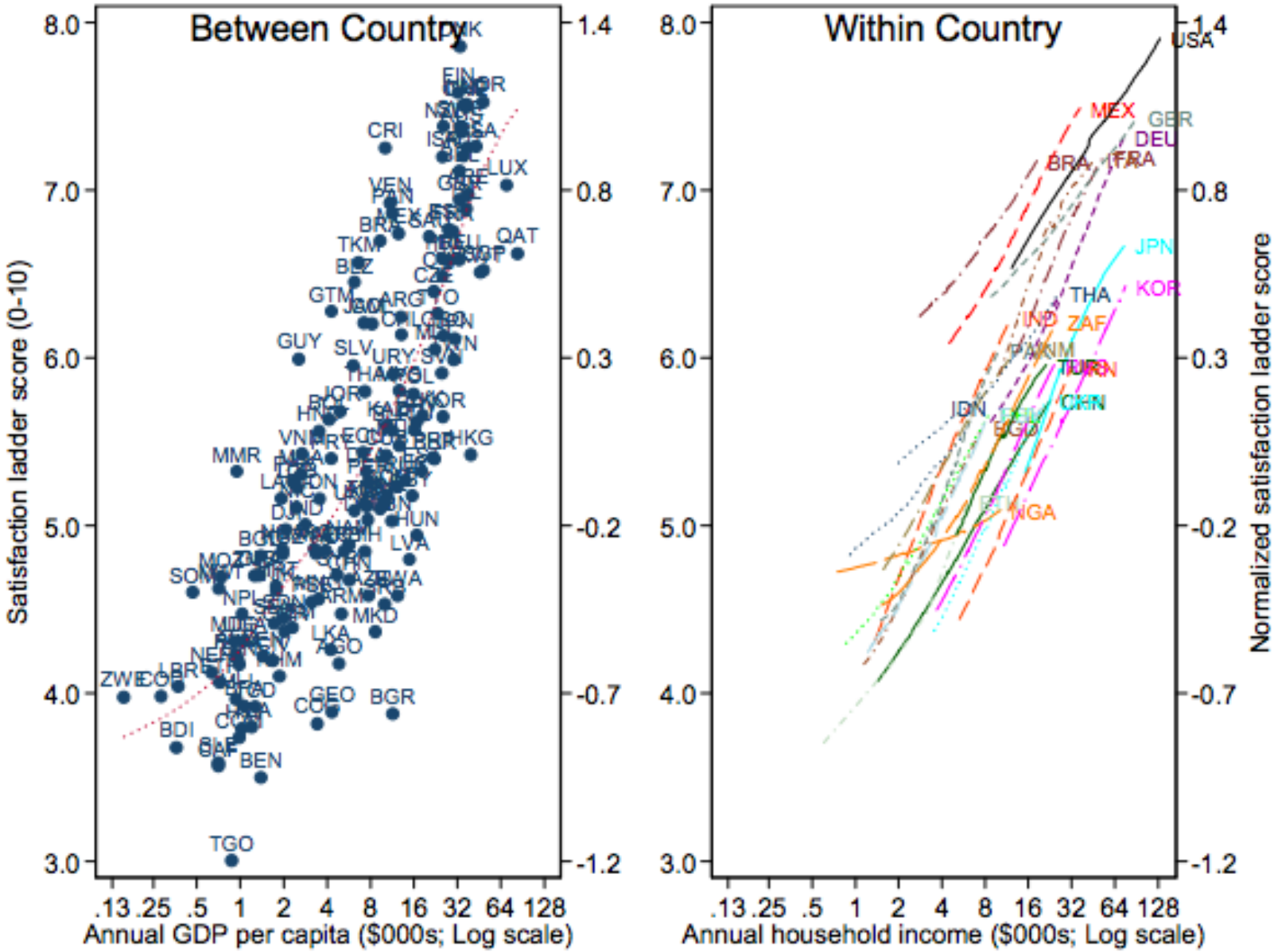
Motivation-II

- The macroeconomic aggregates are how collapse information
  - GDP: how is the "local" economy doing?
  - GNP: how well are nationals in a country doing?
  - Unemployment: is the labor market functioning well?
  - Inflation: how much money do you have to have in 2015 to be just as happy as in 1985?[1]
  - Before we start, it's natural to ask...are they any good?
  - Maybe you put stock in happiness surveys (N.B.: A priori, this is a terrible idea from my perspective!)

[1] Yes, this description is correct to a first-order approximation!

Stevenson & Wolfers, 2008

Figure 1



Nominal and Real GDP-I

- GDP is a flow
- Dollar amount of "final" goods and services **produced** per unit of time

Nominal and Real GDP-I

- GDP is a flow
- Dollar amount of "final" goods and services **produced** per unit of time
  - Why dollars? Aren't they meaningless?

Nominal and Real GDP-I

- GDP is a flow
- Dollar amount of "final" goods and services **produced** per unit of time
  - Why dollars? Aren't they meaningless?
- What's the problem with counting up dollar value of everything *produced?*

Nominal and Real GDP-I

- GDP is a flow
- Dollar amount of "final" goods and services **produced** per unit of time
  - Why dollars? Aren't they meaningless?
- What's the problem with counting up dollar value of everything *produced?*
  - Government production

Nominal and Real GDP-I

- GDP is a flow
- Dollar amount of "final" goods and services **produced** per unit of time
  - Why dollars? Aren't they meaningless?
- What's the problem with counting up dollar value of everything *produced?*
  - Government production
  - Durable goods

Nominal and Real GDP-I

- GDP is a flow
- Dollar amount of "final" goods and services **produced** per unit of time
  - Why dollars? Aren't they meaningless?
- What's the problem with counting up dollar value of everything *produced?*
  - Government production
  - Durable goods
- How do we solve it?

Nominal and Real GDP-I

- GDP is a flow
- Dollar amount of "final" goods and services **produced** per unit of time
  - Why dollars? Aren't they meaningless?
- What's the problem with counting up dollar value of everything *produced?*
  - Government production
  - Durable goods
- How do we solve it?
  - Value government inputs at cost.

Nominal and Real GDP-I

- GDP is a flow
- Dollar amount of "final" goods and services **produced** per unit of time
  - Why dollars? Aren't they meaningless?
- What's the problem with counting up dollar value of everything *produced?*
  - Government production
  - Durable goods
- How do we solve it?
  - Value government inputs at cost.
  - Impute rental value of housing

Nominal and Real GDP-II

- If I sell you a used car, does it count? (Hotseat!)

Nominal and Real GDP-II

- If I sell you a used car, does it count? (Hotseat!)
- If we're trying to add up everything produced, we need to use prices

Nominal and Real GDP-II

- If I sell you a used car, does it count? (Hotseat!)
- If we're trying to add up everything produced, we need to use prices
- But prices change from year to year...aren't we comparing apples and oranges?

