Chapter 6

A Real Business Cycle Model

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General Equilibrium

- So far, we've only discussed partial equilibrium (PE)
  - Instance where not all markets clear

- **General equilibrium (GE)** is when all markets clear
  - Labor market effects goods market, which has feedback effects in the labor market…

Studying Economic Movements

- One approach to study short run movements is through **Real Business Cycle (RBC) Models**

- The most basic models assume flexible prices and study responses to changes from real variables

A Bit of Modern History

- RBC models were born out of addressing supply and inflation issues in the 1970's

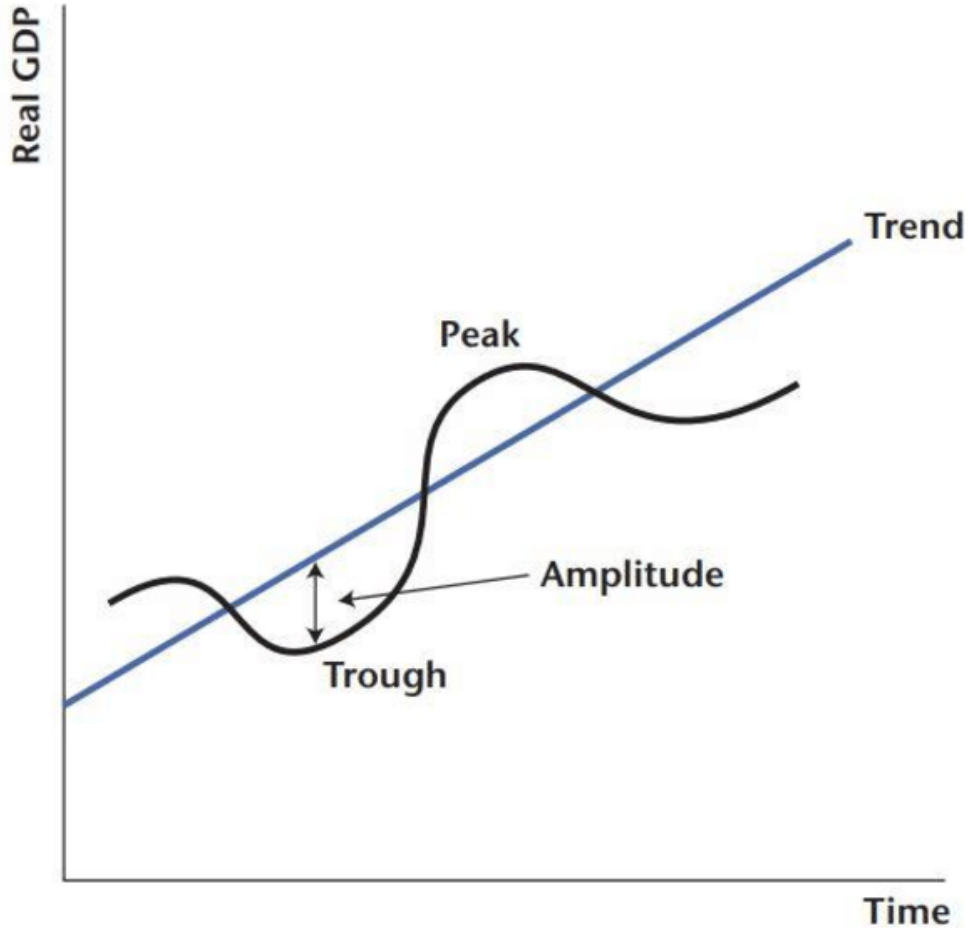
- RBC models built in more microfoundations to study output movements
  - Rely on expectations to study complicated dynamics
  - Remember the motivations discussed in Ch. 1

General RBC Model Outline

- RBC models are mainly used to study business cycles
  - Data is collected and filtered to remove the "trend" component
  - A model is written down based on micro theory
  - The model is **calibrated** to match data
    - Setting values for parameter (e.g. $\delta = 0.07$)
  - Model simulations are compared to real world data

- If the model is successful, it can be used to test counterfactuals
  - "What would happen if the government did this instead?"

A Typical Business Cycle



Williamson, Stephen D. *Macroeconomics.* 6th ed. Pearson Education Inc., 2016. Figure 3.1

Comovements with GDP

- Many variables correlate with GDP:
  - **Procyclical** variables increase with GDP
  - **Countercyclical** variables decrease with GDP
  - **Acyclical** variables have no correlation with GDP

- Depending on the timing, they can be:
  - **Leading:** rise/fall before GDP
  - **Lagging:** rise/fall after GDP
  - **Coinciding:** rise/fall around the same time as GDP

Comovements with GDP: Examples

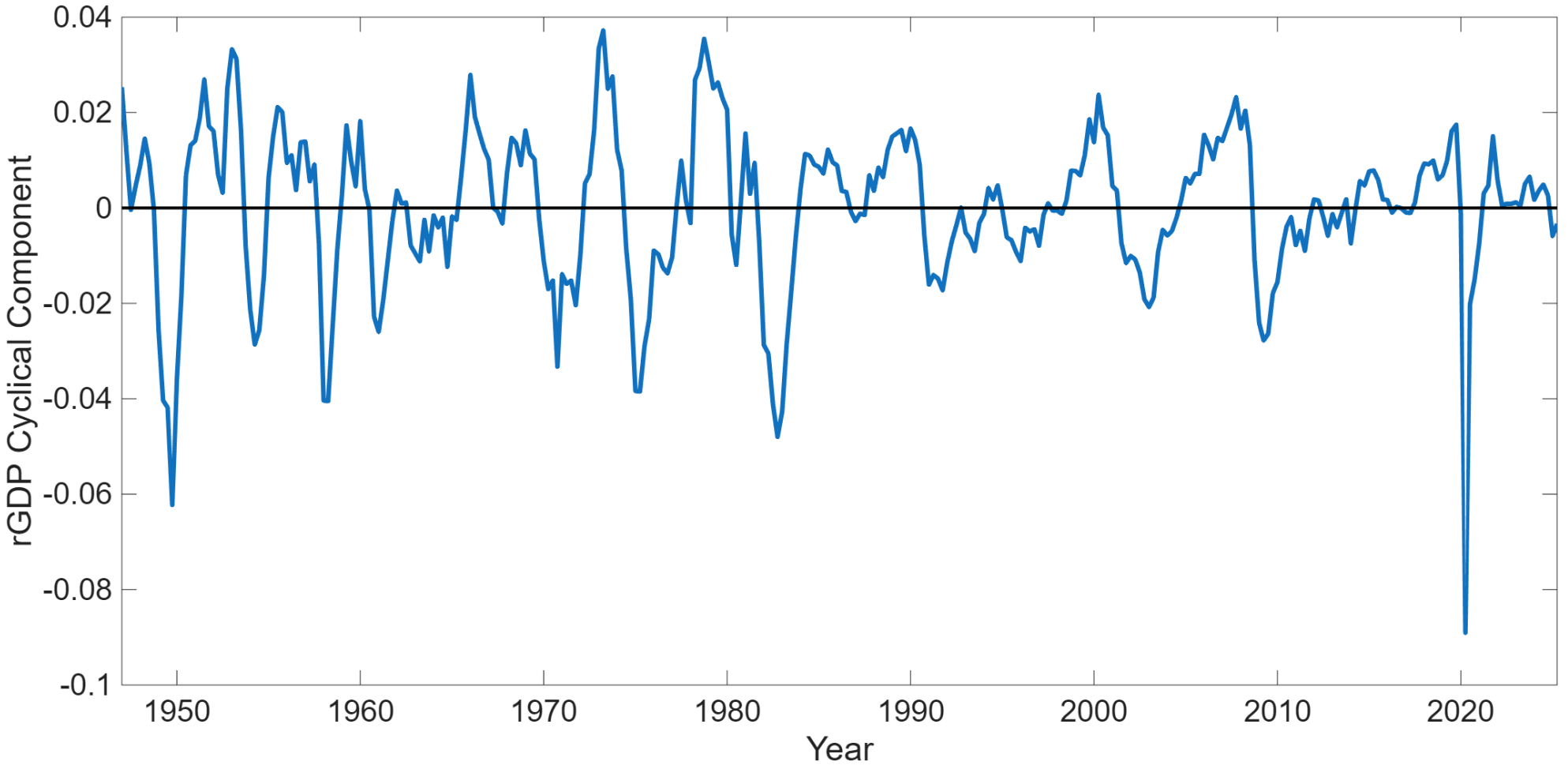
Variable	Cyclicality	Timing	Variable	Cyclicality	Timing
Consumption	Procyclical	Coinciding	**Labor hours**	Procyclical	Coinciding
Investment	Procyclical	Coinciding	**Final Sales**	Procyclical	Coinciding
Equipment	Procyclical	Lagging	**Net Inventory Investment**	Procyclical	Coinciding
Nonresidential Structures	Pro/Acyclical	Lagging	**Real Wage**	Procyclical	-
Residential Structrues	Procyclical	Leading	**Money Supply**	Procyclical	Leading
Consumer Durables	Procyclical	Coinciding	**Inflation**	Procyclical	Lagging
Government	Acyclical	-	**Nominal Interest Rate**	Procyclical	Lagging
Net Exports	Counter/Acyclical	-	**Real Interest Rate**	Acyclical	-
Exports	Acyclical	-	**Stock Prices**	Procyclical	Leading
Imports	Procyclical	Lagging			

Quantities Sample: US NIPA 1954Q1-2009Q3 (BEA Nov. 2009) , hours data 1954Q1-2009Q3 from CPS (Cociuba et al Novemb detrended with Hodrick-Precott filter using a weight of 1600. All data are in logs, except net exports and net inventory investment which are shares of GDP. Correlations are contemporaneous correlations with log real GDP.

