

# Technology, Productivity, and the Labor Market: Implications for Long-Run Growth

William Wascher  
Federal Reserve Board

June 15, 2018

*Exhibits by Bo Yeon Jang*

The opinions expressed are my own and do not necessarily reflect the views of anyone else in the Federal Reserve System.

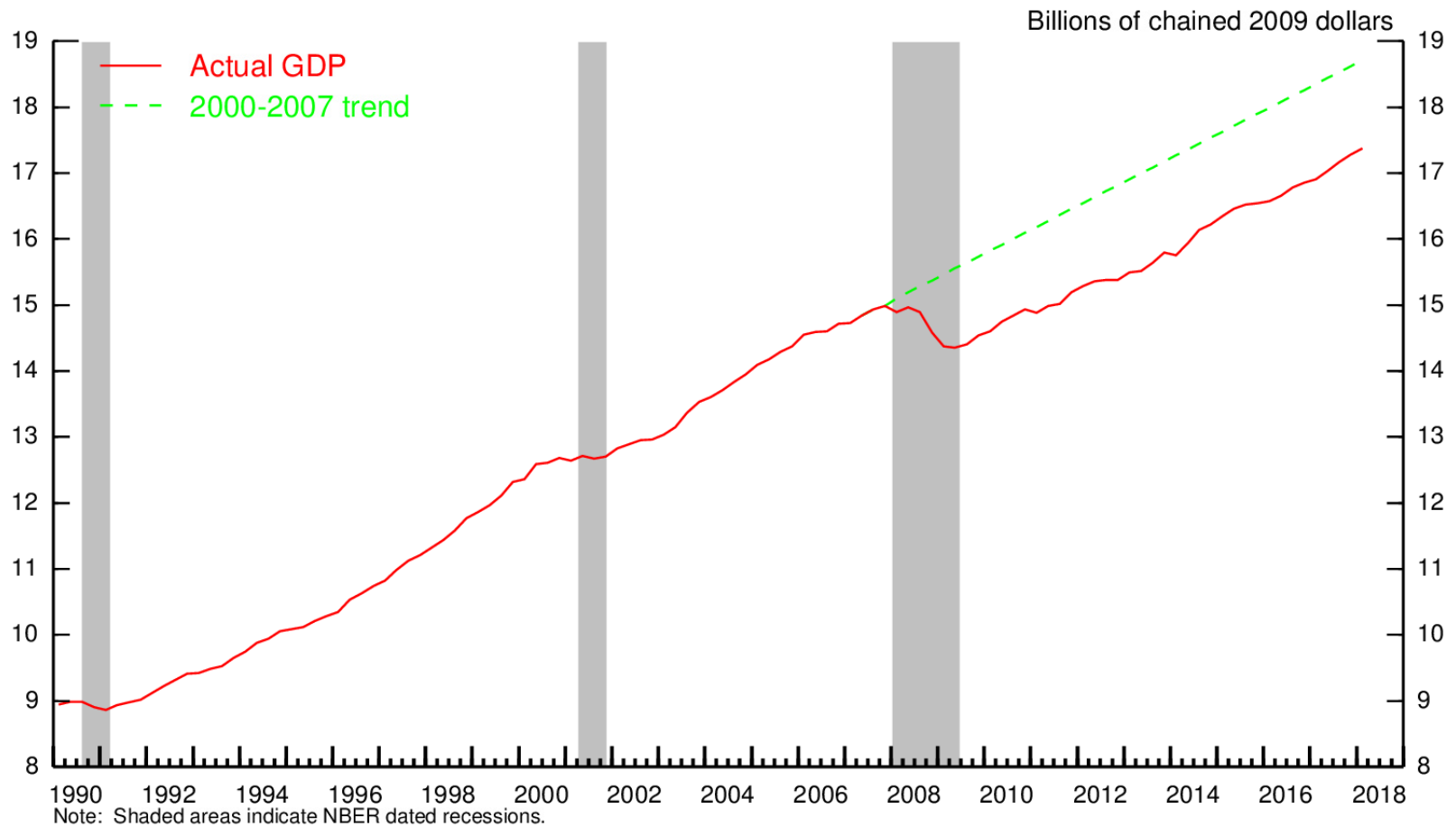
# Overview

1. The growth rate of potential output in the United States appears to have slowed over the past decade or so
2. When did the slowdown begin?
3. What are the sources of this slowing?
4. Was the financial crisis a contributing influence?
5. Is there a new productivity paradox?
6. What is the outlook for the next decade?

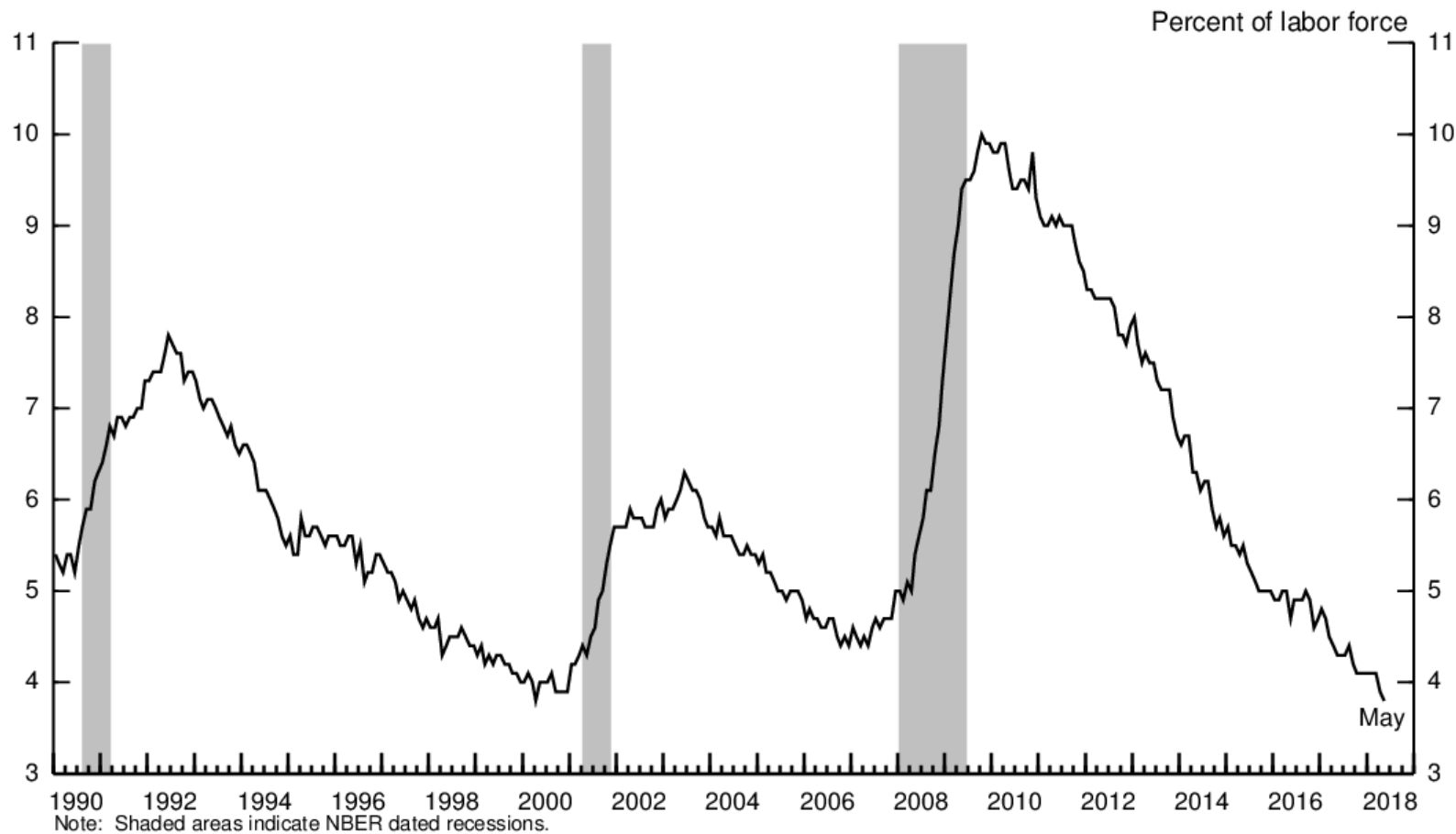
# Previous Literature

- Financial crises lead to persistent shortfalls in real GDP
  - Reinhart and Rogoff (2010)
  - Cerra and Saxena (2008)
- Severe recessions have a sustained effect on the trend level of real GDP
  - Reifschneider, Wilcox, and Wascher (2015)
  - Martin, Munyan, and Wilson (2015)
  - Hall (2014)
- The slowdown in potential output growth preceded the Great Recession
  - Gordon (2016)
  - Fernald, et al. (2017)

## GDP Before and After the Crisis



# Unemployment Rate



# Okun's Law Example

- $\Delta \text{Log}(Y_t) - \Delta \text{Log}(Y_t^*) = 2(\Delta U_t)$ 
  - Use average growth rates from 2009:Q4 – 2018:Q1
  - GDP growth: 2.2% per year;
  - Decline in unemployment rate: 0.7pp per year
  - Implies potential output growth of 0.8% annually

# Estimating potential output: A state-space model

- A production function

$$y_t \equiv \sum x_{it}$$

- A decomposition of each factor of production:

$$x_{it} = \lambda_i(L)cyc_t + x_{it}^* + \mu_{it}$$

- A specification of the time-series behavior of cycle and trend

$$cyc_t = \delta_1 cyc_{t-1} + \delta_2 cyc_{t-2} + \xi_t$$

$$x_{it}^* = \alpha_{i,t} + x_{i,t-1}^* + \eta_{it}$$

- A new-Keynesian Phillips Curve:

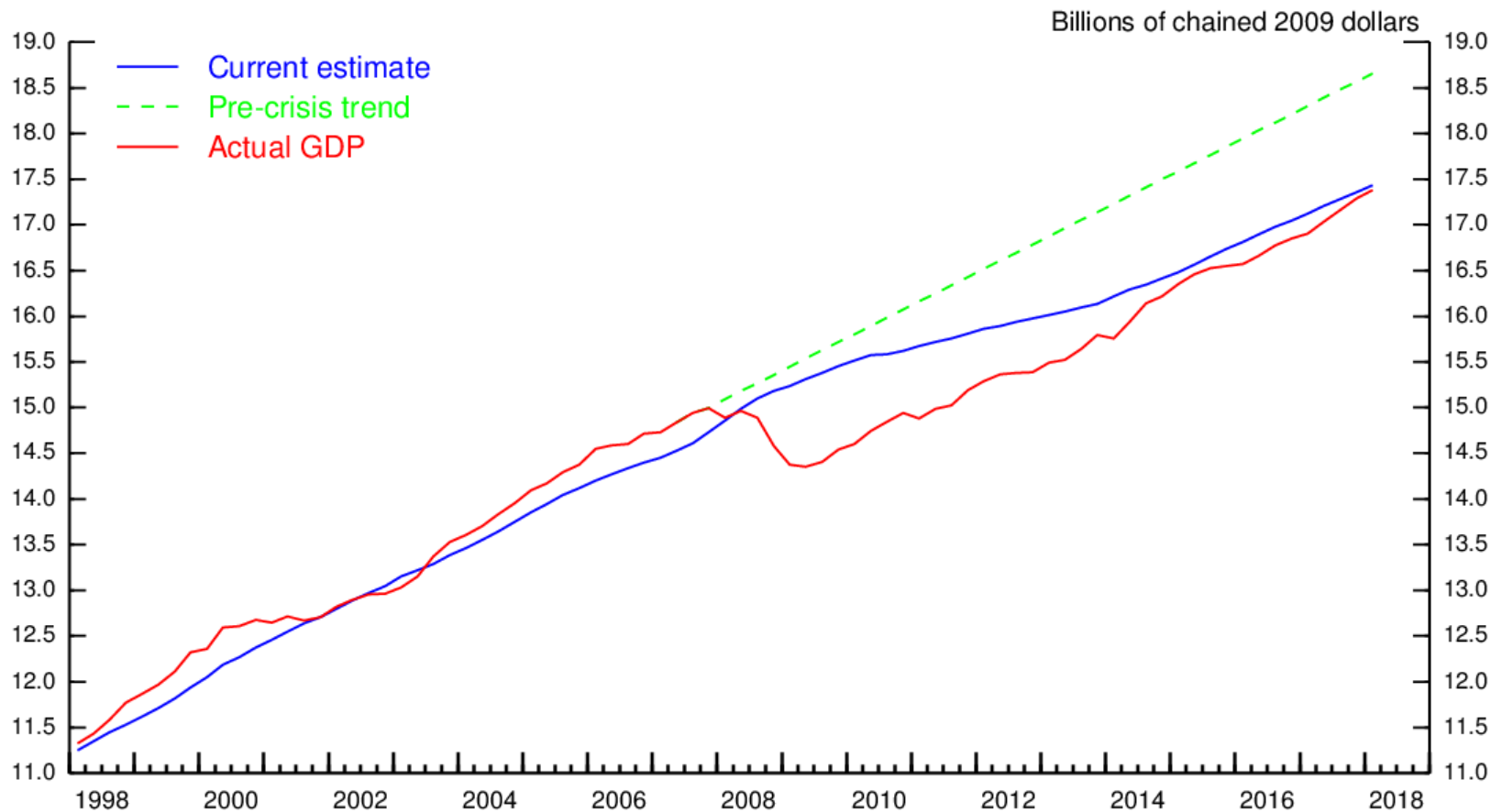
$$\Delta p_t = \omega \Delta p_t^e + (1-\omega) \Delta p_{t-1} + \beta cyc_t + Z_t \Gamma + \varepsilon_t$$

# Key Results from the State-Space Model

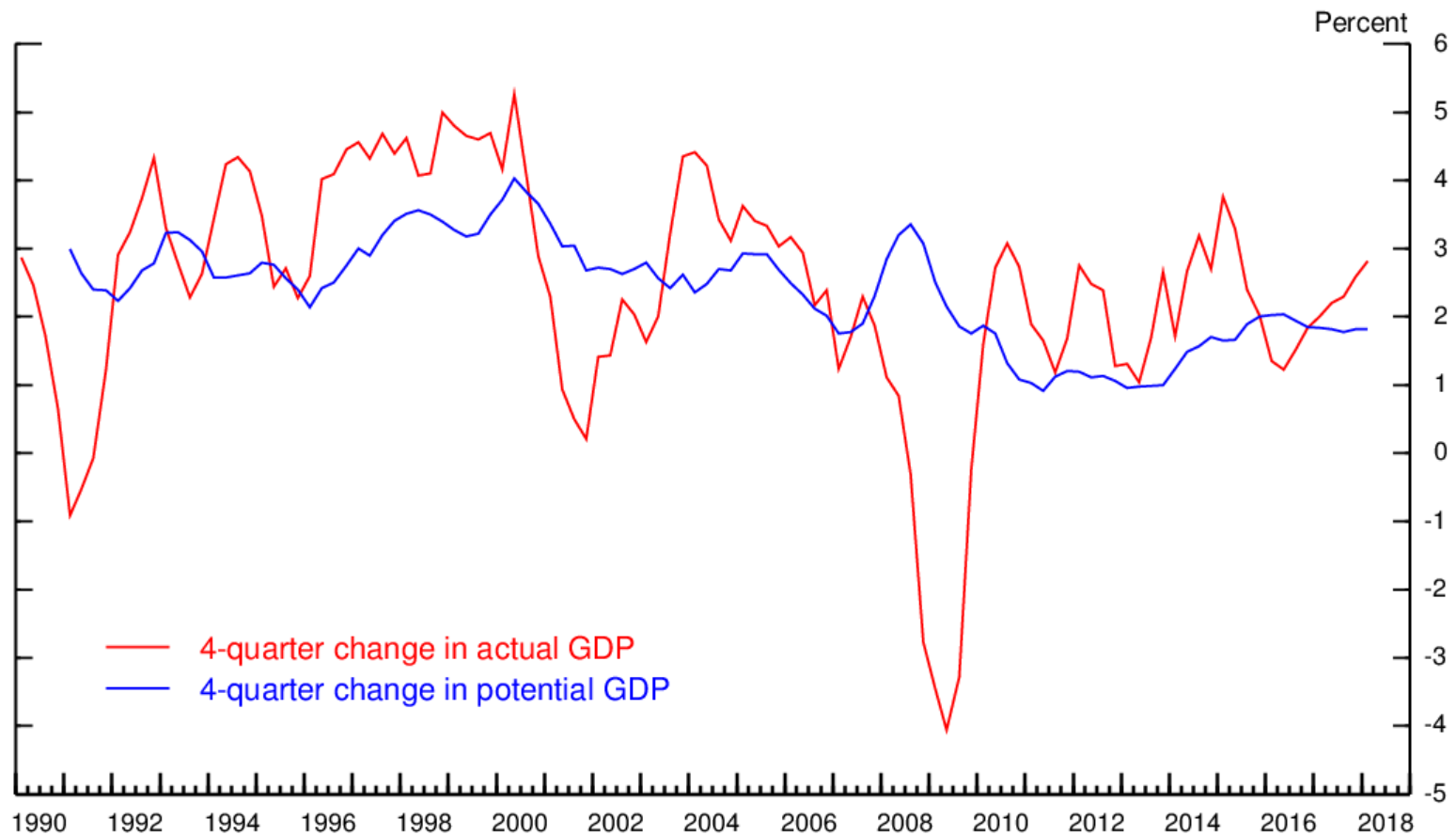
- Level of potential output in 2018:Q1 was 7 percent below its pre-recession trend.
  - Current growth rate of potential is estimated to be a little under 2 percent



## Results from the State-Space Model: Potential GDP Level



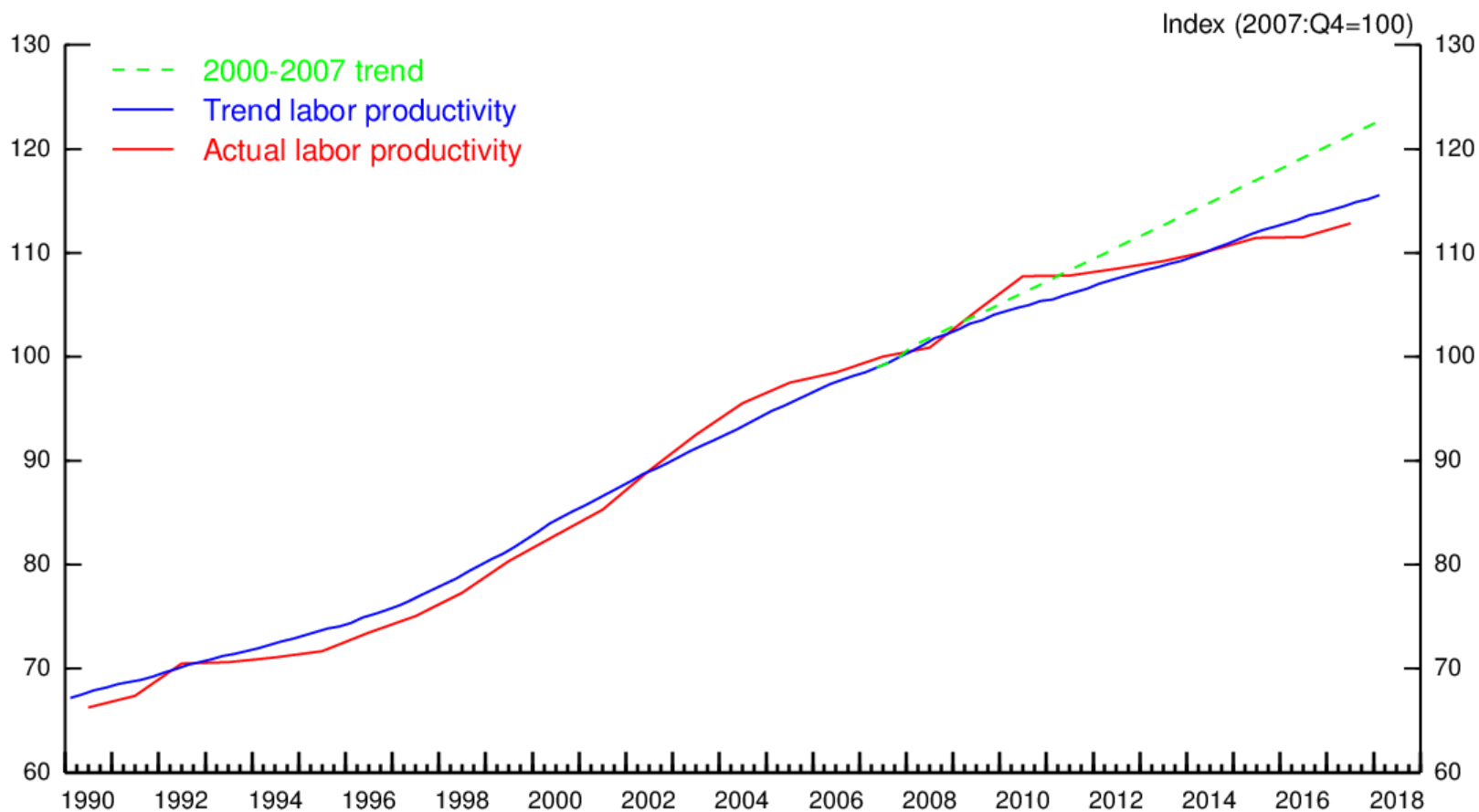
## Results from the State-Space Model: Potential GDP Growth