Example: Calculating Nominal GDP

- Take a set of N goods

$$\text{NomGDP}_t = \sum_{i=1}^{N} P_{i,t} Q_{i,t}$$

Year	$P_{a,t}$	$P_{b,t}$	$Q_{a,t}$	$Q_{b,t}$	$GDP_{a,t}$	$GDP_{b,t}$	GDP_t
2010	\$1	\$1	1	1	\$1	\$1	\$2
2011	\$1	\$2	1	0.4	\$1	\$0.8	\$1.8
2012	\$2	\$1	0.8	1	\$1.6	\$1	\$2.6
2013	\$2	\$2	1	1	\$2	\$2	\$4
2014	\$2	\$2	0.5	0.5	\$1	\$1	\$2
Eq.	·	·	·	·	$P_{a,t}Q_{a,t}$	$P_{b,t}Q_{b,t}$	$GDP_{a,t}$ $+GDP_{b,t}$

- Why is this troubling?
  - Does 2010 $\rightarrow$ 2012 make sense?
  - Does 2010 $\rightarrow$ 2013 make sense?
  - Does 2010 $\rightarrow$ 2014 make sense?
- How do we fix it?

Example: Calculating GDP in Constant Dollars-I

We'll use 2010 prices (denoted by a bar):

$$\text{RealGDP}_t = \sum_{i=1}^{N} \bar{P}_i Q_{i,t}$$

Year	$P_{a,t}$	$P_{b,t}$	$Q_{a,t}$	$Q_{b,t}$	$GDP_{a,t}$	$GDP_{b,t}$	GDP_t
2010	\$1	\$1	1	1	\$1	\$1	\$2
2011	·	·	1	0.4	\$1	\$0.4	\$1.4
2012	·	·	0.8	1	\$0.8	\$1	\$1.8
2013	·	·	1	1	\$1	\$1	\$2
2014	·	·	0.5	0.5	\$0.5	\$0.5	\$1
Eq.	·	·	·	·	$P_{a,2010} Q_{a,t}$	$P_{b,2010} Q_{b,t}$	$GDP_{a,t} + GDP_{b,t}$

- Does 2010 $\rightarrow$ 2012 make sense now?
- Does 2010 $\rightarrow$ 2013 make sense now?
- Does 2010 $\rightarrow$ 2014 make sense now?

Example: Calculating GDP in Constant Dollars-II

Or use 2014 prices:

Year	$P_{a,t}$	$P_{b,t}$	$Q_{a,t}$	$Q_{b,t}$	$GDP_{a,t}$	$GDP_{b,t}$	GDP_t
2010	·	·	1	1	\$2	\$2	\$4
2011	·	·	1	0.4	\$2	\$0.8	\$2.4
2012	·	·	0.8	1	\$1.6	\$2	\$3.6
2013	·	·	1	1	\$2	\$2	\$4
2014	\$2	\$2	0.5	0.5	\$1	\$1	\$2
Eq.	·	·	·	·	$P_{a,2014}\,Q_{a,t}$	$P_{b,2014}\,Q_{b,t}$	$GDP_{a,t}$ $+GDP_{b,t}$

- Does 2010 $\rightarrow$ 2012 make sense now?
- Does 2010 $\rightarrow$ 2013 make sense now?
- Does 2010 $\rightarrow$ 2014 make sense now?

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?
- Choice of base year can be incredibly important

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?
- Choice of base year can be incredibly important
- We can improve on this with chain-weighted GDP

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?
- Choice of base year can be incredibly important
- We can improve on this with chain-weighted GDP

    1. Get average price between two years for each good:
    $\bar{P}_a = \frac{P_{a,t}+P_{a,t+1}}{2}$, $\bar{P}_b = \frac{P_{b,t}+P_{b,t+1}}{2}$

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?
- Choice of base year can be incredibly important
- We can improve on this with chain-weighted GDP

1. Get average price between two years for each good: $\bar{P}_a = \frac{P_{a,t}+P_{a,t+1}}{2}$, $\bar{P}_b = \frac{P_{b,t}+P_{b,t+1}}{2}$
2. Find the new GDP component for each good: $Q_{a,t}\bar{P}_a + Q_{b,t}\bar{P}_b$ and $Q_{a,t+1}\bar{P}_a + Q_{b,t+1}\bar{P}_b$

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?
- Choice of base year can be incredibly important
- We can improve on this with chain-weighted GDP

1. Get average price between two years for each good: $\bar{P}_a = \frac{P_{a,t}+P_{a,t+1}}{2}$, $\bar{P}_b = \frac{P_{b,t}+P_{b,t+1}}{2}$
2. Find the new GDP component for each good: $Q_{a,t}\bar{P}_a + Q_{b,t}\bar{P}_b$ and $Q_{a,t+1}\bar{P}_a + Q_{b,t+1}\bar{P}_b$
3. Find the percentage difference between the two: $\frac{Q_{a,t+1}\bar{P}_a+Q_{b,t+1}\bar{P}_b}{Q_{a,t}\bar{P}_a+Q_{b,t}\bar{P}_b}$

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?
- Choice of base year can be incredibly important
- We can improve on this with chain-weighted GDP

1. Get average price between two years for each good: $\bar{P}_a = \frac{P_{a,t}+P_{a,t+1}}{2}$, $\bar{P}_b = \frac{P_{b,t}+P_{b,t+1}}{2}$
2. Find the new GDP component for each good: $Q_{a,t}\bar{P}_a + Q_{b,t}\bar{P}_b$ and $Q_{a,t+1}\bar{P}_a + Q_{b,t+1}\bar{P}_b$
3. Find the percentage difference between the two: $\frac{Q_{a,t+1}\bar{P}_a+Q_{b,t+1}\bar{P}_b}{Q_{a,t}\bar{P}_a+Q_{b,t}\bar{P}_b}$
4. This gives the ratio of chain-weighted GDP, the growth, but doesn't give us a level

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?
- Choice of base year can be incredibly important
- We can improve on this with chain-weighted GDP

1. Get average price between two years for each good: $\bar{P}_a = \frac{P_{a,t}+P_{a,t+1}}{2}$, $\bar{P}_b = \frac{P_{b,t}+P_{b,t+1}}{2}$
2. Find the new GDP component for each good: $Q_{a,t}\bar{P}_a + Q_{b,t}\bar{P}_b$ and $Q_{a,t+1}\bar{P}_a + Q_{b,t+1}\bar{P}_b$
3. Find the percentage difference between the two: $\frac{Q_{a,t+1}\bar{P}_a+Q_{b,t+1}\bar{P}_b}{Q_{a,t}\bar{P}_a+Q_{b,t}\bar{P}_b}$
4. This gives the ratio of chain-weighted GDP, the growth, but doesn't give us a level
5. Choose an arbitrary level

Chain-Weighted GDP

- What's the problem with using "constant dollars" GDP?
- Choice of base year can be incredibly important
- We can improve on this with chain-weighted GDP

  1. Get average price between two years for each good: $\bar{P}_a = \frac{P_{a,t}+P_{a,t+1}}{2}$, $\bar{P}_b = \frac{P_{b,t}+P_{b,t+1}}{2}$
  2. Find the new GDP component for each good: $Q_{a,t}\bar{P}_a + Q_{b,t}\bar{P}_b$ and $Q_{a,t+1}\bar{P}_a + Q_{b,t+1}\bar{P}_b$
  3. Find the percentage difference between the two: $\frac{Q_{a,t+1}\bar{P}_a+Q_{b,t+1}\bar{P}_b}{Q_{a,t}\bar{P}_a+Q_{b,t}\bar{P}_b}$
  4. This gives the ratio of chain-weighted GDP, the growth, but doesn't give us a level
  5. Choose an arbitrary level

- Note: this is slightly simpler than what we actually do. See online notes for details.