Filtering Data

- Because we're concerned with deviations from trend, we need to filter out the trend
  - Ex: GDP is trending up since industrial revolution
  - Want to see fluctuations *around* this trend
  - Use **Hodrick–Prescott (HP) Filter** **(Hodrick & Prescott, 1997)**

Filtered Movements



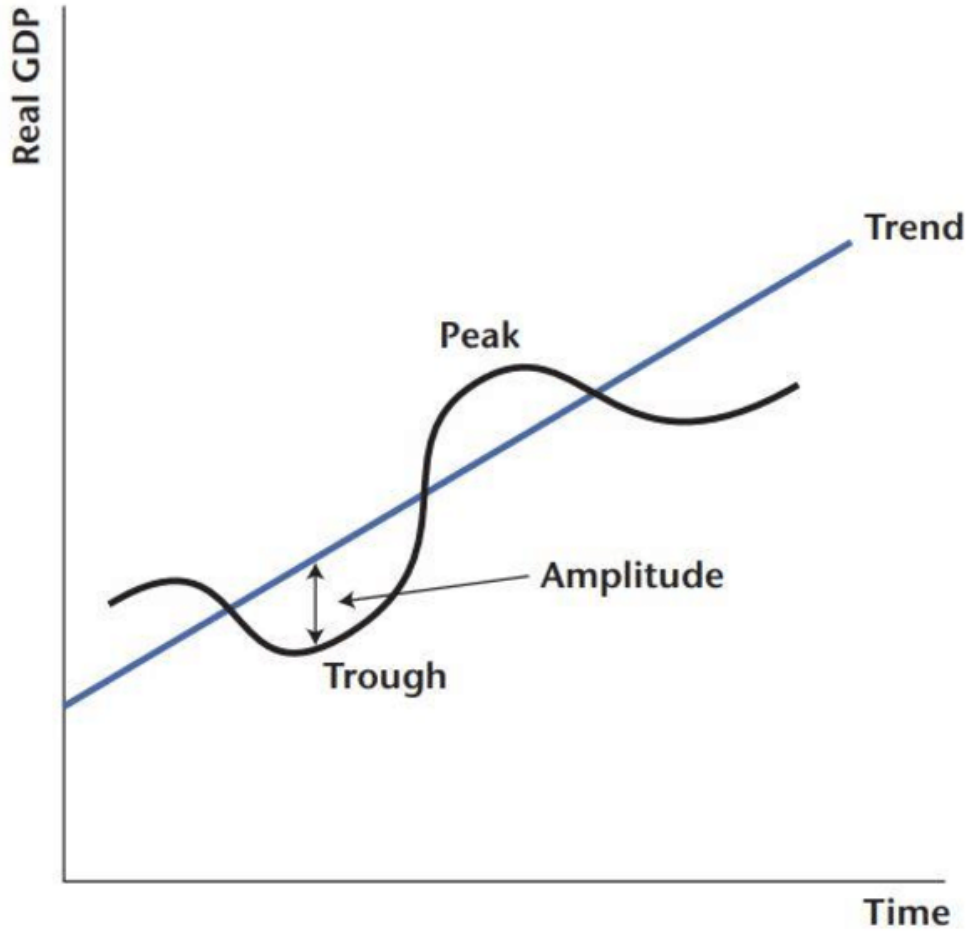
HP filtered data of log of quarterly U.S. real GDP (chained 2017 dollars, seasonally adjusted annual rate); λ=1600. Data: Real Gross Domestic Product (BEA, 2026)

Defining Recession

- **National Bureau of Economic Research (NBER)** defines recessions
  - **Expansion:** time between trough and peak
  - **Recession:** time between peak and trough
  - Unofficial rule: two quarters of negative growth indicate recession

- "However, the time that it takes for the economy to return to its previous peak level of activity or its previous trend path may be quite extended." **"Business Cycle Dating." (NBER, 2026).**

Drawing a Recession



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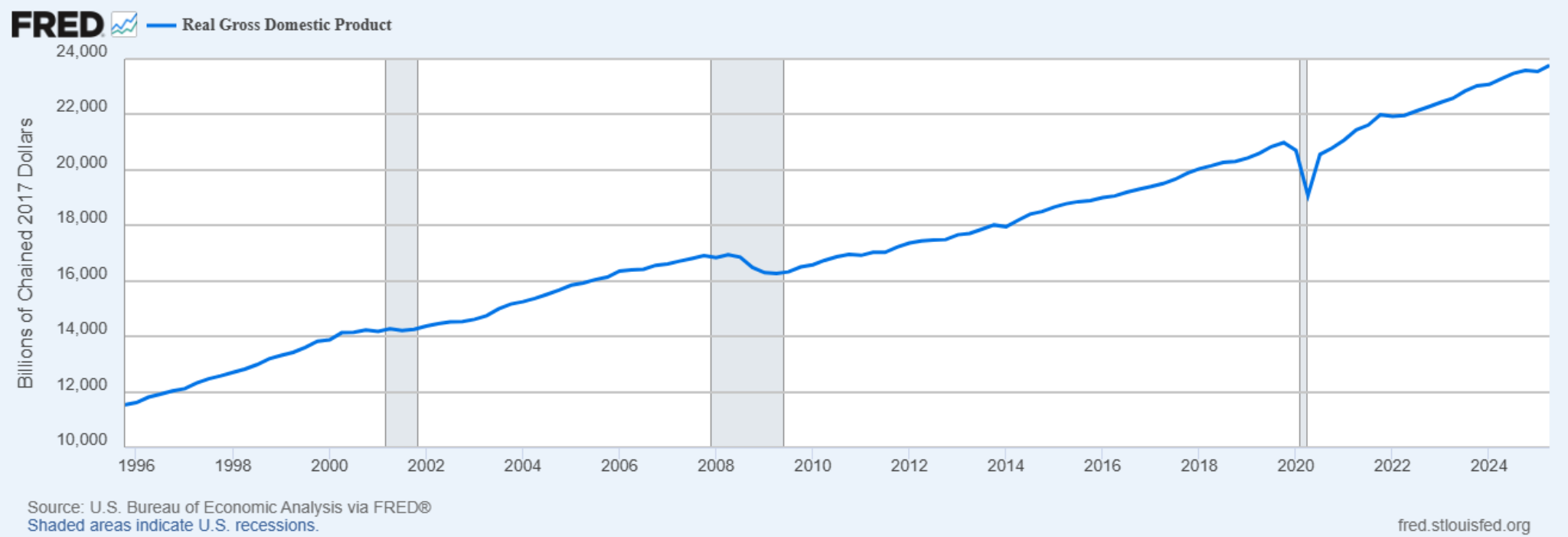
Did We Recover from the Great Recession?