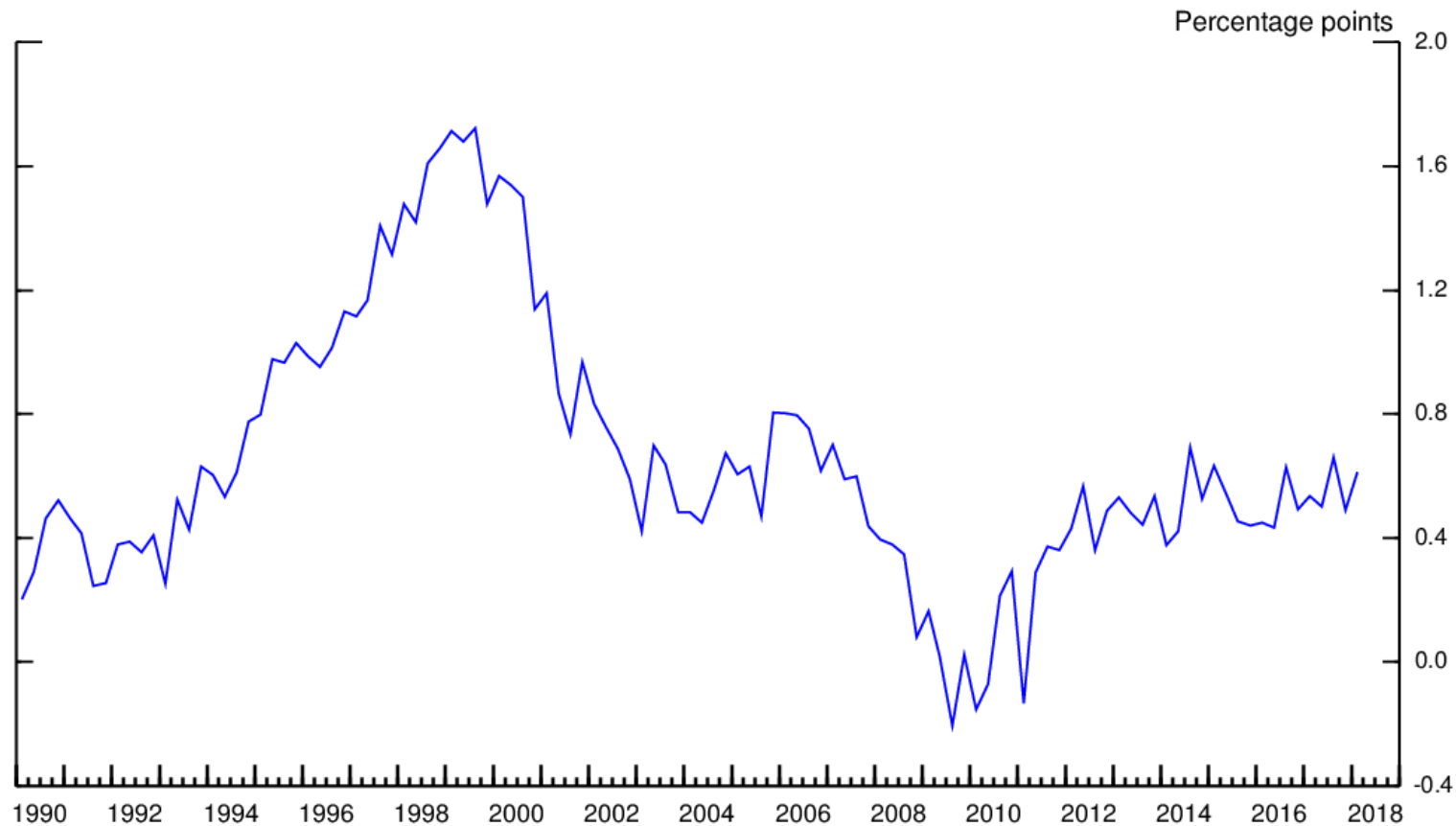
# Key Results from the State-Space Model

- Level of potential output in 2018:Q1 was 7 percent below its pre-recession trend.
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- Largest contributor to shortfall in the level of potential output is from trend productivity growth
  - Both less capital deepening and lower mfp growth

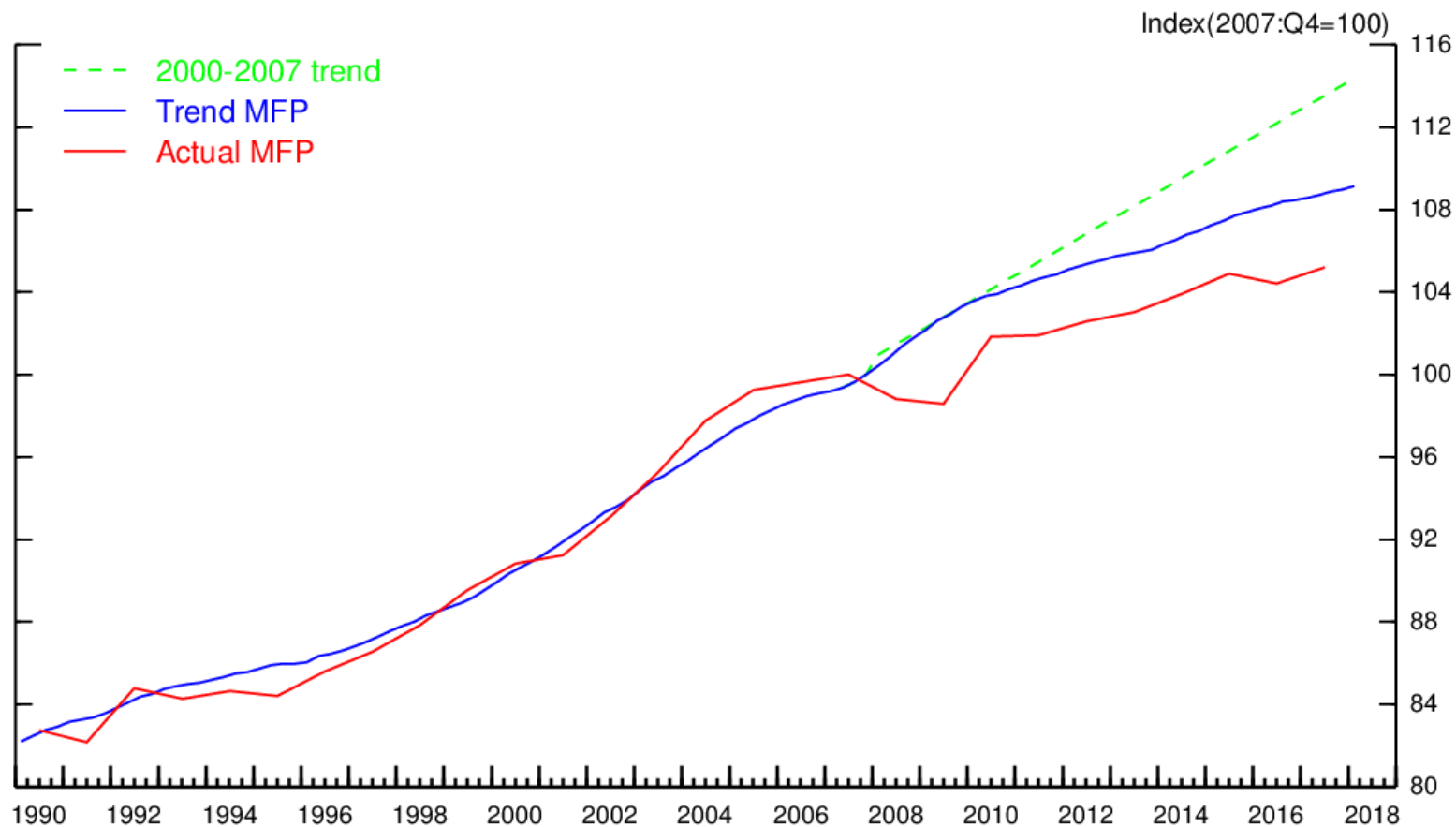
## Results from the State-Space Model: Trend Labor Productivity



## Results from the State-Space Model: Contribution of Capital Deepening



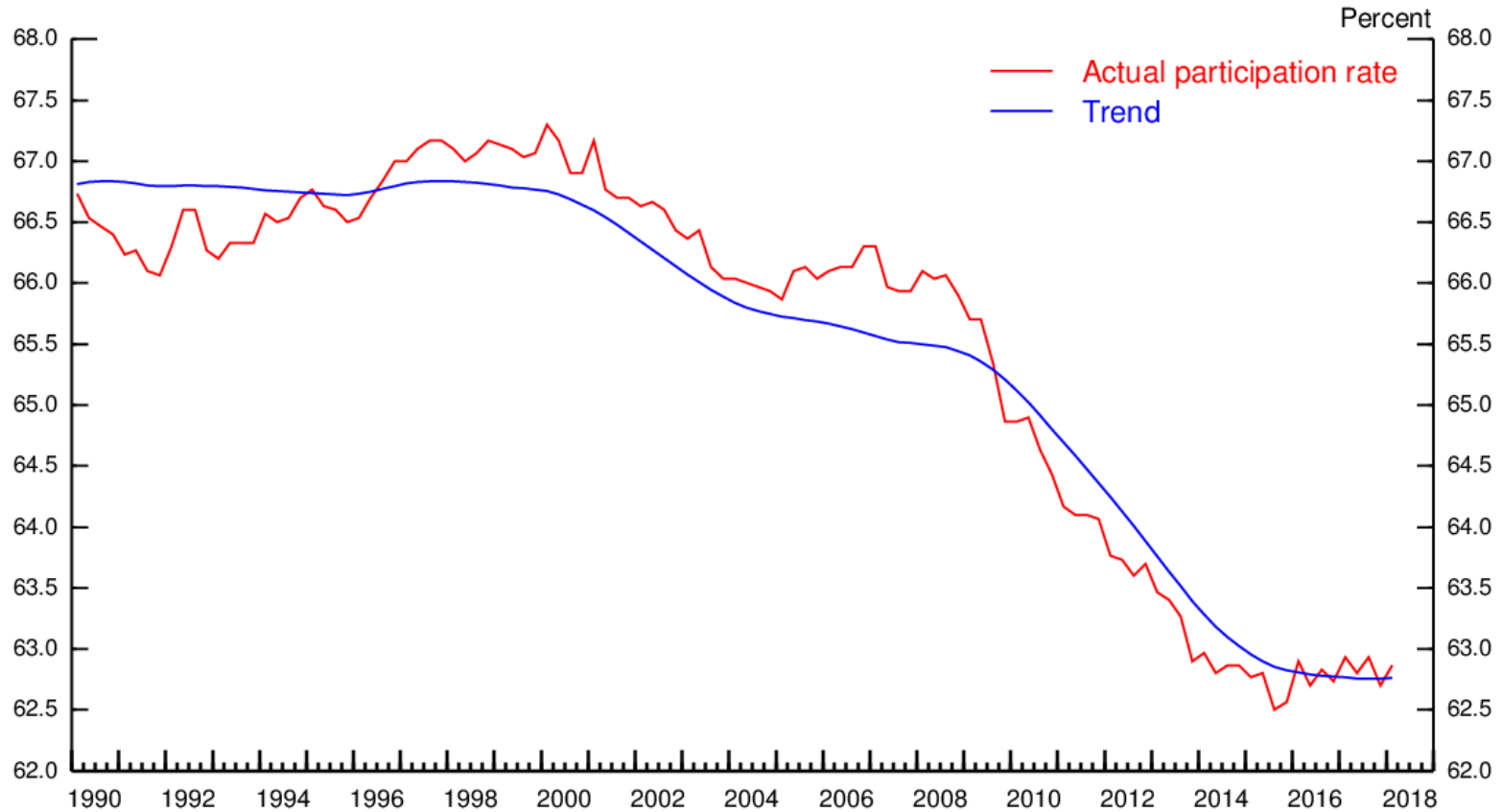
## Results from the State-Space Model: Trend Multifactor Productivity