Example: Chain-Weighted GDP

Year	$P_{a,t}$	$P_{b,t}$	$Q_{a,t}$	$Q_{b,t}$	$\frac{GDP_t}{GDP_{t-1}}$	GDP_t
2010	\$1	\$1	1	1	·	100
2011	\$1	\$2	1	0.4	0.64	64
2012	\$2	\$1	0.8	1	1.29	82.6
2013	\$2	\$2	1	1	1.13	93.3
2014	\$2	\$2	0.5	0.5	0.5	46

- We now have the relative change in GDP between each period.
- Chain them together and choose an arbitrary starting point

Problems with GDP

- GDP isn't perfect.
- Doesn't measure changes in income distribution
- Doesn't measure non-market goods, such as childcare
- Doesn't measure leisure
- Nevertheless, it seems to be quite important and correlates with things we think are correlated with welfare (health, mental health, happiness, mortality)
    - Recall our previous discussion of causality!

Measuring GDP

- GDP is measured three different ways
- First, recall that every dollar spent is a dollar "earned"
  - All goods purchased by households ("expenditure")
  - All goods produced by firms ("value added")
  - All income earned by entities ("income")
- All three should add up to the same thing

Measuring GDP: Expenditure

$$Y = C + I + G + X - Im$$

- Consumption-purchases for consumption by HH's
  - Nondurable goods
  - Durable goods
- Investment-purchases of new capital goods by businesses (not financial instruments!)
- Government expenditure and gross investment-government purchases and "investment"
  - Does include expenditures of all levels of government!
  - Does *not* include all government *spending*!
- Net Exports-Value of what we send out minus what we bring in
- Note that things fall apart, depreciate: net domestic product, $NDP = GDP -$depreciation.

Measuring GDP: Income Approach

- Rather than measuring final good consumption, could measure income
- For every dollar paid in for the final good, one is paid out
- In the end, all payments go to compensation of employees, proprietors, capital, or taxes: add it all up by recipient

Measuring GDP: Value-Added Approach

- Income approach measured income by group
- We could instead measure net income by sector/firm
- In the end, firm gets the difference between what you sold it for and the raw goods you purchased (the value added)

GDP, GDI, Value-Added

Table: Corn and Cornbread's Contribution to GDP

Step	Input Cost	Gross Revenue	Net Revenue
Farmer→Miller	$0	$0.10	$0.10
Miller→Baker	$0.10	$1	$0.90
Baker→Supermarket	$1	$10	$9
Supermarket→ Household	$10	*$11*	$1

Two ways

$$\underbrace{C + I + G + X - M}_{Outflows} = Y = \underbrace{wL + \pi + rK + T}_{Inflows}$$

Failures of GDP

- What are some failures of GDP?

Failures of GDP

- What are some failures of GDP?
  - No measures of distribution

Failures of GDP

- What are some failures of GDP?
  - No measures of distribution
  - Only what we measure (black market)

Failures of GDP

- What are some failures of GDP?
  - No measures of distribution
  - Only what we measure (black market)
  - No measure of leisure time or household production

Failures of GDP

- What are some failures of GDP?
  - No measures of distribution
  - Only what we measure (black market)
  - No measure of leisure time or household production
  - No measure of nonmonetary production like environmental goods

Aside on Exponential Growth-I

- Let's say something is continuously exponentially growing:

$$Y_t = \bar{Y} \exp(\gamma t)$$

Then:

$$\begin{aligned} Y_t &= \bar{Y} \exp(\gamma t) \\ \log(Y_t) &= \log(\bar{Y} \exp(\gamma t)) \\ &= \log(\bar{Y}) + \log(\exp(\gamma t)) \\ &= \log(\bar{Y}) + \gamma \cdot t \end{aligned}$$

- So logging an exponential object with growth rate ("frequency" γ) turns it into a linear function with slope γ.

Aside on Exponential Growth-I

- Let's say something is continuously exponentially growing:

$$Y_t = \bar{Y} \exp(\gamma t)$$

Then:

$$\begin{aligned} Y_t &= \bar{Y} \exp(\gamma t) \\ \log(Y_t) &= \log(\bar{Y} \exp(\gamma t)) \\ &= \log(\bar{Y}) + \log(\exp(\gamma t)) \\ &= \underbrace{\log(\bar{Y})}_{\text{intercept}} + \underbrace{\gamma}_{\text{slope}} \cdot \underbrace{t}_{\text{variable}} \end{aligned}$$

- So logging an exponential object with growth rate ("frequency" γ) turns it into a linear function with slope γ.

Aside on Exponential Growth-II

- Let's say something is discretely exponentially growing:

$$Y_t = Y_{t-1}(1+\gamma)$$

Then:

$$\begin{aligned}
Y_t &= Y_{t-1}(1+\gamma) \\
&= Y_{t-2}(1+\gamma)(1+\gamma) \\
&= Y_{t-2}(1+\gamma)^2 \\
&= Y_0(1+\gamma)^t \\
\log(Y_t) &= \log(Y_0(1+\gamma)^t) \\
&= \log(Y_0) + \log((1+\gamma)^t) \\
&= \log(Y_0) + t\log((1+\gamma)) \\
&\approx \log(Y_0) + \quad \gamma \quad \cdot \quad t
\end{aligned}$$

- So logging an exponential object with growth rate ("frequency" γ) turns it into a linear function with slope γ.

Aside on Exponential Growth-II

- Let's say something is discretely exponentially growing:

$$Y_t = Y_{t-1}(1+\gamma)$$

Then:

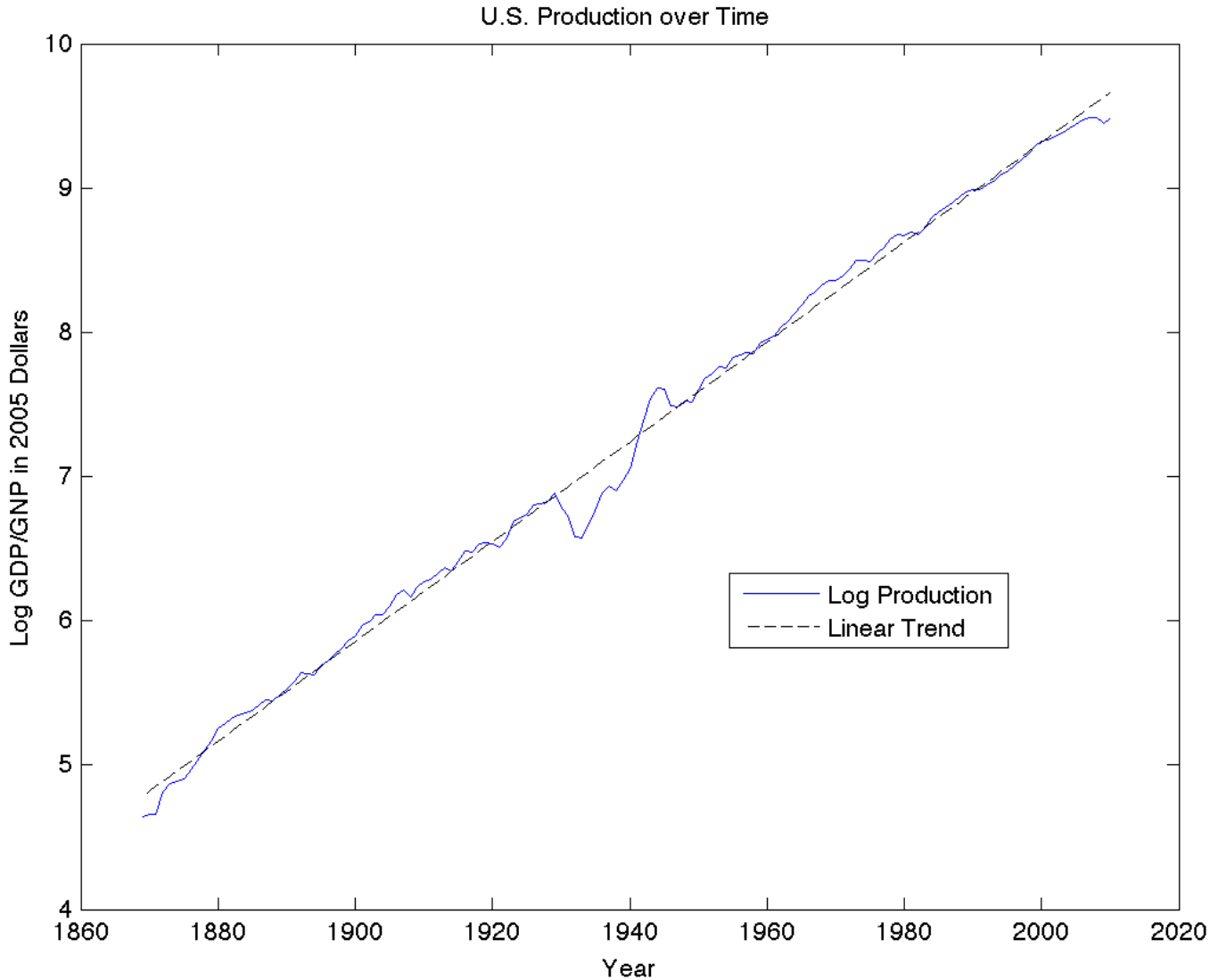
$$\begin{aligned}
Y_t &= Y_{t-1}(1+\gamma) \\
&= Y_{t-2}(1+\gamma)(1+\gamma) \\
&= Y_{t-2}(1+\gamma)^2 \\
&= Y_0(1+\gamma)^t \\
\log(Y_t) &= \log(Y_0(1+\gamma)^t) \\
&= \log(Y_0) + \log((1+\gamma)^t) \\
&= \log(Y_0) + t\log((1+\gamma)) \\
&\approx \underbrace{\log(Y_0)}_{\text{intercept}} + \underbrace{\gamma}_{\text{slope}} \cdot \underbrace{t}_{\text{variable}}
\end{aligned}$$

- So logging an exponential object with growth rate ("frequency" γ) turns it into a linear function with slope γ.

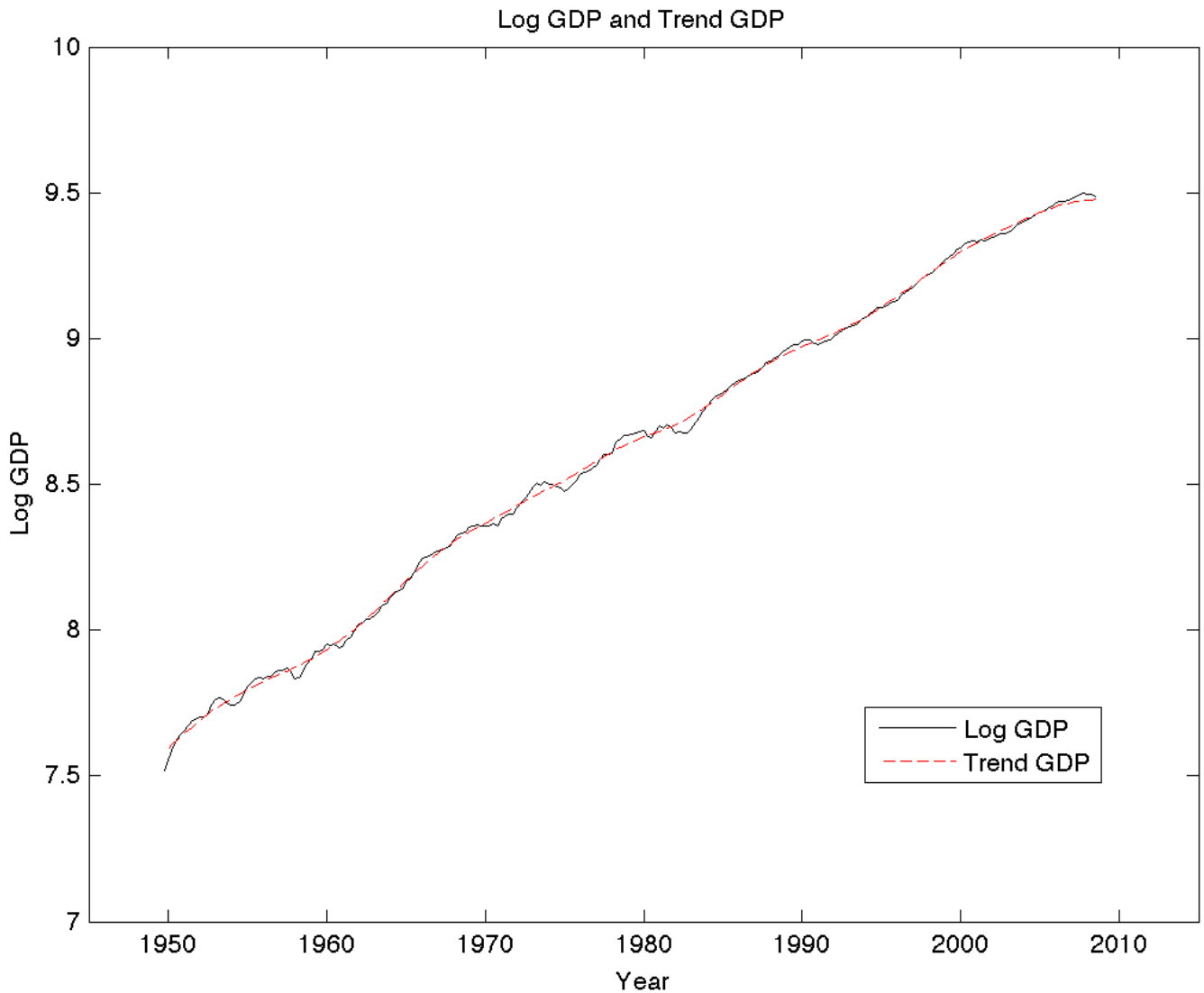
Aside on Exponential Growth-III

- For those of you who are dubious, recall that when x is small, $1 + x$ is near 1.
- When log is evaluated near 1, it's nearly linear
- You can see the same thing from a first-order taylor expansion