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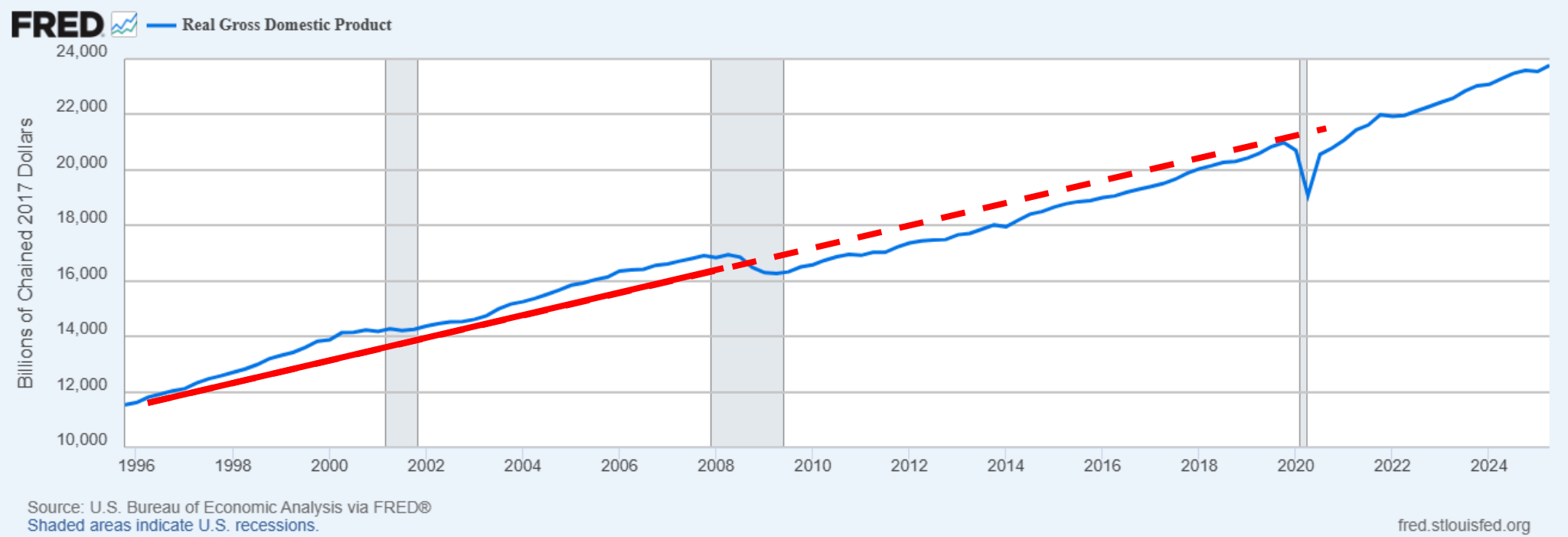


GE in a Simple RBC Model

› Let's assume an economy of firms, HH's, and government

› Firms and HH's have familiar conditions:

- $\frac{MU(\ell)}{MU(c)} = w$ (and) $\frac{MU(c)}{\beta MU(c')} = 1+r$
- $MPN = w$ (and) $MPk' - \delta = r$

› Assume (perhaps unreasonably) gov balances its budget:

$$T + \frac{T'}{(1+r)} = G + \frac{G'}{(1+r)}$$

The Role of Expectations

- Including future taxes in the model allows us to understand how HHs base choices on expectations of future variables

- Here, we've assumed they know the gov budget constraint
  - Know exactly how taxes move with *G*

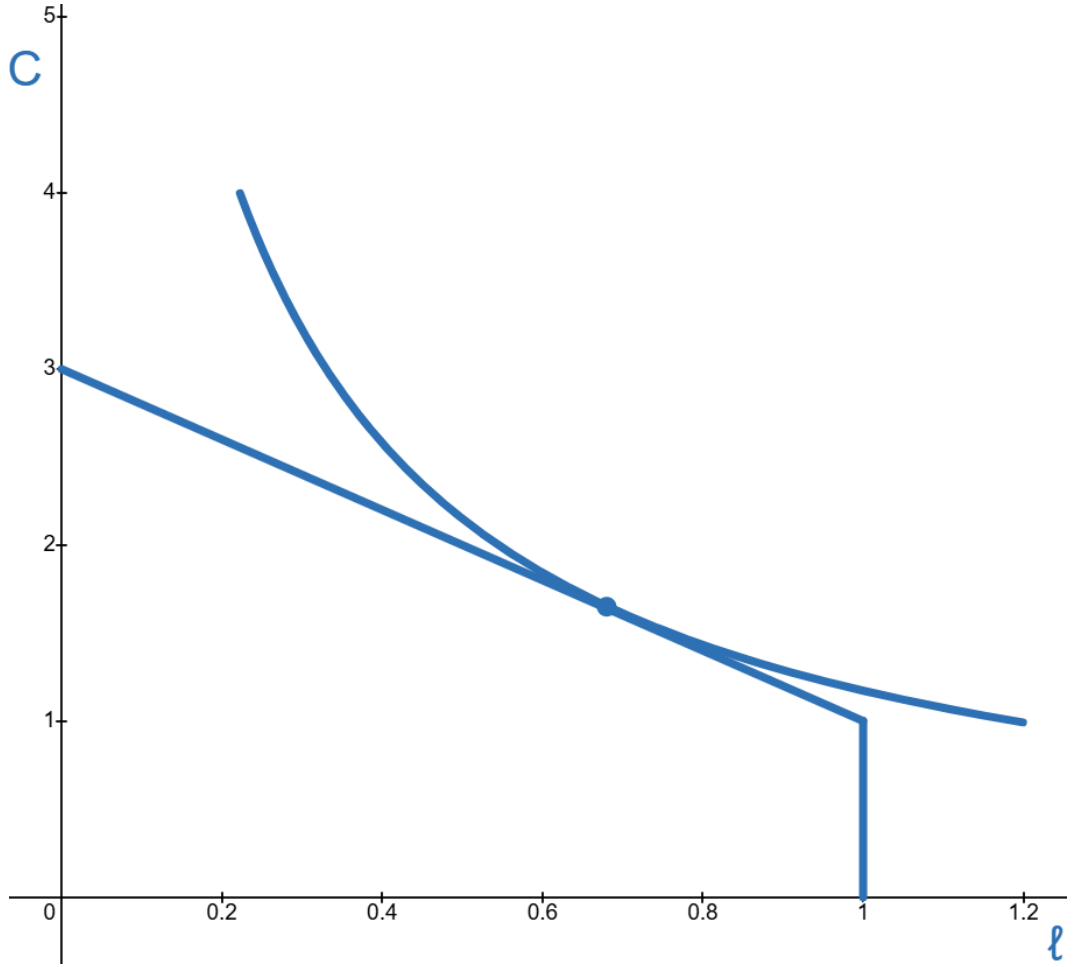
- In richer models this foresight isn't perfect, but the mechanics are the same

Expectations and *G*

- Suppose *G* were to increase
  - HH knows the gov has to pay for more spending *eventually*
  - Can happen today or tomorrow, but *T* must increase

- Let *X* contain present value of *future* non-labor income
  - Negative wealth effect
  - Doesn't matter if *T* or *T'* increase to pay for *G*

HH Response to Increase in *G* (*G'* constant)



Labor Supply Curve from *r*

› Going back to HH equations:

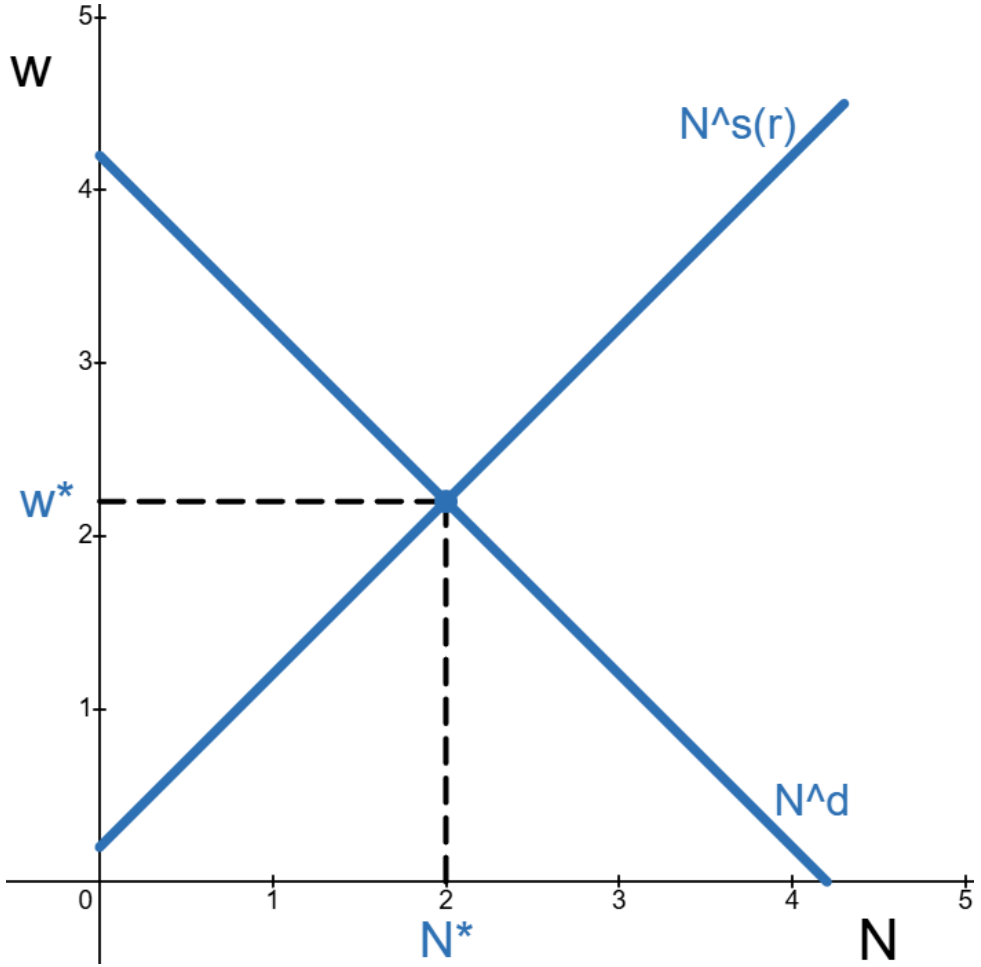
- $\frac{MU(\ell)}{MU(c)} = w$ (and) $\frac{MU(c)}{\beta MU(c')} = 1+r$

$$MU(\ell) = w(1+r)\beta MU(c')$$

› Labor supply is a function of *r*

– What happens to ℓ when *r* increases?