# Key Results from the State-Space Model

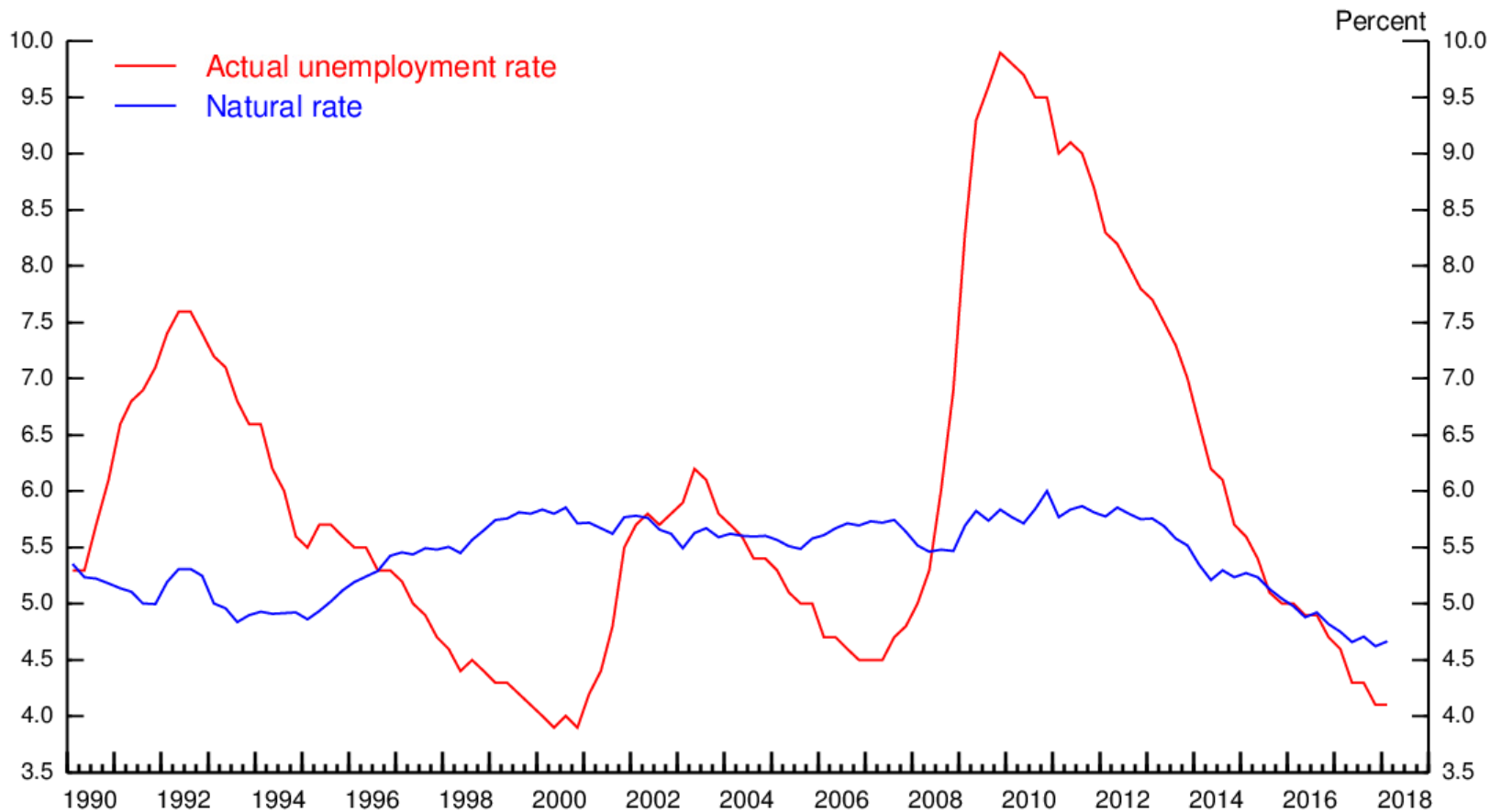
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- Trend growth of labor input also slowed
  - Steeper decline in trend LFPR
  - Partially offset by a decline in the natural rate of unemployment

## Results from the state-space model: The Labor Force Participation Rate





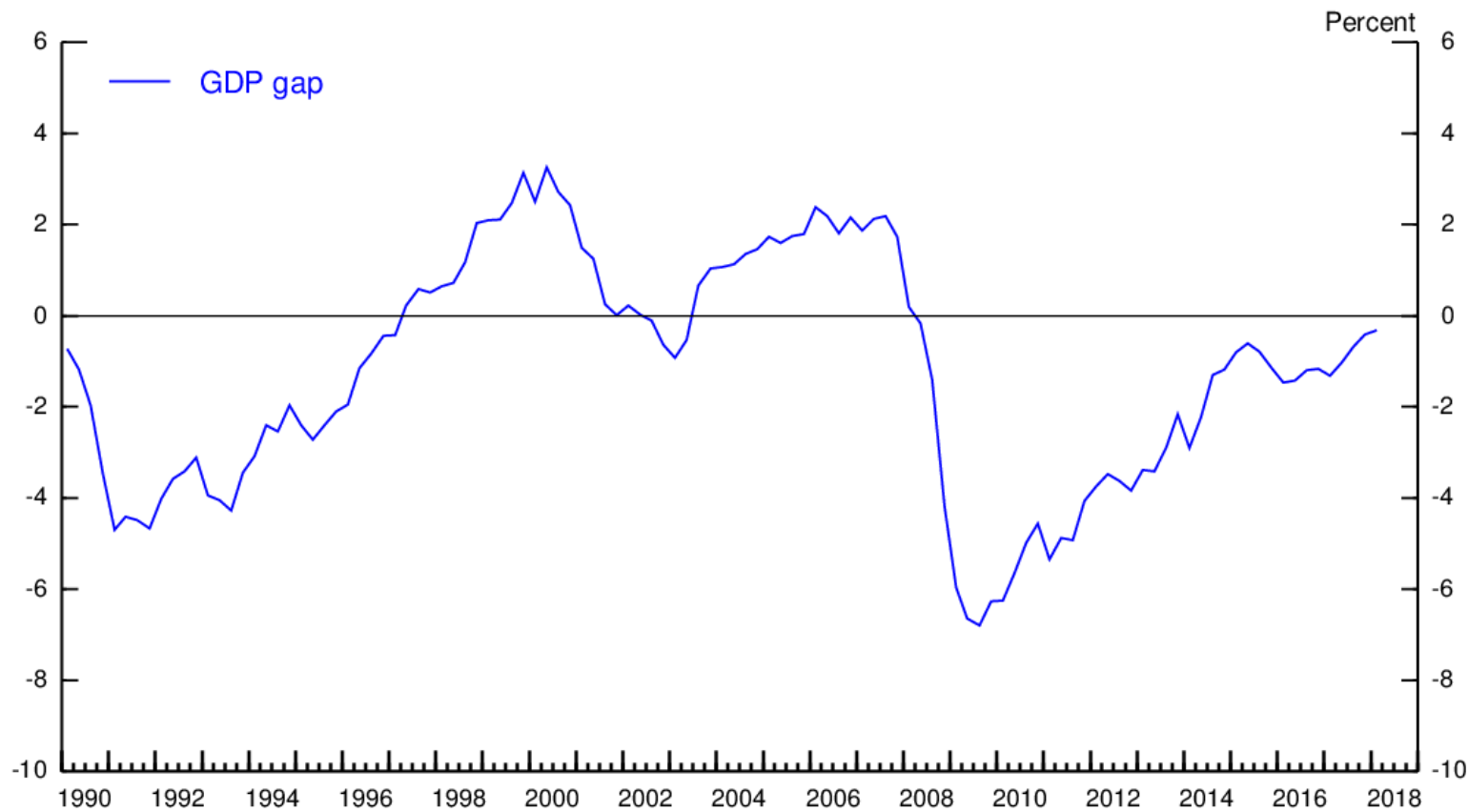
## Results from the State-Space Model: The Natural Rate of Unemployment