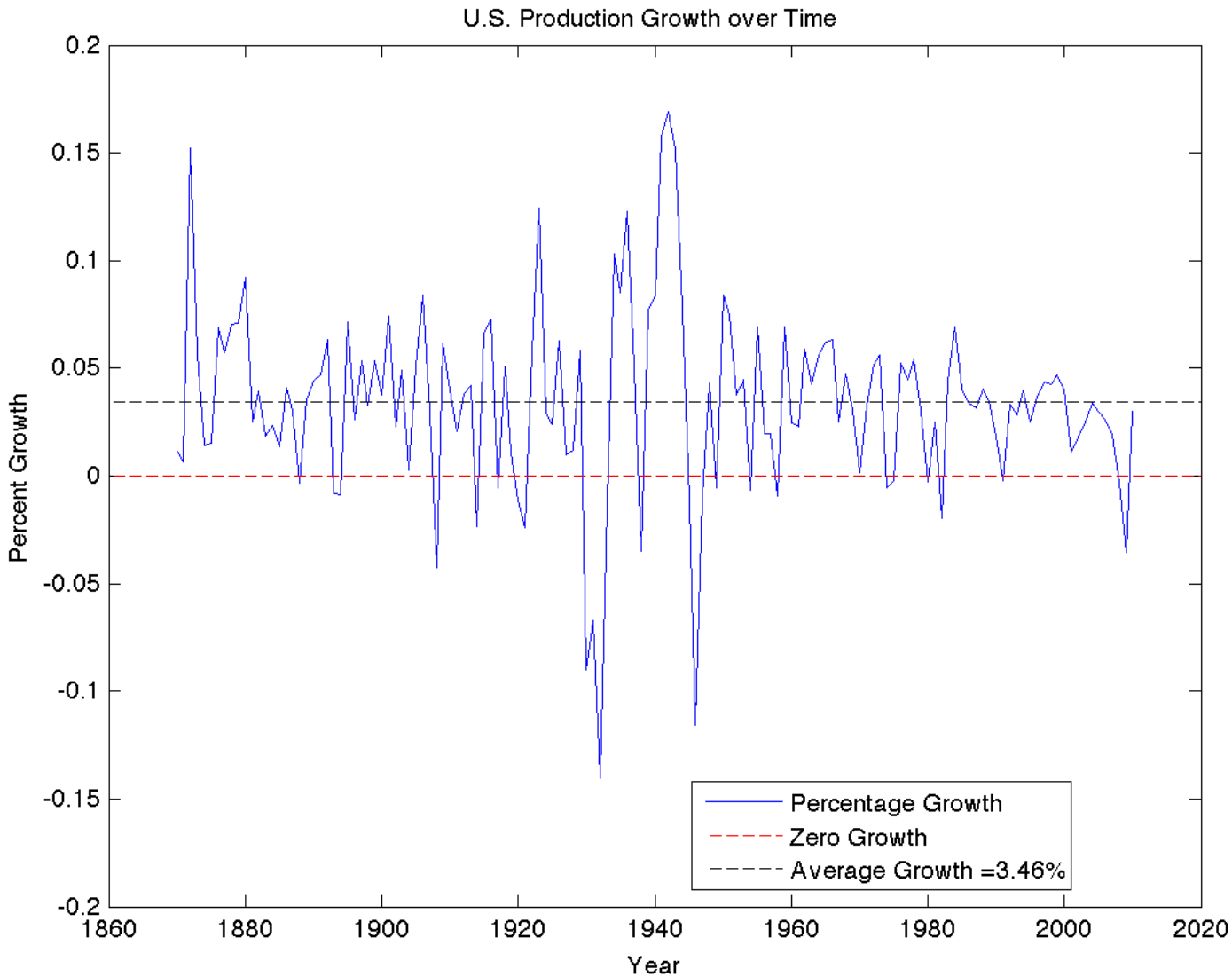
U.S. GDP over Time: Historical Yearly Series