Graphing $N^s(r)$



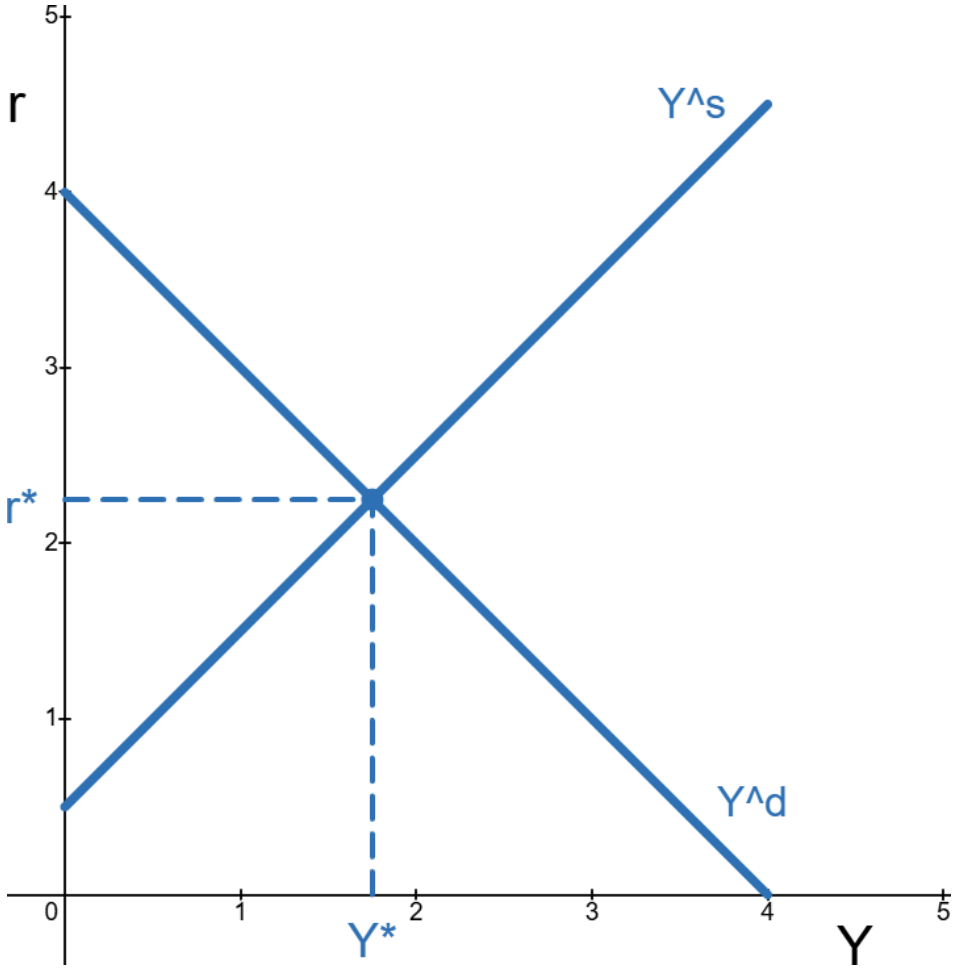
Output Supply and Demand

- Output supply (Y^s) and demand (Y^d) are standard:
  - $zF(K,N) = C + I + G$
  - *Production* = *Expenditure* (ch. 3)

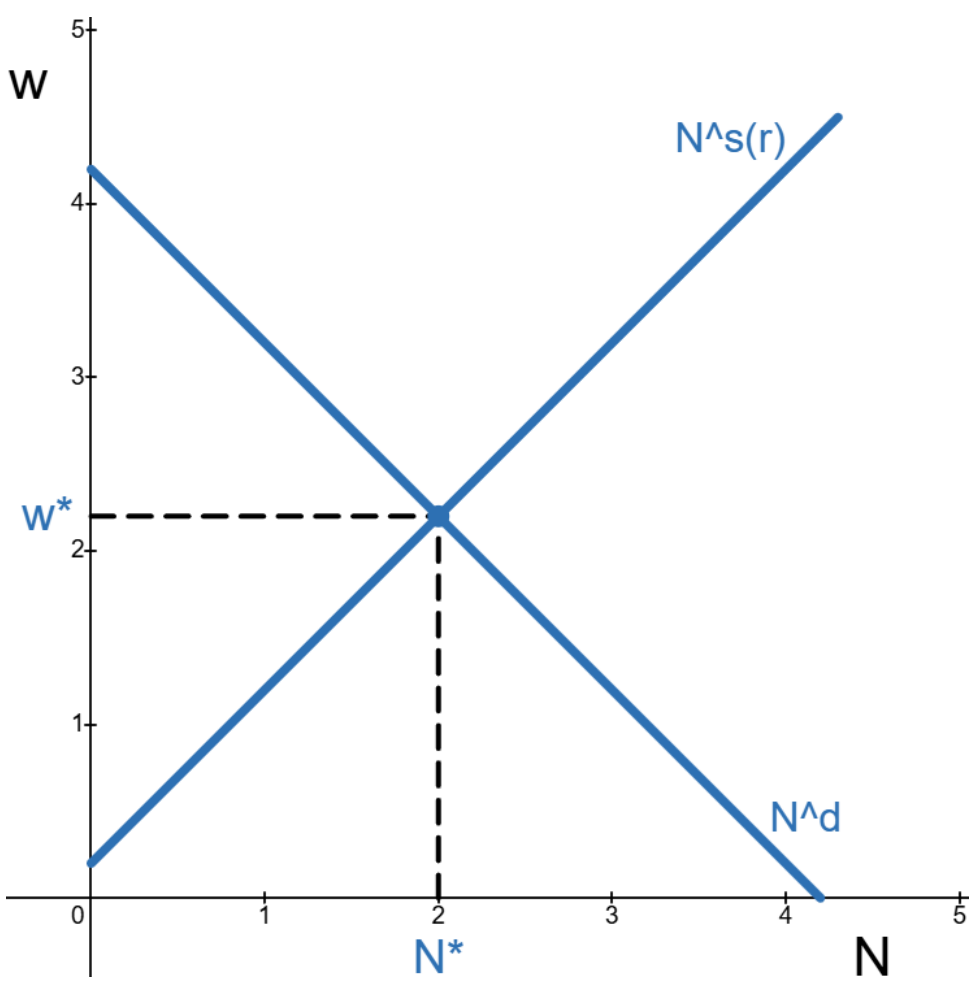
- We know N increases with r, so Y^s increases with r