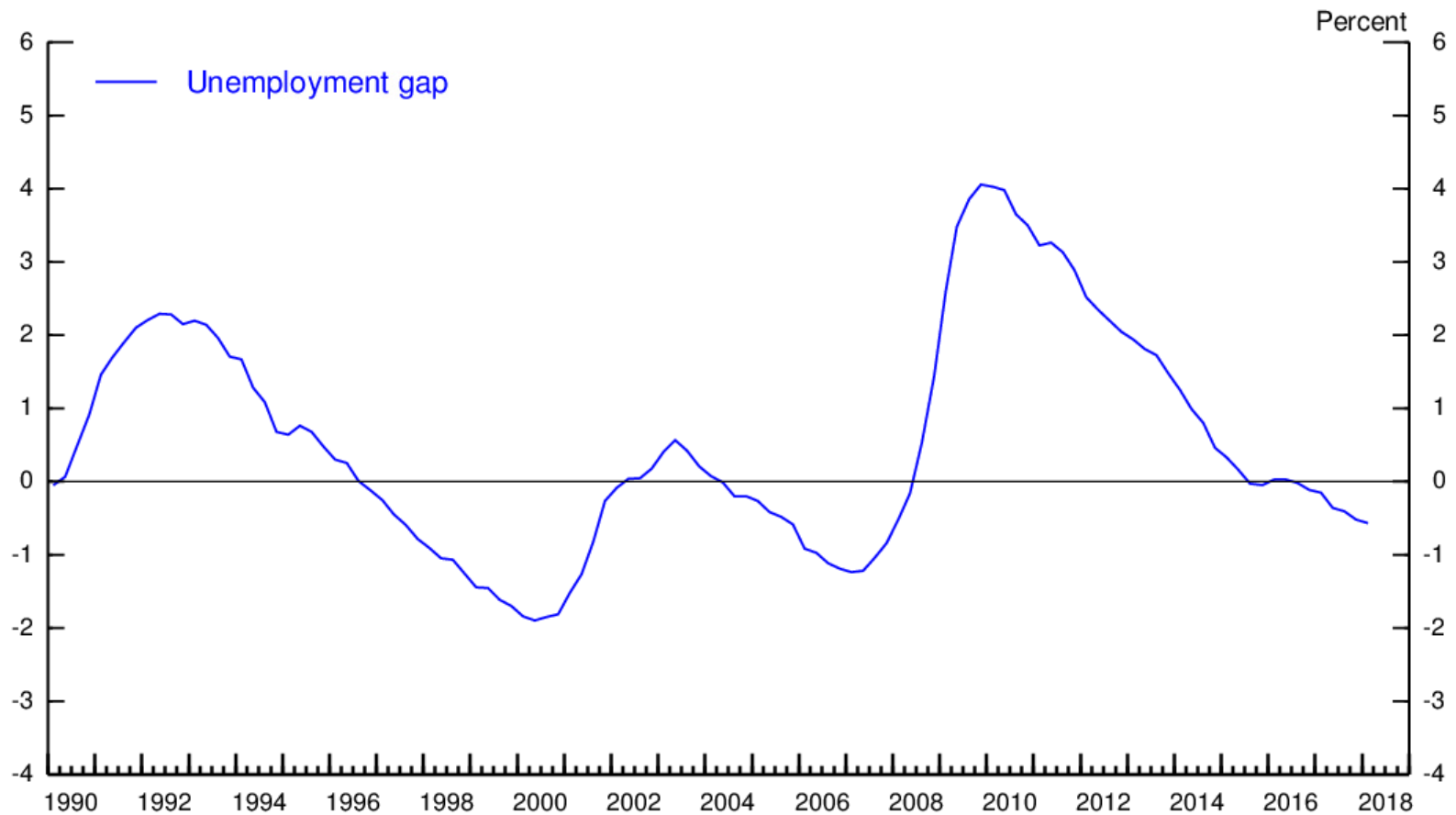
# Key Results from the State-Space Model

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- Trend growth of labor input also slowed
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  - Partially offset by a decline in the natural rate of unemployment
- Model estimates the output gap to be about zero in 2018:Q1

## Results from the State-Space Model: The Output Gap



## Results from the State-Space Model: The Unemployment Gap



# Caveats

- Considerable uncertainty about these estimates
  - 95% confidence interval around potential GDP growth is  $\pm 1$  pp
  - 95% confidence interval around natural rate is  $\pm 1\frac{1}{4}$  pp
  - Doesn't include other possible sources of uncertainty (e.g., data revisions, model uncertainty, etc.)

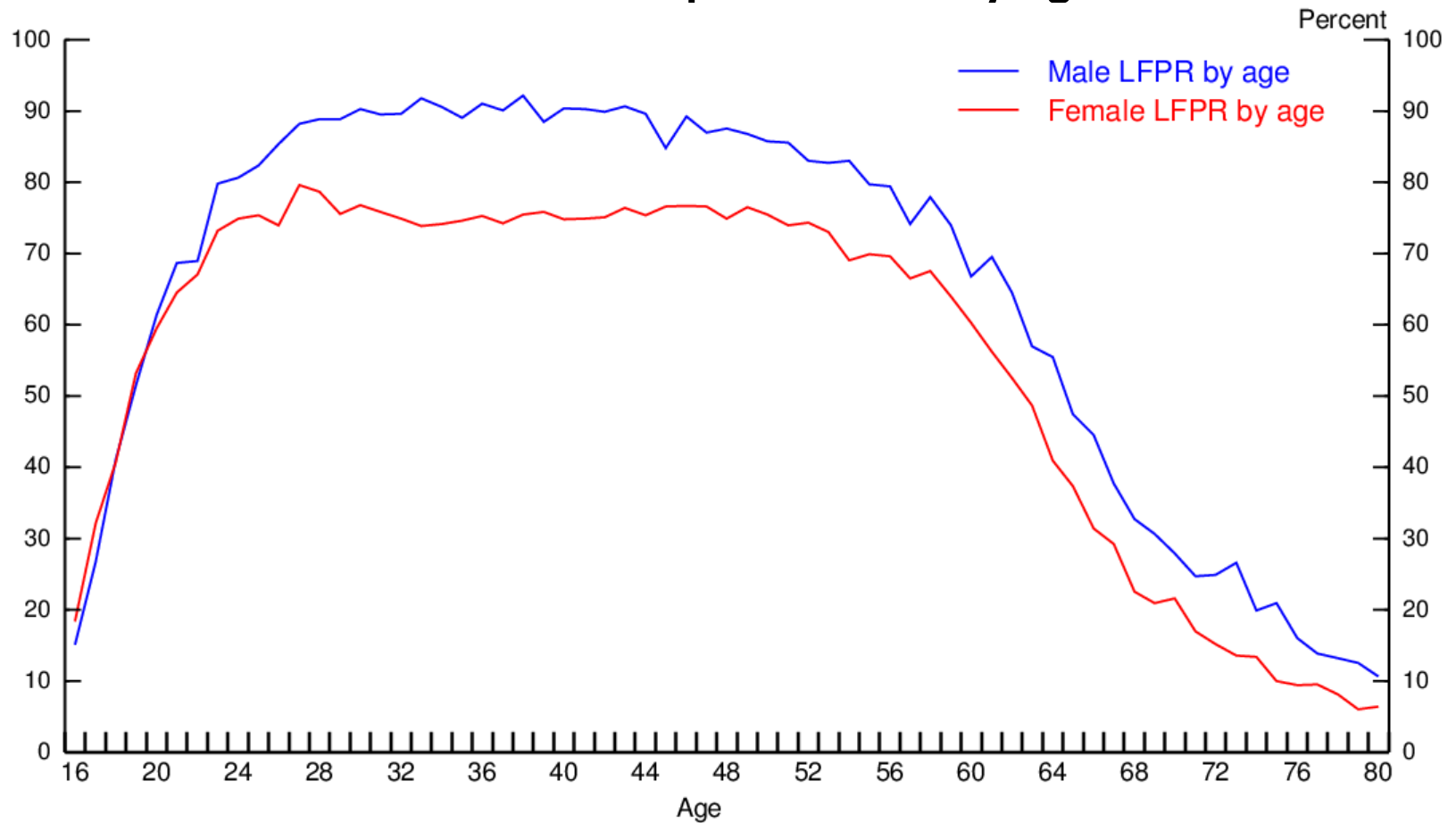
## Some answers from the model

- When the Did Slowdown in Potential Output Growth Begin?
  - Some indication that it started in the early 2000s
  - But clearly steepened around 2009
- What are the underlying reasons for the slowdown
  - Labor force growth – notably participation
  - Productivity growth – low investment; weak multifactor productivity
- Does not necessarily implicate the financial crisis
- Worth doing a deeper dive

# Labor Force Participation

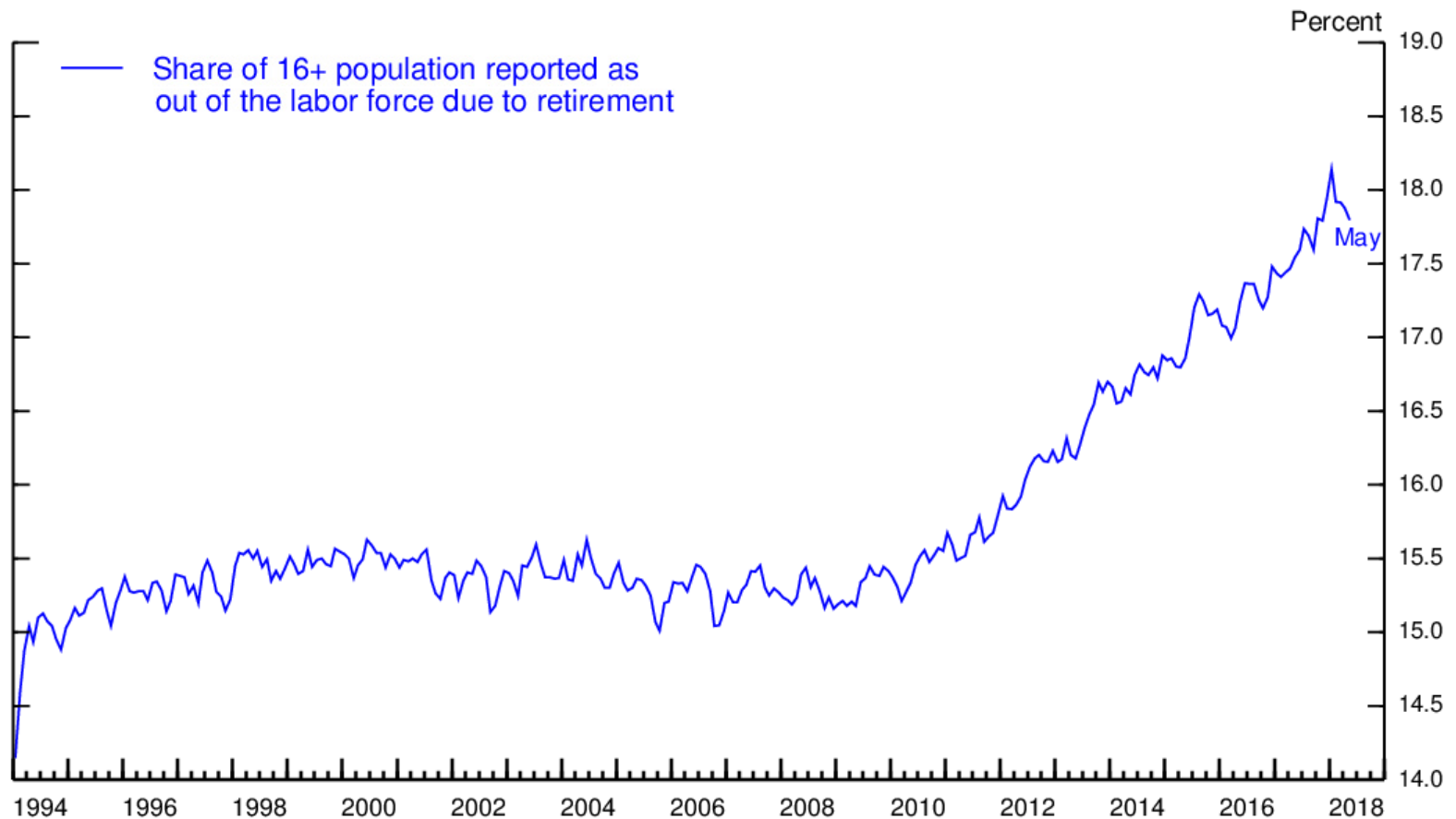
- Role of demographics
- Explanations for low participation rates of prime-age workers
- Updates to Aaronson, et al (2006, 2014)