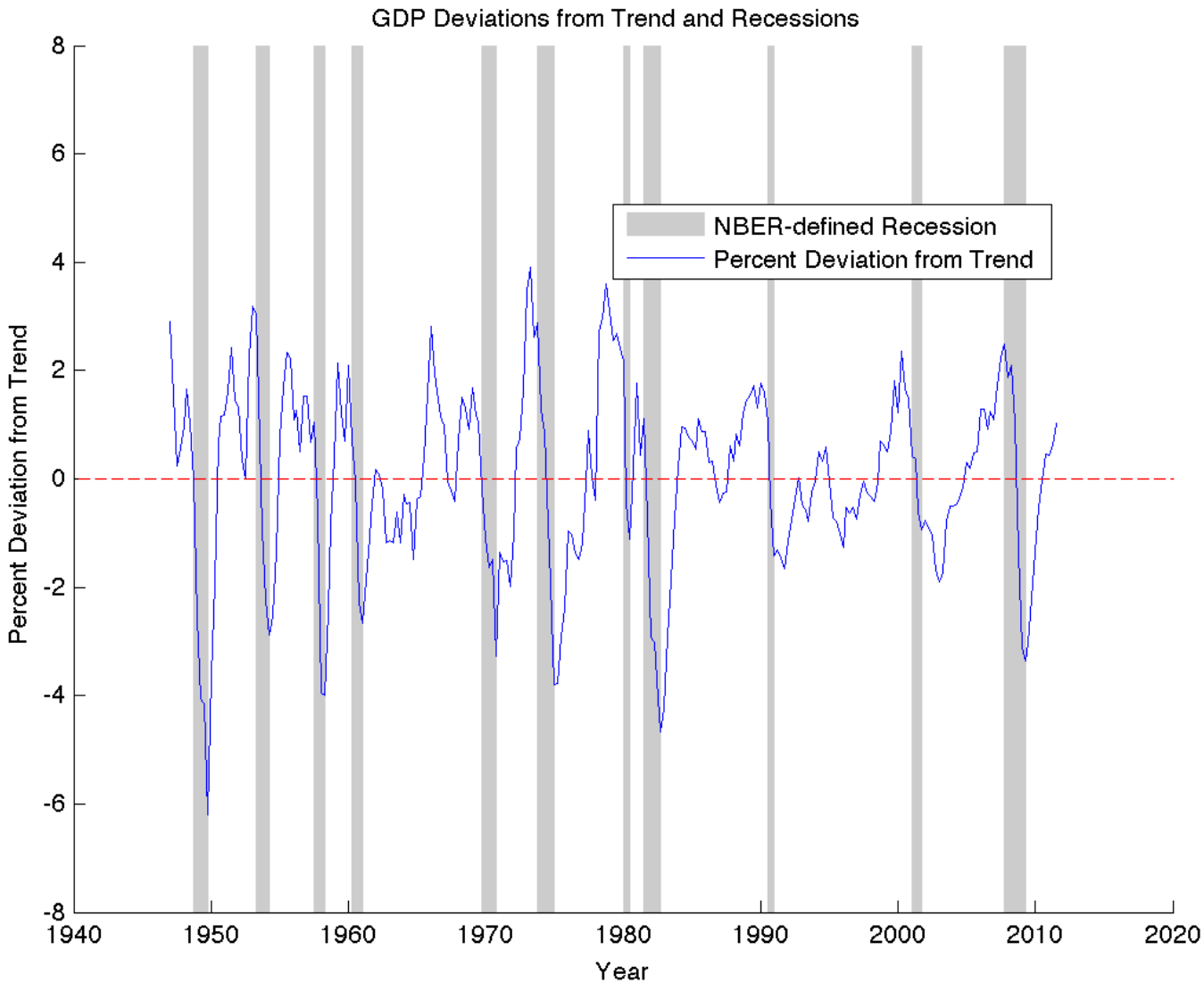
U.S. GDP over Time: NIPA Quarterly



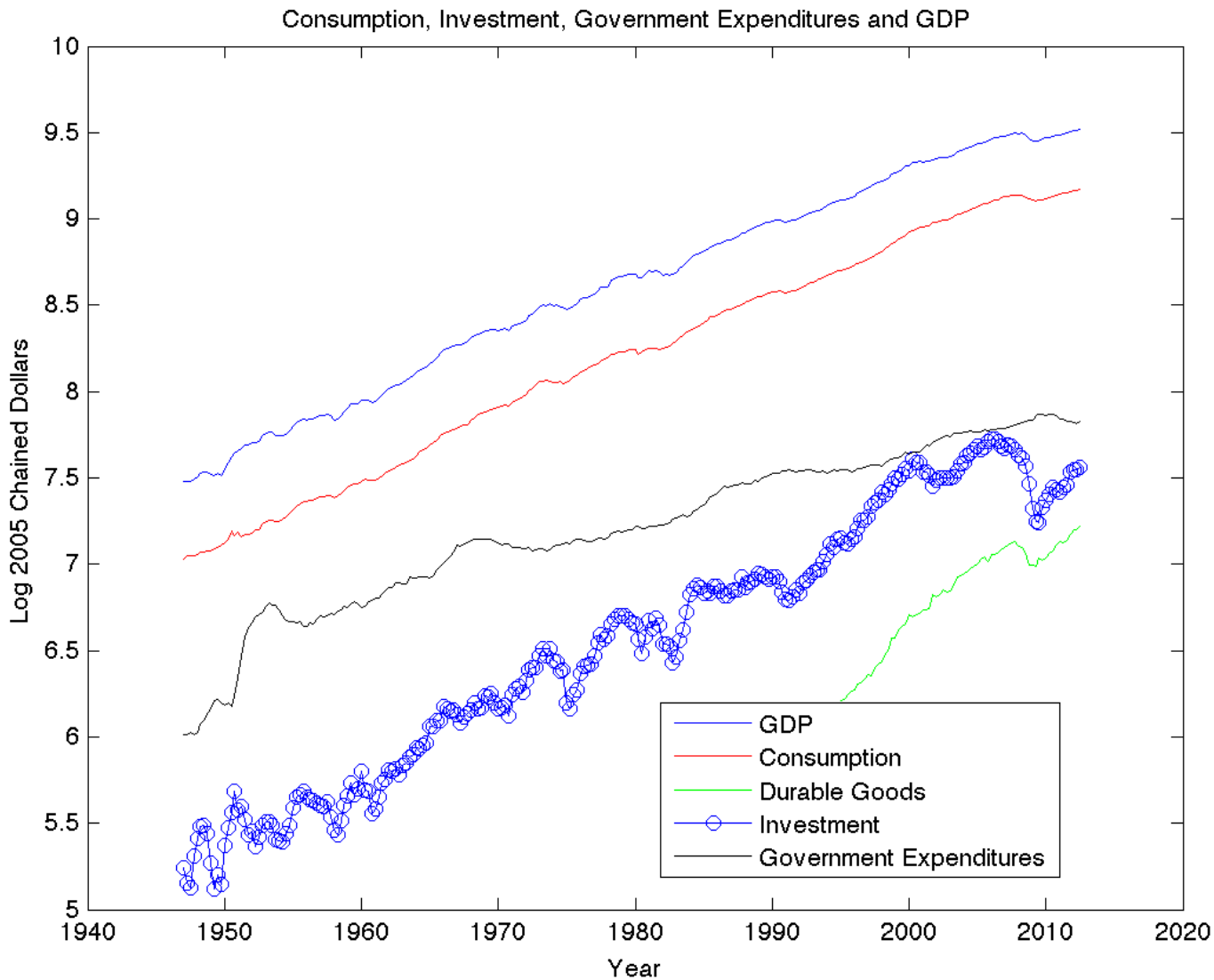
U.S. GDP over Time: Growth Rate (Quarterly)



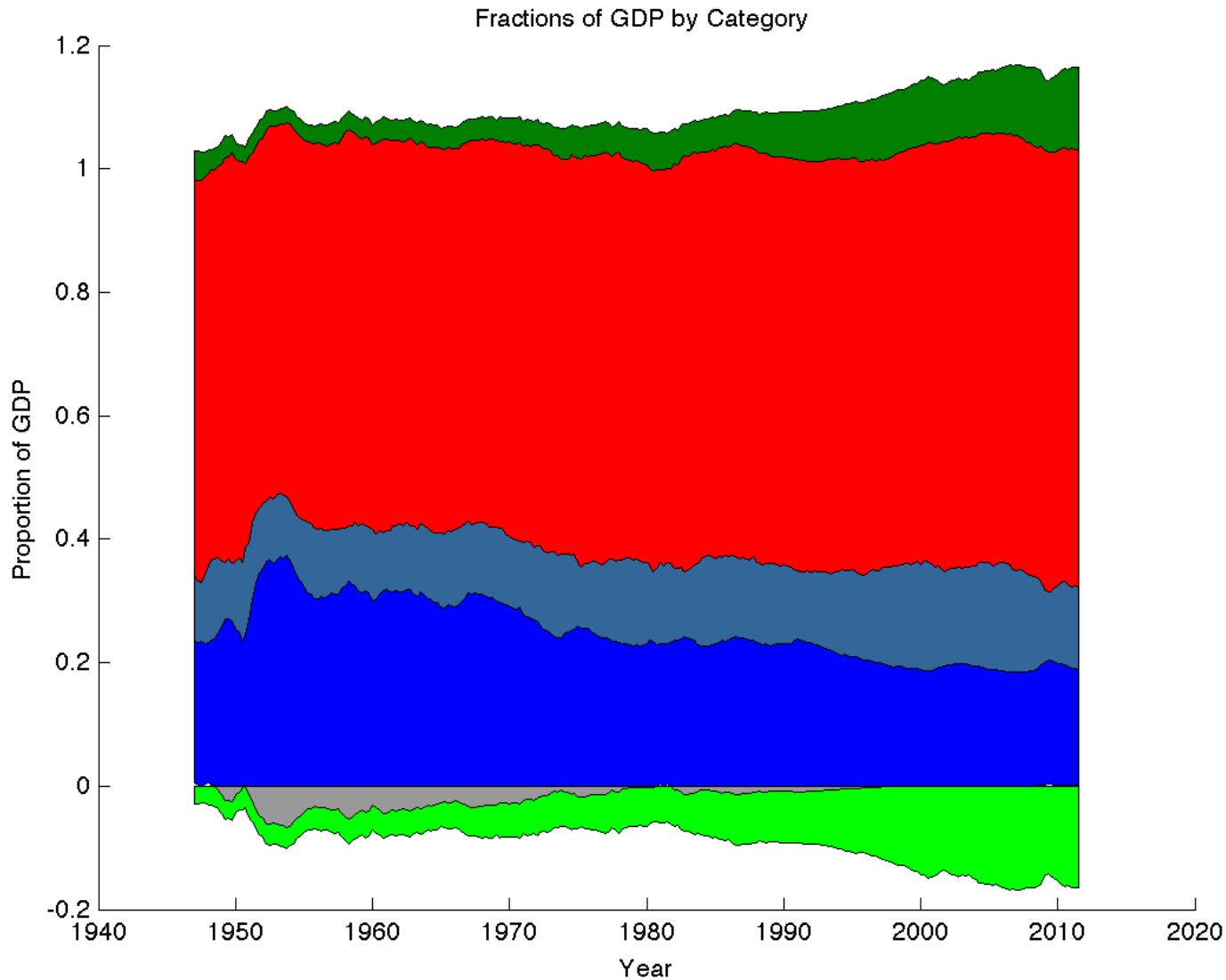
U.S. GDP over Time: Growth Rate (Quarterly)