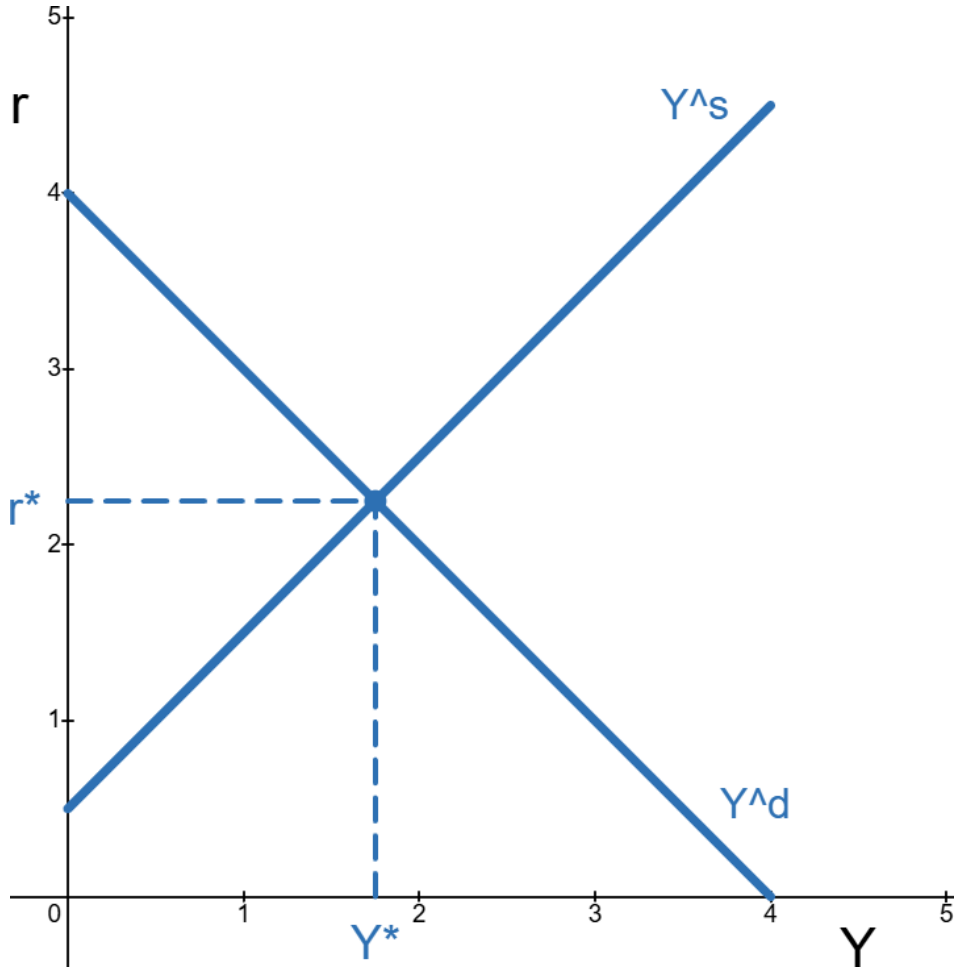
- Y^d decreases with r
  - SE ($c\downarrow$) and investment costs

Graphing Output



Continuing with Our Increase in *G*





Why Does Y^d shift More than Y^s? (1/3)

- Shift in Y^d comes from C and G
- Shift in Y^s comes from rise in N
- Let's unpack each…

Why Does Y^d shift More than Y^s? (2/3)

› Let's start with *G*, which increased

› HH understands taxes have to pay for this
  – Negative WE; less consumption

› Can we say $\Delta G > \Delta C$?

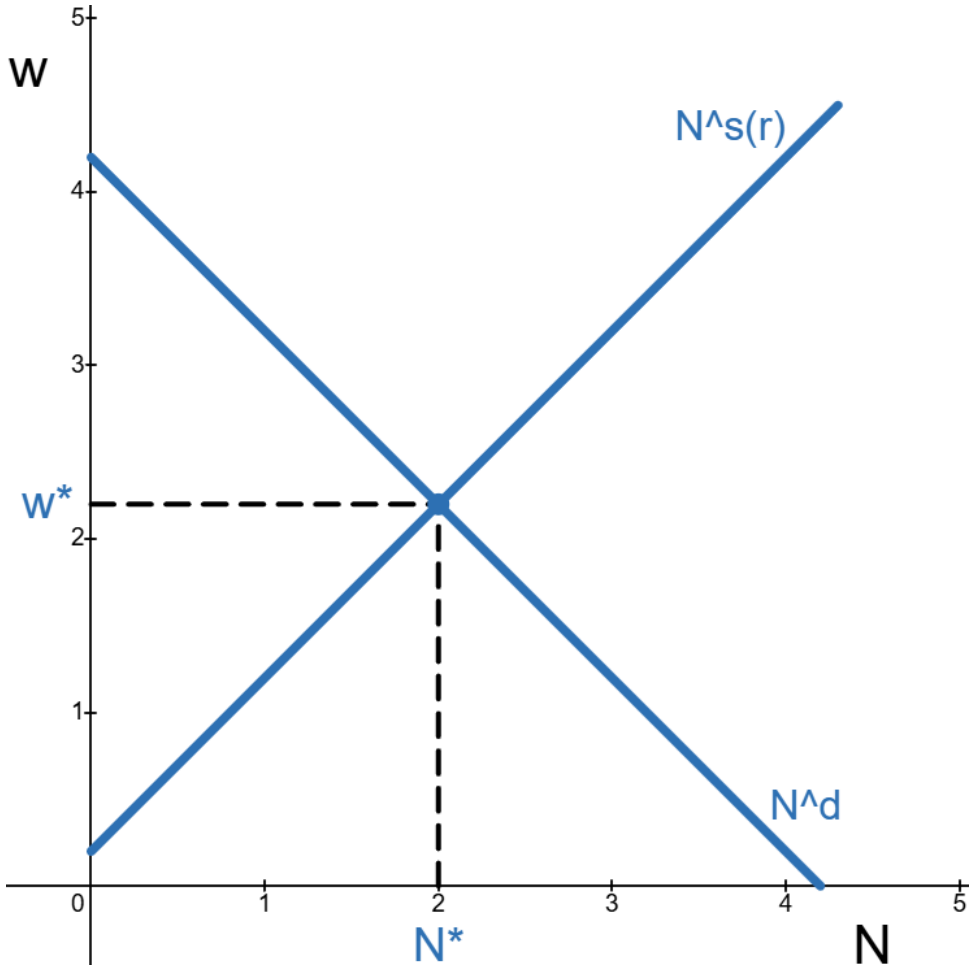
Why Does Y^d shift More than Y^s? (3/3)

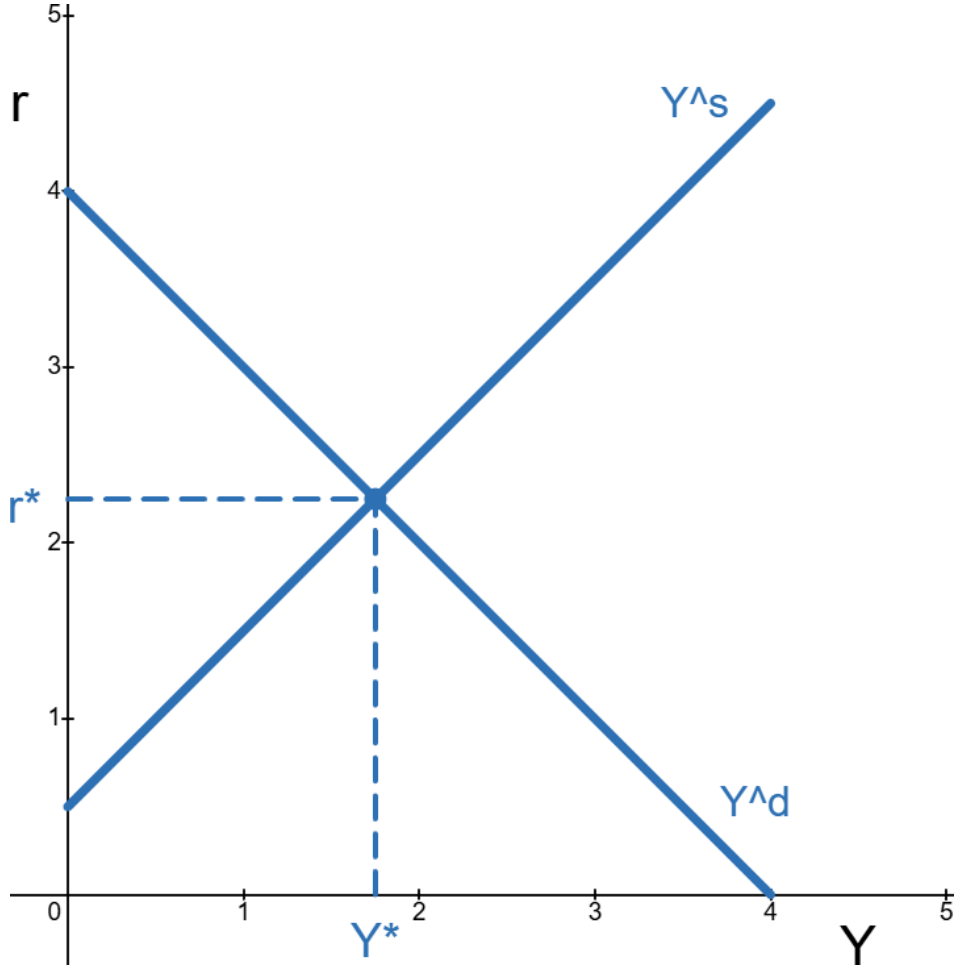
- Moving to Y^s, N and C move proportionally
  - Rise in N offset by fall in C
  - Not a 1-for-1 increase

- Further, each additional N has diminishing returns
  - $Y^s = zF(K,N)$

- *Two offsetting effects of N on Y^s*

So *r* rises??