## 2017 Labor Force Participation Rates by Age and Sex

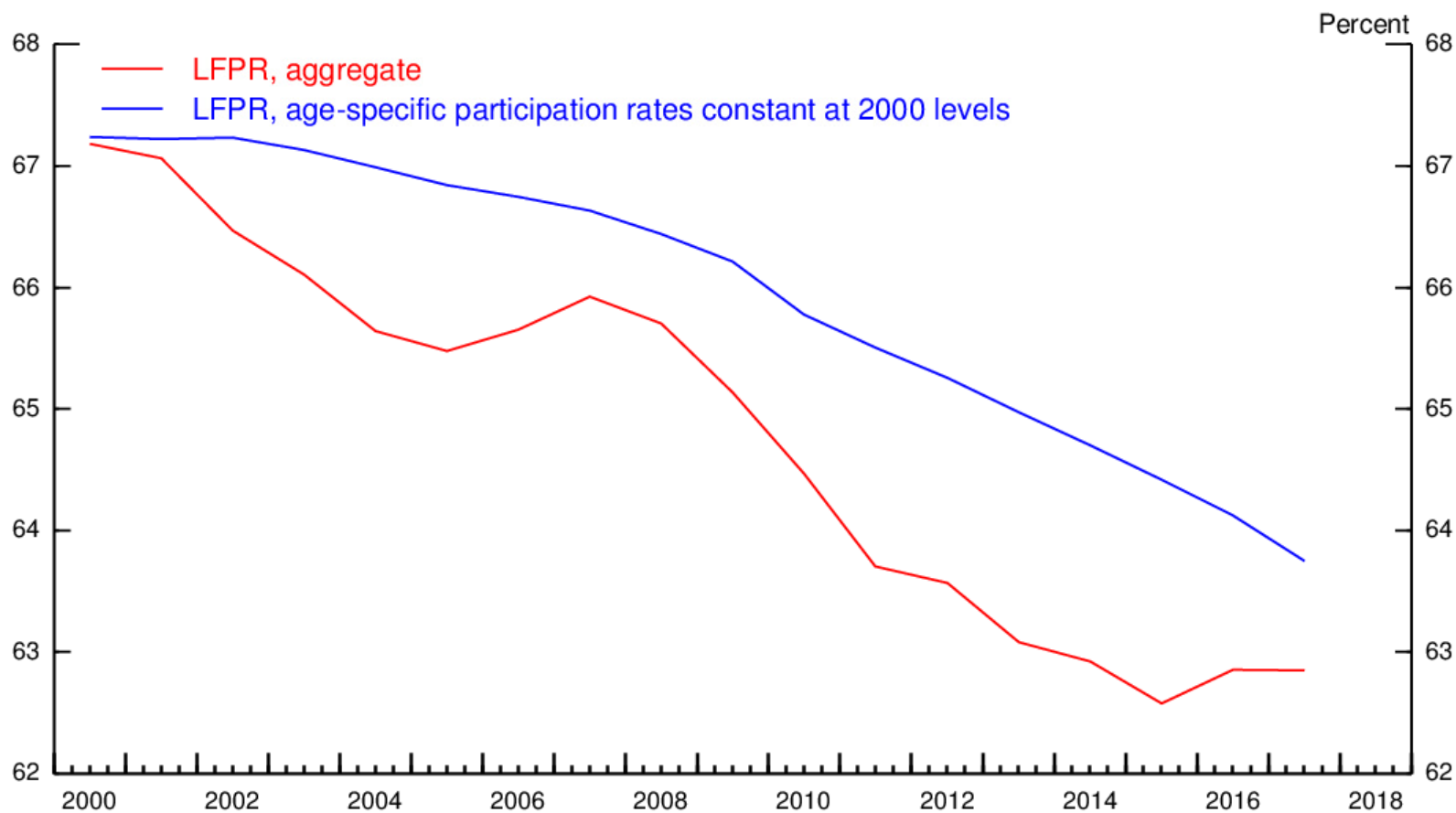




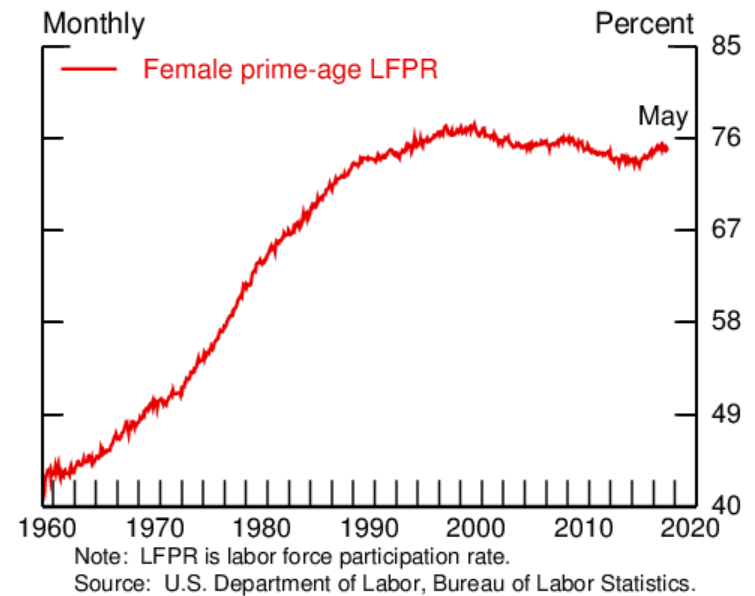
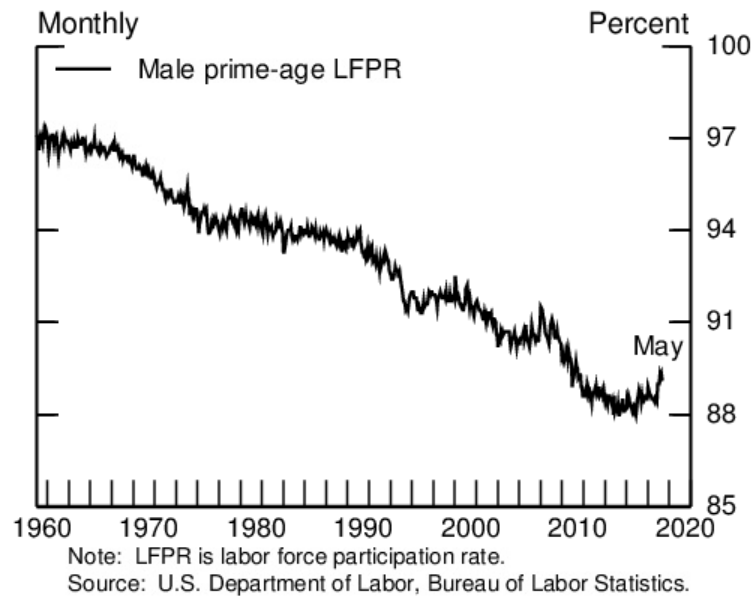
## Share of Population Aged 16+ Self-reported as Out of the Labor Force Due to Retirement



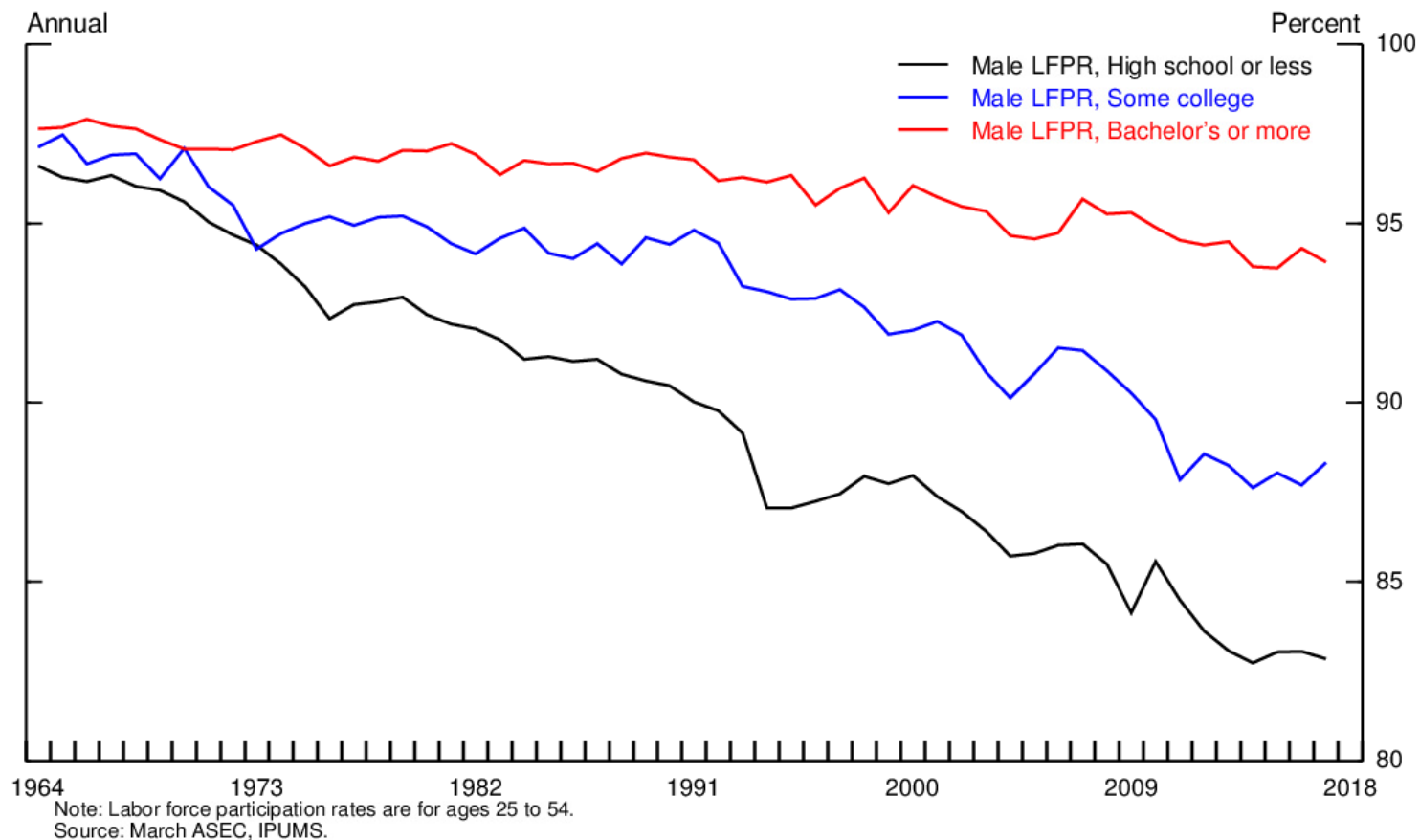
## Labor Force Participation: Effects of Population Aging