Components of U.S. GDP over Time



Components of U.S. GDP over Time



Can you figure out which color is what category?

Components of U.S. GDP over Time: Legend

- Red is consumption: it's the biggest and is quite smooth
- Gray-blue is investment, and is quite volatile for its size
- Light blue is government consumption and investment...note the trend
- Light green is imports, they weren't produced in U.S. but were consumed so we take them out
- Dark green is exports, they were produced in U.S. but weren't consumed, so we keep them in
- Dark gray is a statistical error

Components of U.S. GDP over Time: Legend

- Red is consumption: it's the biggest and is quite smooth
- Gray-blue is investment, and is quite volatile for its size
- Light blue is government consumption and investment...note the trend (?)
- Light green is imports, they weren't produced in U.S. but were consumed so we take them out
- Dark green is exports, they were produced in U.S. but weren't consumed, so we keep them in
- Dark gray is a statistical error

Inflation

- Inflation is measured by a basket of goods
- It's the flipside of the nominal vs. real GDP discussion above
- We have a few baskets to care about:
  - Basket of goods and services produced domestically: GDP Deflator
  - Basket of goods and services consumed by households: Consumer Price Index
  - Basket of goods consumed by "producers" (no services, primarily raw materials and intermediate goods): Producer Price Index
- Let's see what they look like

Misstated Inflation

- It is generally accepted by economists that inflation is misstated

Misstated Inflation

- It is generally accepted by economists that inflation is misstated
- It is frequently asserted by non-economists that inflation is misstated

Misstated Inflation

- It is generally accepted by economists that inflation is misstated
- It is frequently asserted by non-economists that inflation is misstated
- We typically think that measured inflation is *too high* [sic]

Misstated Inflation

- It is generally accepted by economists that inflation is misstated
- It is frequently asserted by non-economists that inflation is misstated
- We typically think that measured inflation is *too high* [sic]
- Why?

Misstated Inflation

- It is generally accepted by economists that inflation is misstated
- It is frequently asserted by non-economists that inflation is misstated
- We typically think that measured inflation is *too high* [sic]
- Why?
  - Substitution bias

Misstated Inflation

- It is generally accepted by economists that inflation is misstated
- It is frequently asserted by non-economists that inflation is misstated
- We typically think that measured inflation is *too high* [sic]
- Why?
  - Substitution bias
  - Quality improvements

Misstated Inflation

- It is generally accepted by economists that inflation is misstated
- It is frequently asserted by non-economists that inflation is misstated
- We typically think that measured inflation is *too high* [sic]
- Why?
  - Substitution bias
  - Quality improvements
- Gallen's Theorem: Stated inflation *must* be too high, because Social Security is indexed to it.

Misstated Inflation

- It is generally accepted by economists that inflation is misstated
- It is frequently asserted by non-economists that inflation is misstated
- We typically think that measured inflation is *too high* [sic]
- Why?
  - Substitution bias
  - Quality improvements
- Gallen's Theorem: Stated inflation *must* be too high, because Social Security is indexed to it.
- Proof by contradiction: I could find no photos of old people rioting in the streets

Misstated Inflation

- The BLS makes its price data available to researchers, rougher data to public

Misstated Inflation

- The BLS makes its price data available to researchers, rougher data to public
- Others make their own price indicies from scanner data

Misstated Inflation

- The BLS makes its price data available to researchers, rougher data to public
- Others make their own price indicies from scanner data
- Still others get their data from online