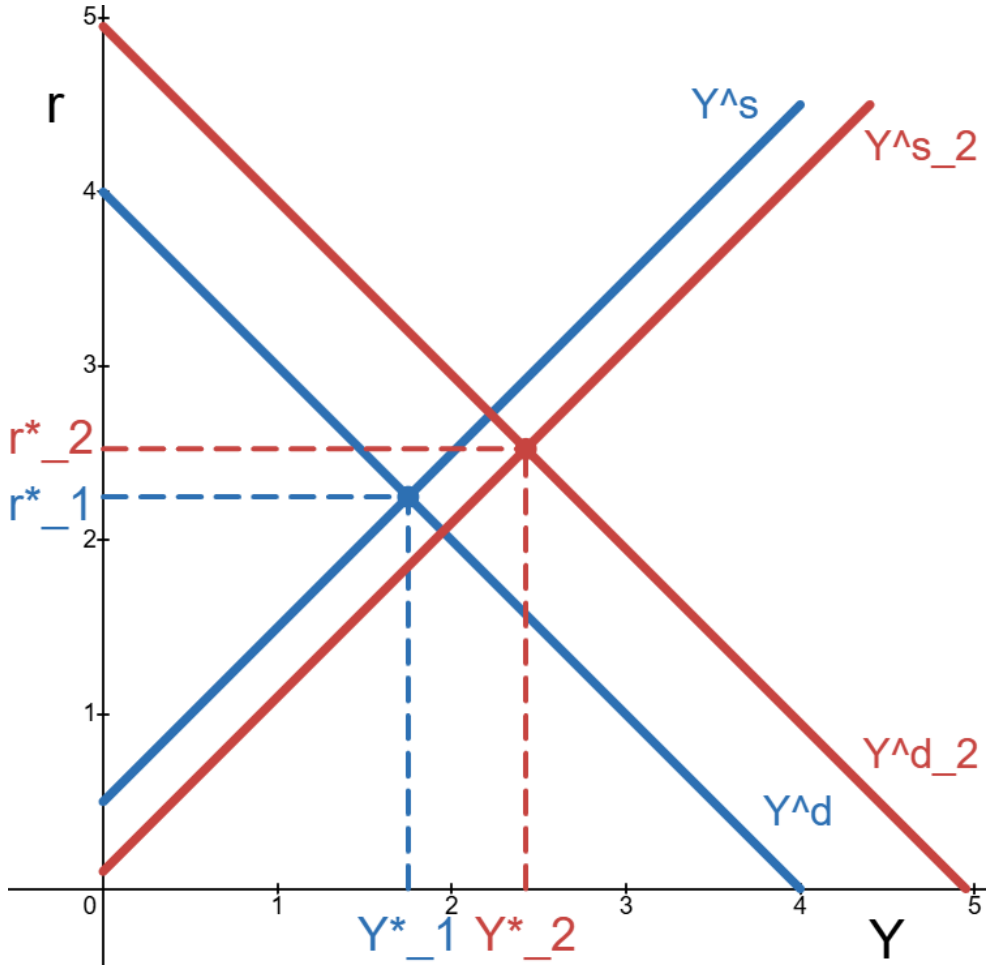


Crowding Out

- In the savings-investment market, the fall in income means a fall in savings
  - Another way to show the increase in *r*

- We should expect a movement back along Y^d when *r* rises
  - Why?

Crowding Out: Graph

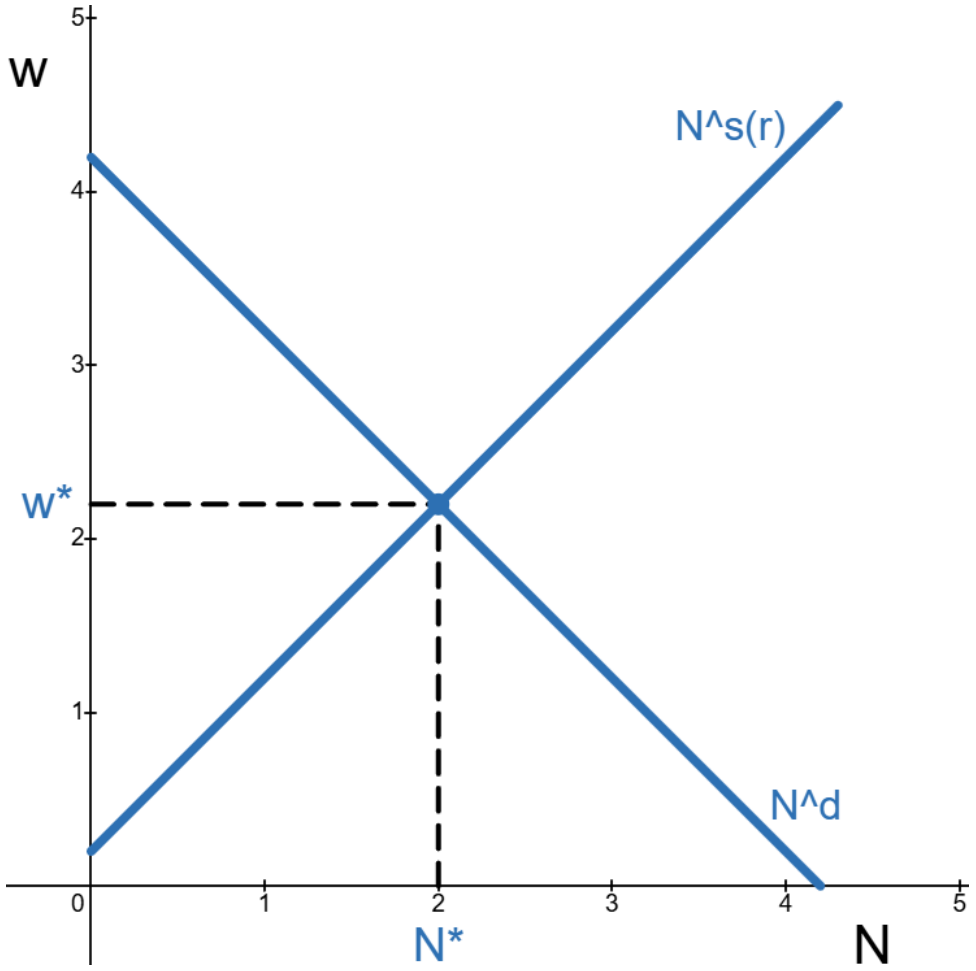


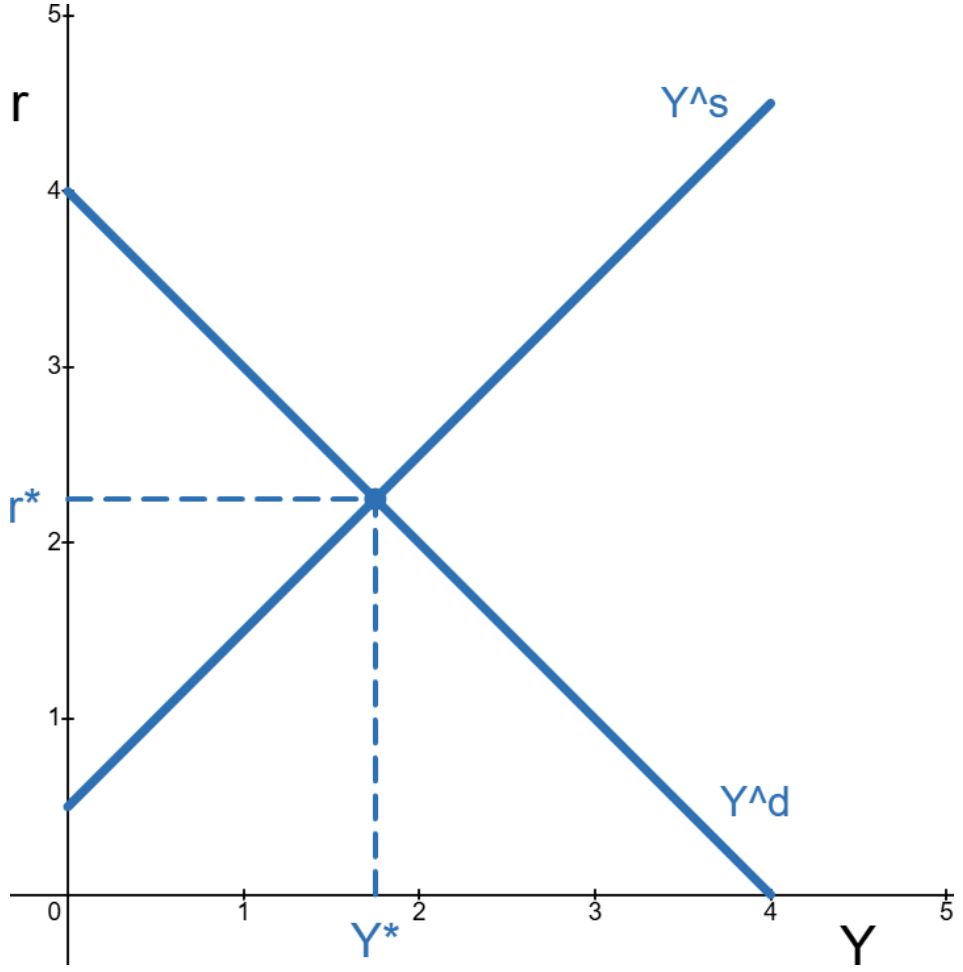
TFP Shocks

- The basic RBC model is very successful in matching data using random TFP shocks only