## Prime-age labor force participation rates



# Male labor force participation rate by level of educ. attainment

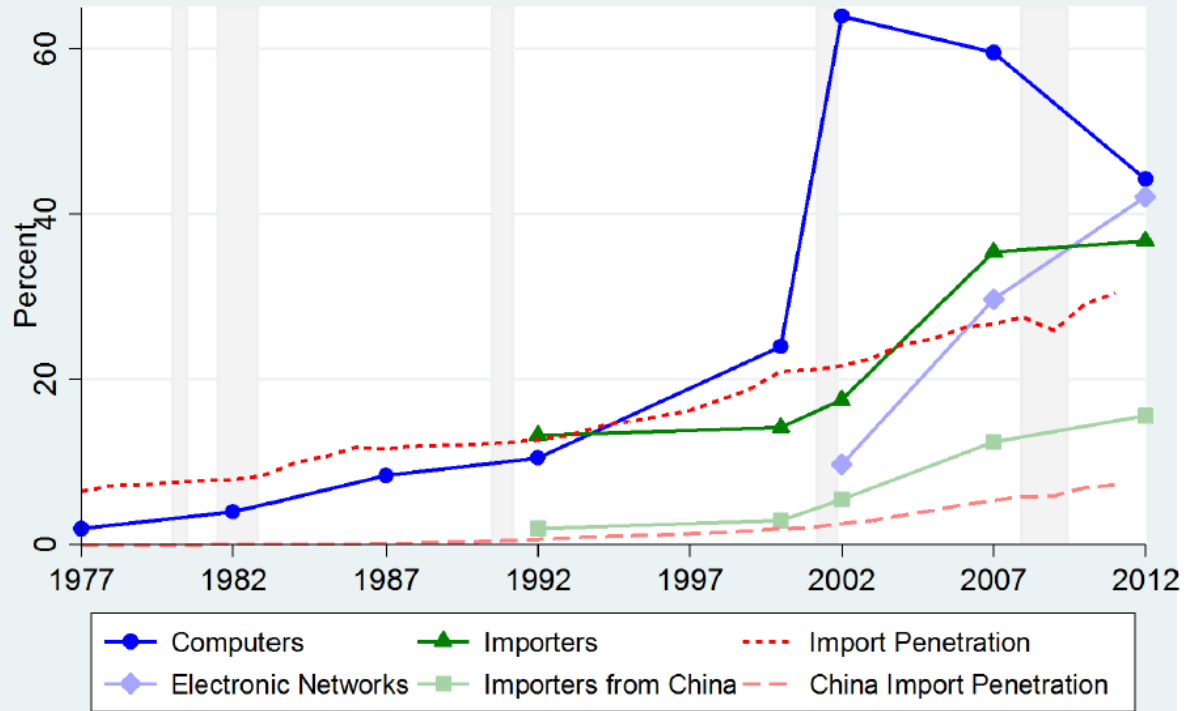


# Contributing Factors

- Demand side most important – roughly  $\frac{1}{2}$  of the decline since 2000 (Abraham and Kearney)
  - Trade
  - Technology
- Particularly evident in manufacturing employment

## Importing and Technology Adoption

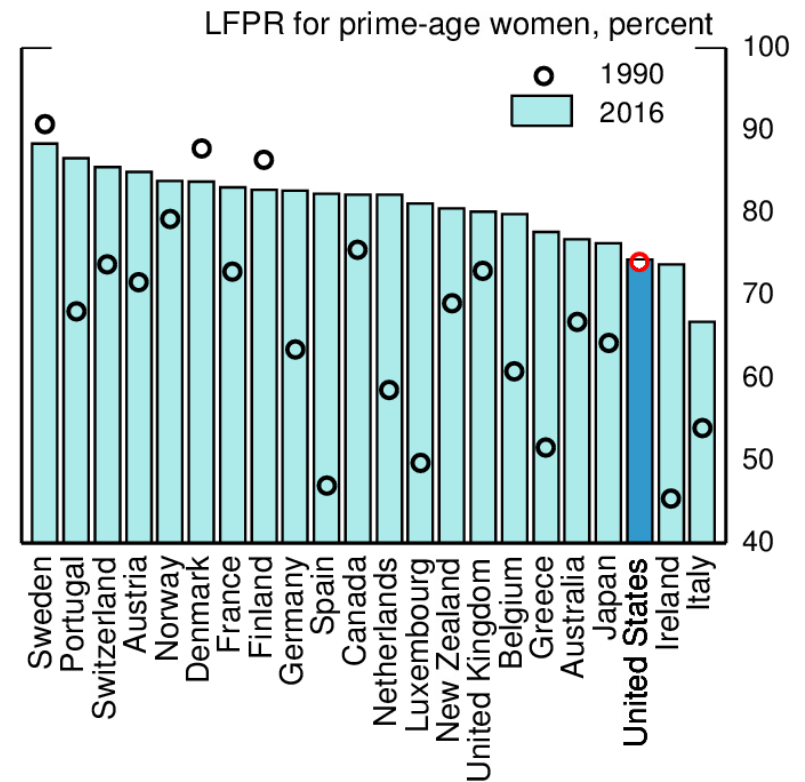
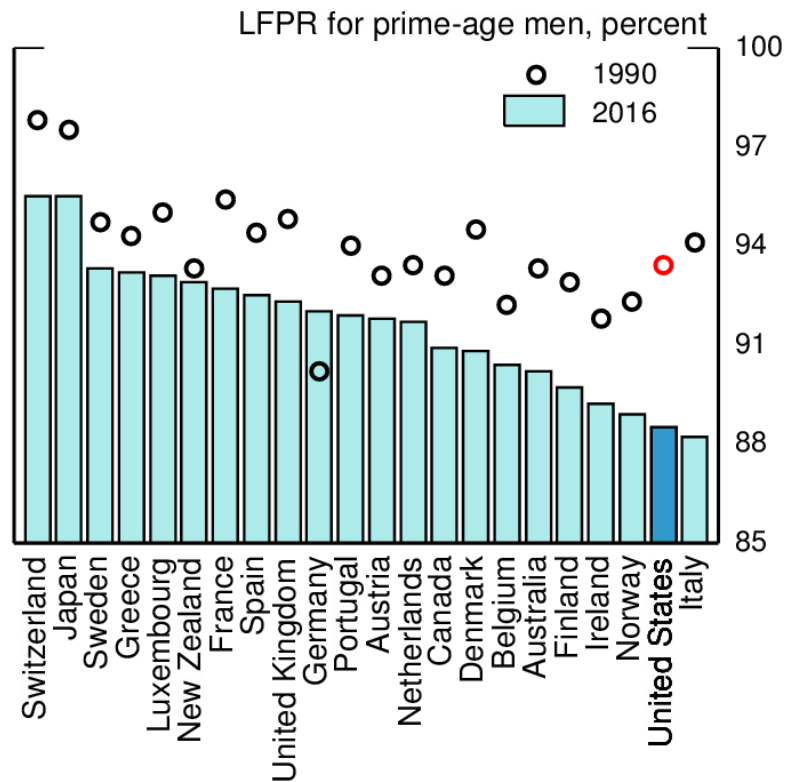
1977-2012



# Manufacturing Employment



## Changes in LFPRs Across Countries



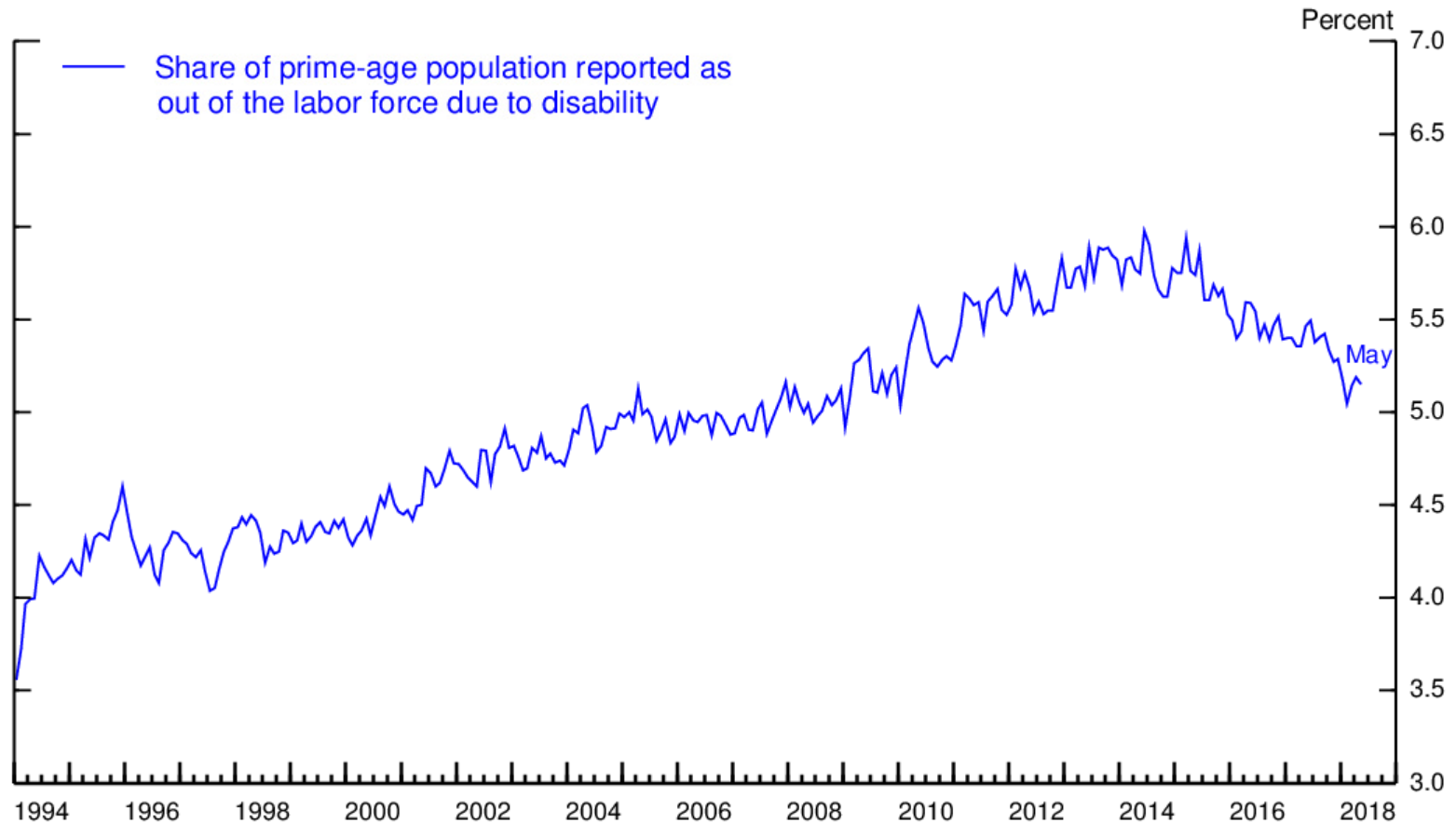
Note: For Austria, the 1990 data refer to 1994; for Switzerland, the 1990 data refer to 1991.  
 Source: Organisation for Economic Co-operation and Development.