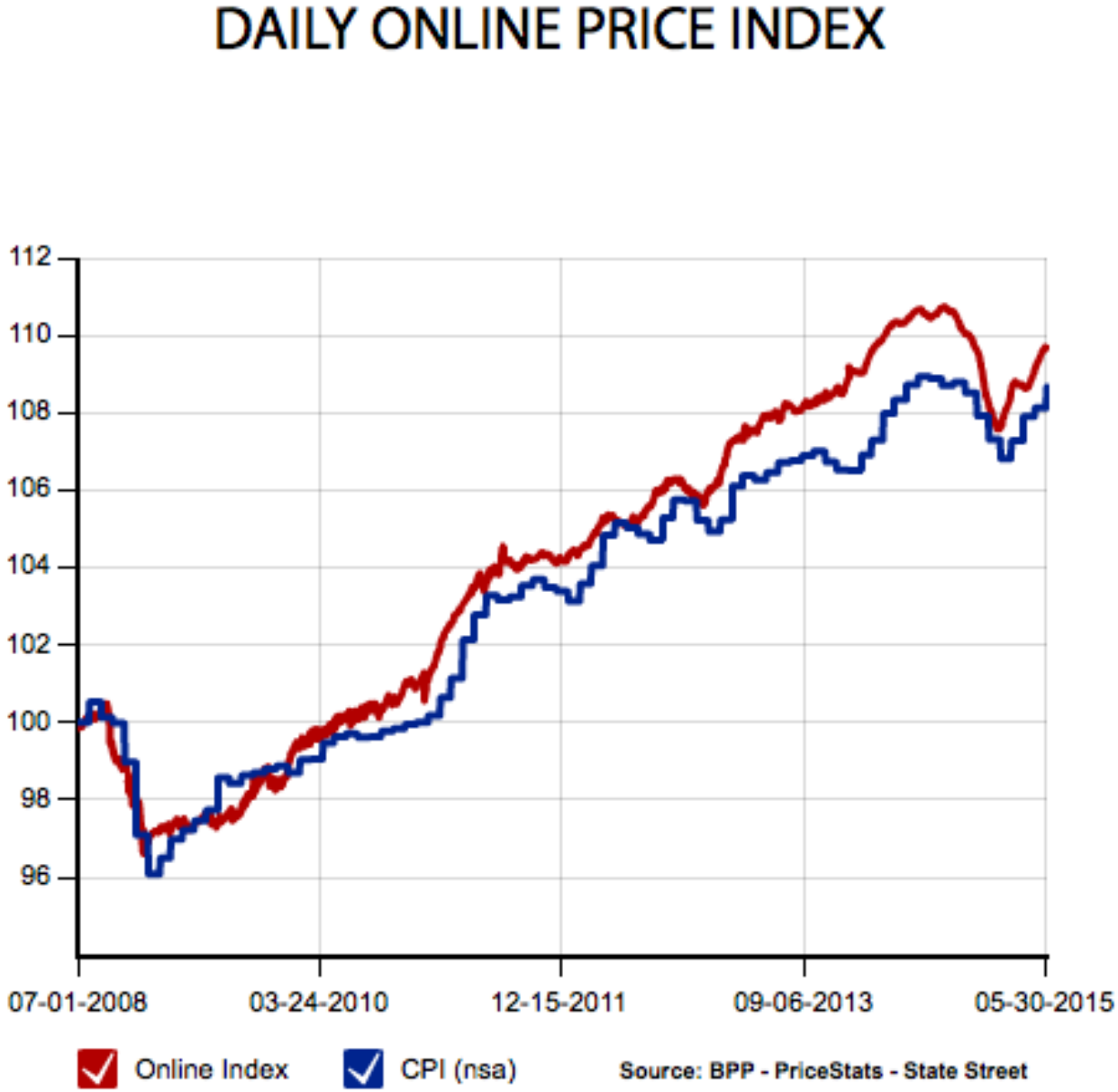
Misstated Inflation

- The BLS makes its price data available to researchers, rougher data to public
- Others make their own price indicies from scanner data
- Still others get their data from online
- General result: it's all fairly similar, some say it overstates, some it understates

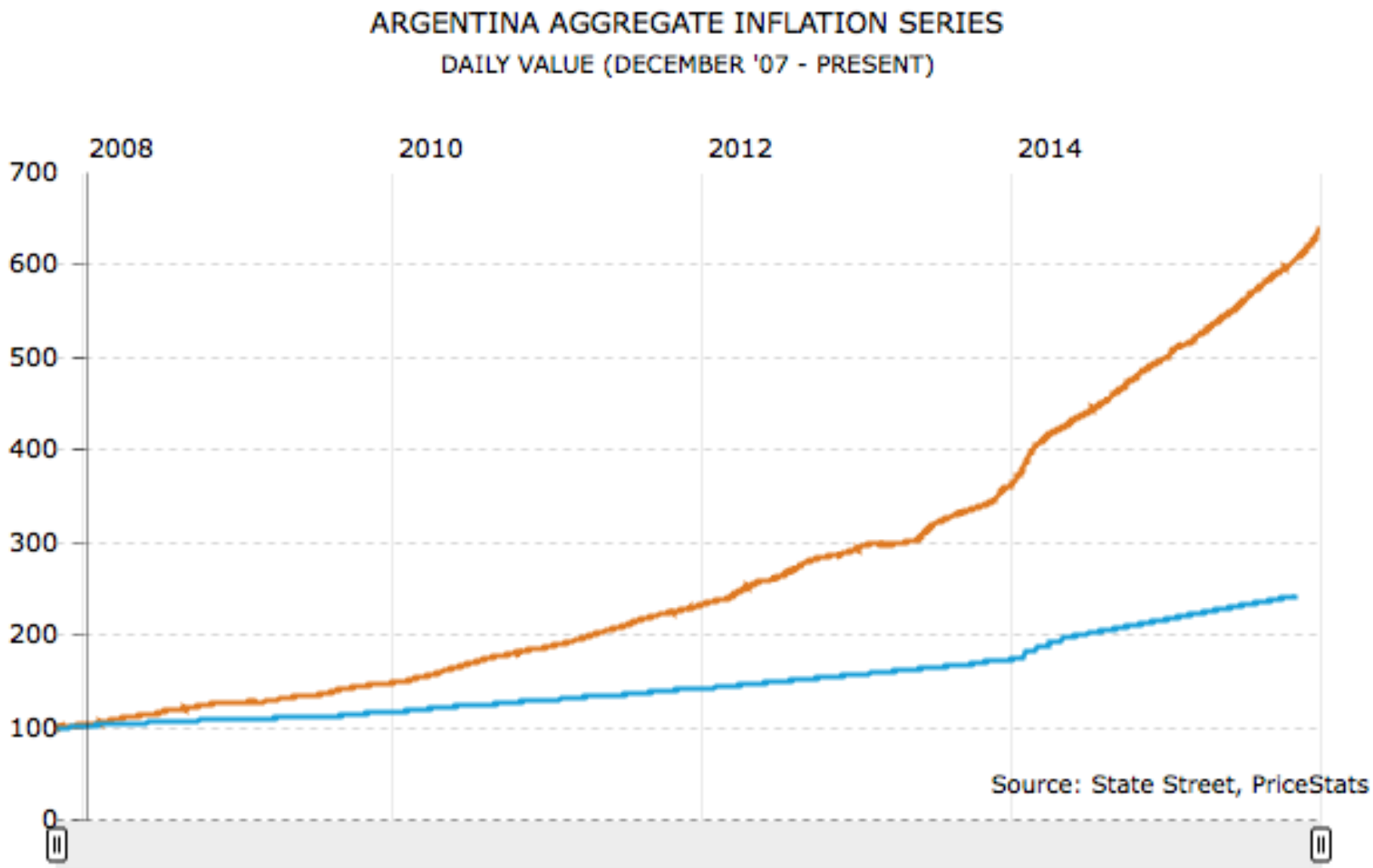
Misstated Inflation

- The BLS makes its price data available to researchers, rougher data to public
- Others make their own price indicies from scanner data
- Still others get their data from online
- General result: it's all fairly similar, some say it overstates, some it understates
- In some instances, it suggests that inflation is misstated by about 15% per year (??)

Misstated Inflation



Misstated Inflation



Misstated Inflation

Unemployment

- U-1: persons unemployed 15 weeks or longer, as a percent of the civilian labor force
- U-2: job losers and persons who completed temporary jobs, as a percent of the civilian labor force
- U-3: total unemployed, as a percent of the civilian labor force
- U-4: total unemployed plus discouraged workers, as a percent of the civilian labor force plus discouraged workers
- U-5: total unemployed, plus discouraged workers, plus all other marginally attached workers, as a percent of the civilian labor force plus all marginally attached workers
- U-6: total unemployed, plus all marginally attached workers, plus total employed part time for economic reasons, as a percent of the civilian labor force plus all marginally attached workers

Unemployment Rates