- Let's see what happens after a 1-time change in z

Temporary Increase in *z*



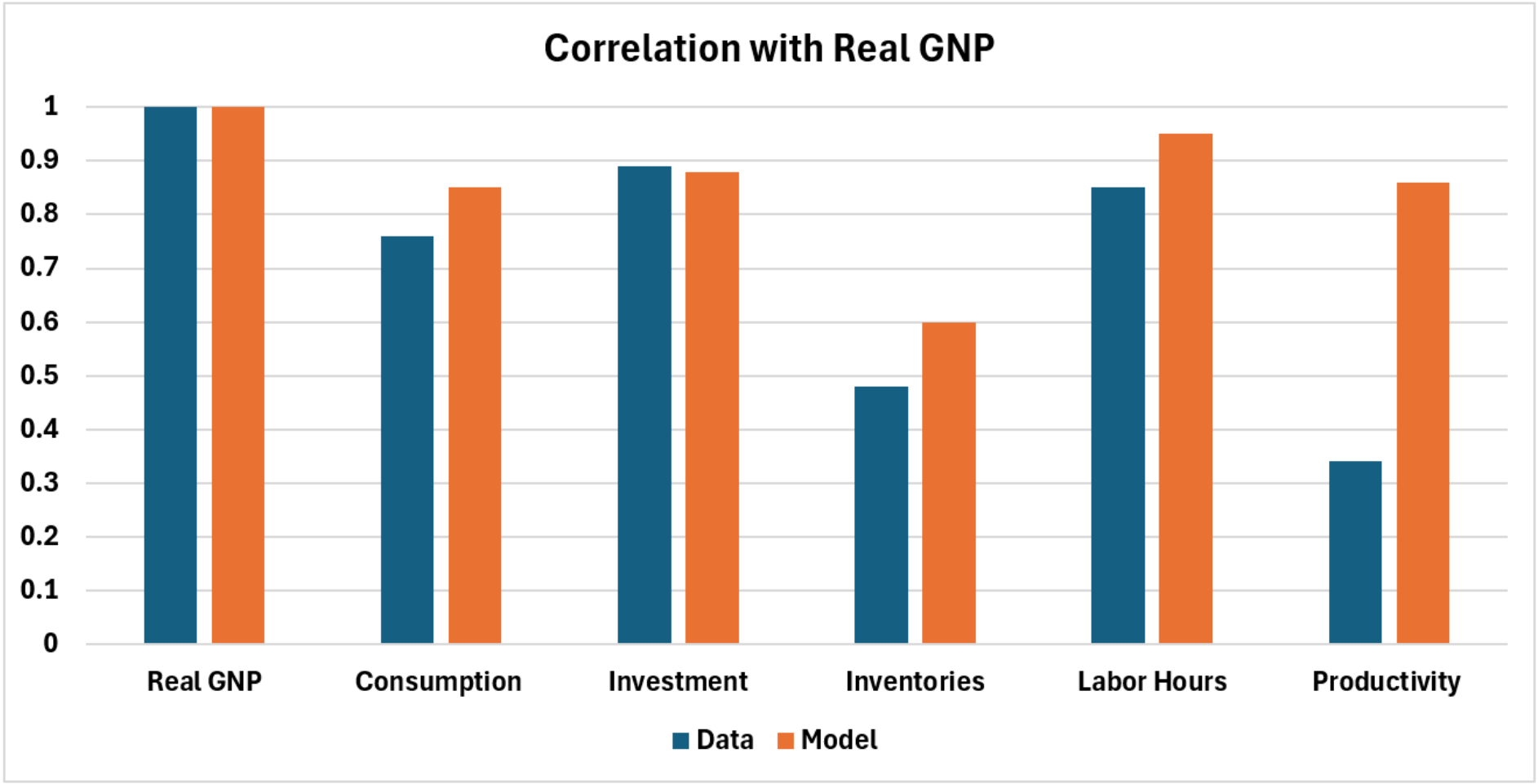


Does *N* Fall or Rise??

- In the data *N* rises. Our theory should predict this

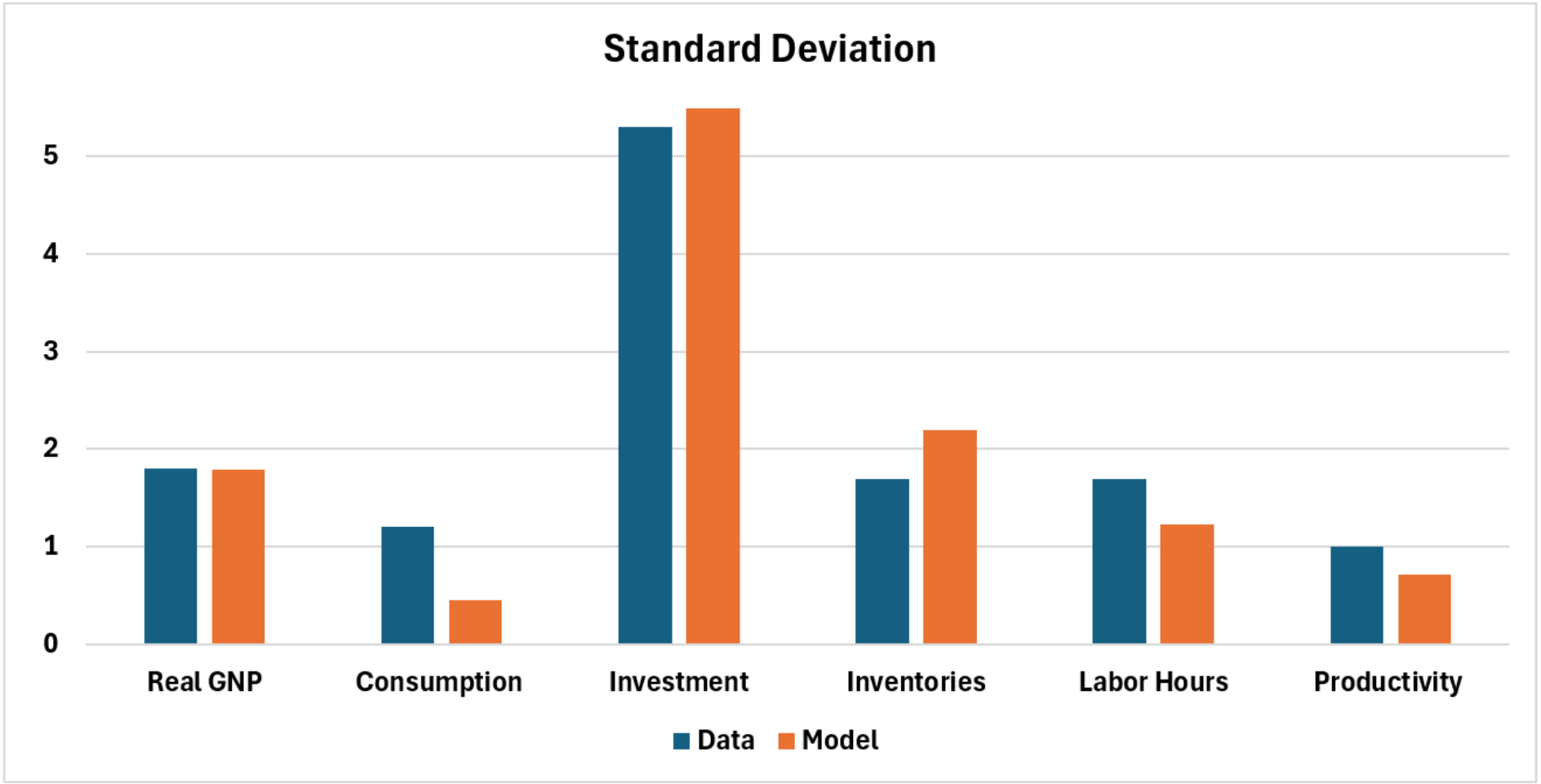
- From before: $MU(\ell) = w(1+r)\beta MU(c')$
  - Effects of *r* considered secondary to *z*
  - More offsetting from other variables

Early RBC Success: Correlations with rGNP



(Prescott, 1986)

Early RBC Success: Standard Deviation



(Prescott, 1986)

Criticisms of the RBC Model

- Two main points:
  1. The world is not TFP shocks alone
  2. Labor is not a "free" choice
     - Great Depression's 25% unemployment just mass vacation?
       - **"New Classical Macroeconomics" (Hoover, 2008)**

New Neoclassical Synthesis

- Today there is a **New Neoclassical Synthesis**
  - Pricing frictions incorporated into RBC models
  - **(Ottonello & Winberry, 2020)**

- Frictions are not assumed, but derived out of more detailed microfoundations
  - We'll start this after the midterm

References

1. “Business Cycle Dating.” *NBER,* https://www.nber.org/research/business-cycle-dating. Accessed 12 Feb 2026.

2. Hodrick, Robert J., and Edward C. Prescott. "Postwar US business cycles: an empirical investigation." *Journal of Money, Credit, and Banking* (1997): 1-16.

3. Hoover, Kevin D. “New Classical Macroeconomics.” *The Library of Economics and Liberty.* https://www.econlib.org/library/Enc/NewClassicalMacroeconomics.html. Accessed 12 Feb 2026.

4. Ottonello, Pablo, and Thomas Winberry. "Financial heterogeneity and the investment channel of monetary policy." *Econometrica* 88.6 (2020): 2473-2502.

5. Prescott, Edward C. "Theory ahead of business-cycle measurement." *Carnegie-Rochester conference series on public policy*. Vol. 25. North-Holland, 1986.

6. U.S. Bureau of Economic Analysis, Real Gross Domestic Product [GDPC1], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDPC1, February 12, 2026.

7. Williamson, Stephen D. *Macroeconomics*. 6th ed. Pearson Education Inc., 2016. Figure 3.1

A. All non-cited graphs for this course made by me on Desmos.

APPENDIX

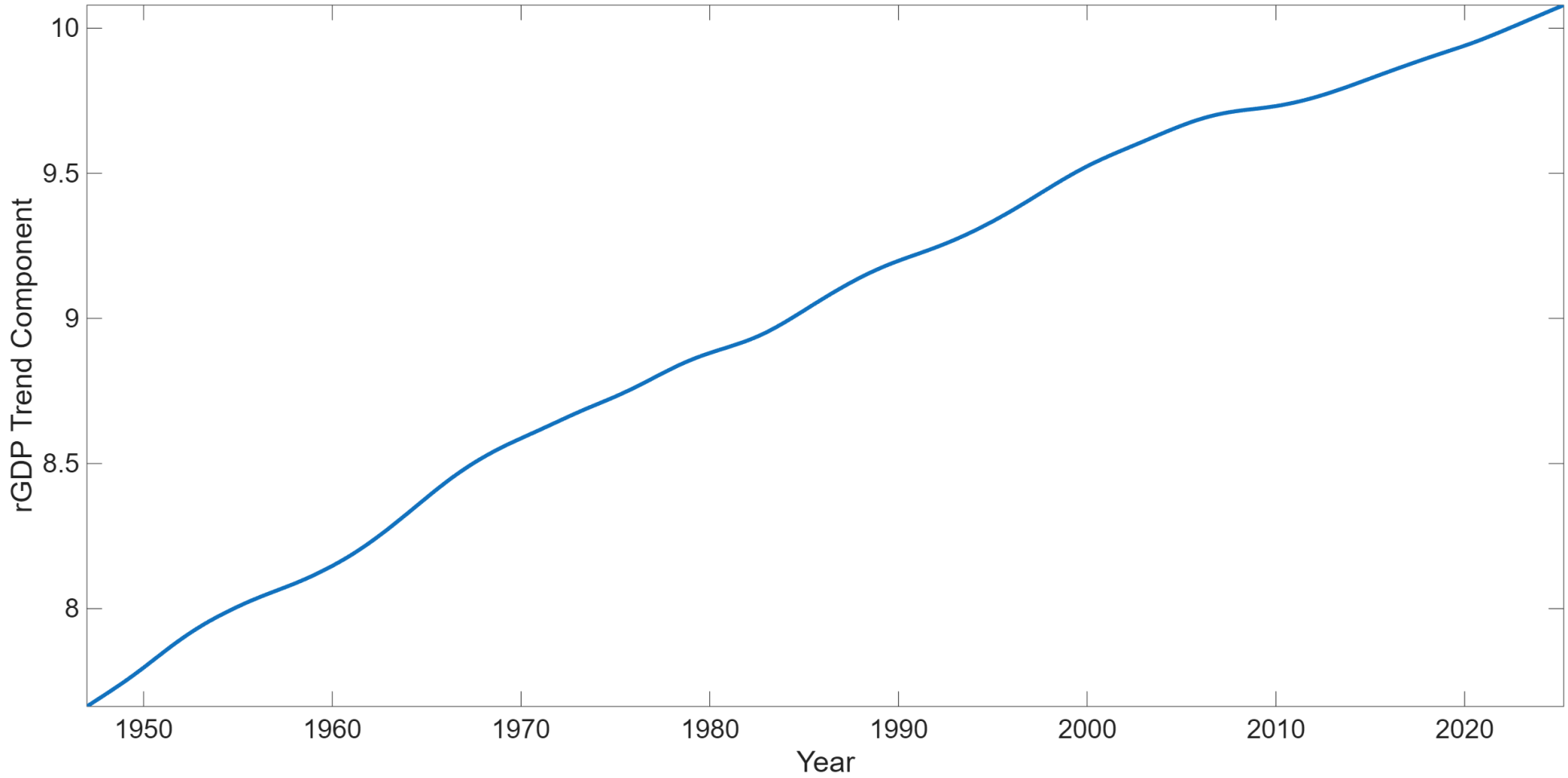
The HP Filter

$$\min_{\{\tau_t\}_1^N} \sum_{t=1}^{N} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{N-1} \left[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})\right]^2 \qquad (1)$$

- This is a minimisation problem in N variables.
  - Economic time series is y_t
  - These variables are the trend terms, $\tau_1, \ldots, \tau_N$.
- The weight λ applies to a sum of changes in the slope of the trend.
  - A high value of λ will result in a linear trend with less change in slope
  - A low value will result is a trend that is very close to the actual time series, y_t.

Source: A screenshot from Aubhik Khan's notes. Sue me.

Trend Corresponding to Slide 11



HP filtered data of log of quarterly U.S. real GDP (chained 2017 dollars, seasonally adjusted annual rate); λ=1600. Data: Real Gross Domestic Product (BEA, 2026)

Early RBC Success

Variable x	Standard Deviation	Cross Correlation of GNP With $x(t-1)$	$x(t)$	$x(t+1)$
Gross National Product	1.8%	.82	1.00	.82
Personal Consumption Expenditures				
Services	.6	.66	.72	.61
Nondurable Goods	1.2	.71	.76	.59
Fixed Investment Expenditures	5.3	.78	.89	.78
Nonresidential Investment	5.2	.54	.79	.86
Structures	4.6	.42	.62	.70
Equipment	6.0	.56	.82	.87
Capital Stocks				
Total Nonfarm Inventories	1.7	.15	.48	.68
Nonresidential Structures	.4	−.20	−.03	.16
Nonresidential Equipment	1.0	.03	.23	.41
Labor Input				
Nonfarm Hours	1.7	.57	.85	.89
Average Weekly Hours in Mfg.	1.0	.76	.85	.61
Productivity (GNP/Hours)	1.0	.51	.34	−.04

Source of basic data: Citicorp's Citibase data bank

Variable x	Standard Deviation	Cross Correlation of GNP With $x(t-1)$	$x(t)$	$x(t+1)$
Gross National Product	1.79%	.60	1.00	.60
	(.13)	(.07)	(—)	(.07)
Consumption	.45	.47	.85	.71
	(.05)	(.05)	(.02)	(.04)
Investment	5.49	.52	.88	.78
	(.41)	(.09)	(.03)	(.03)
Inventory Stock	2.20	.14	.60	.52
	(.37)	(.14)	(.08)	(.05)
Capital Stock	.47	−.05	.02	.25
	(.07)	(.07)	(.06)	(.07)
Hours	1.23	.52	.95	.55
	(.09)	(.09)	(.01)	(.06)
Productivity (GNP/Hours)	.71	.62	.86	.56
	(.06)	(.05)	(.02)	(.10)
Real Interest Rate (Annual)	.22	.65	.60	.36
	(.03)	(.07)	(.20)	(.15)

*These are the means of 20 simulations, each of which was 116 periods long. The numbers in parentheses are standard errors.
Source: Kydland and Prescott 1984

(Prescott, 1986)

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