# Contributing Factors

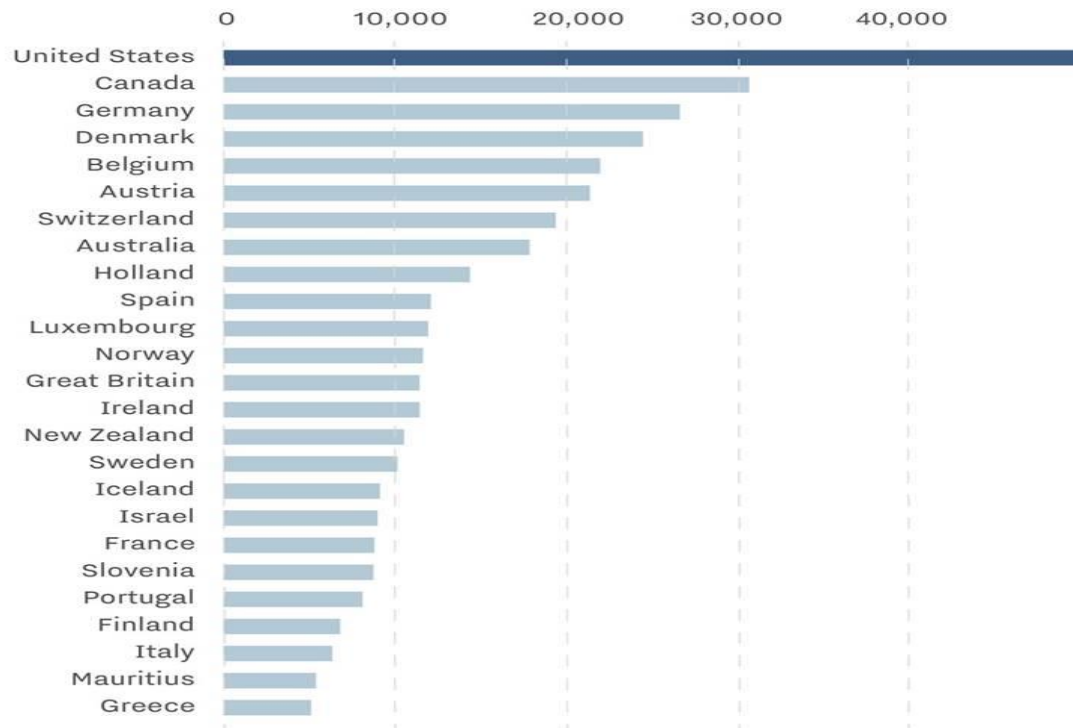
- Demand side most important – roughly  $\frac{1}{2}$  of the decline since 2000 (Abraham and Kearney)
  - Trade
  - Technology
- Possible supply side effects as well
  - Disability insurance
  - Criminal records
  - Opioid crisis

## Share of Population Aged 25-54 Self-reported as Out of the Labor Force Due to Disability



# Americans consume more opioids than any other country

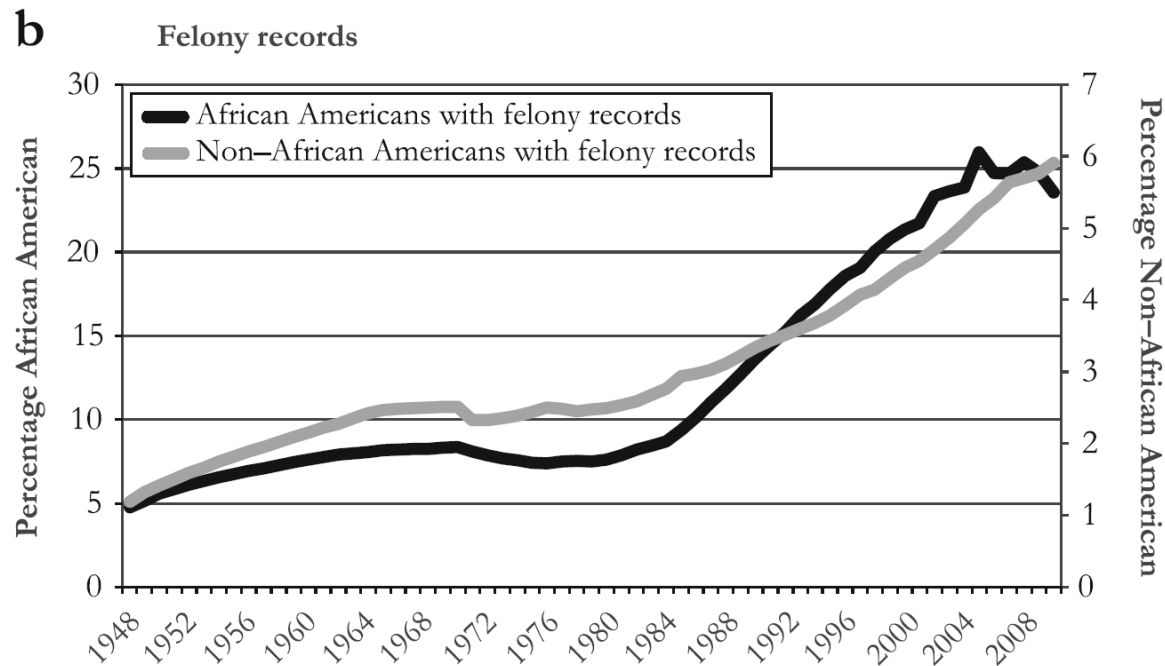
*Standard daily opioid dose for every 1 million people*



Source: United Nations International Narcotics Control Board  
Credit: Sarah Frostenson

**Vox**

# Rising Percentage of Adults with Criminal Record



Percentage of U.S. adult population with prison and felony records by race, 1948–2010

Source: Shannon et al. (2017)

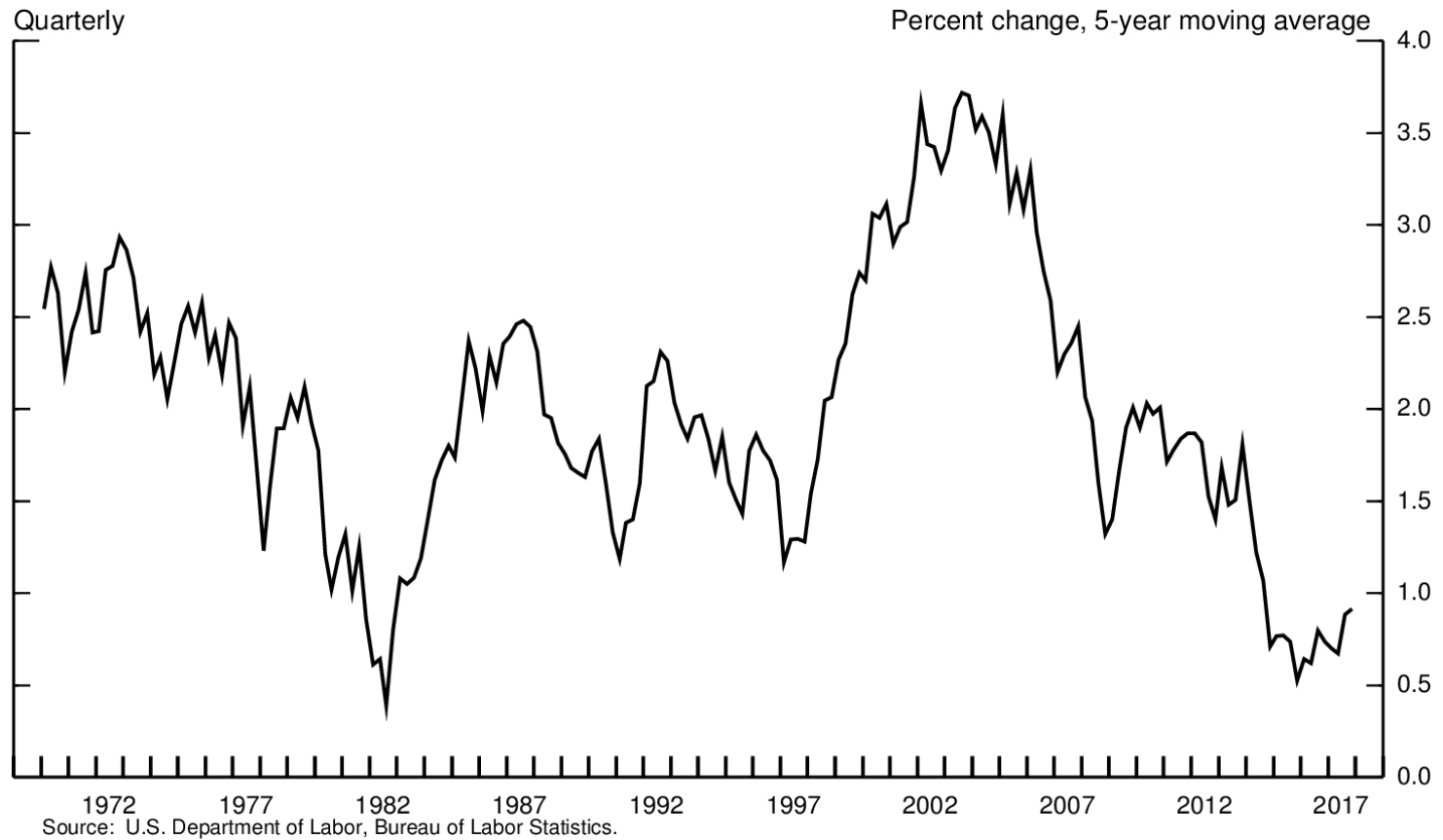
# Contributing Factors

- Demand side most important – roughly  $\frac{1}{2}$  of the decline since 2000 (Abraham and Kearney)
  - Trade
  - Technology
- Possible supply side effects as well
  - Disability insurance
  - Criminal records
  - Opioid crisis
- Financial crisis probably less important

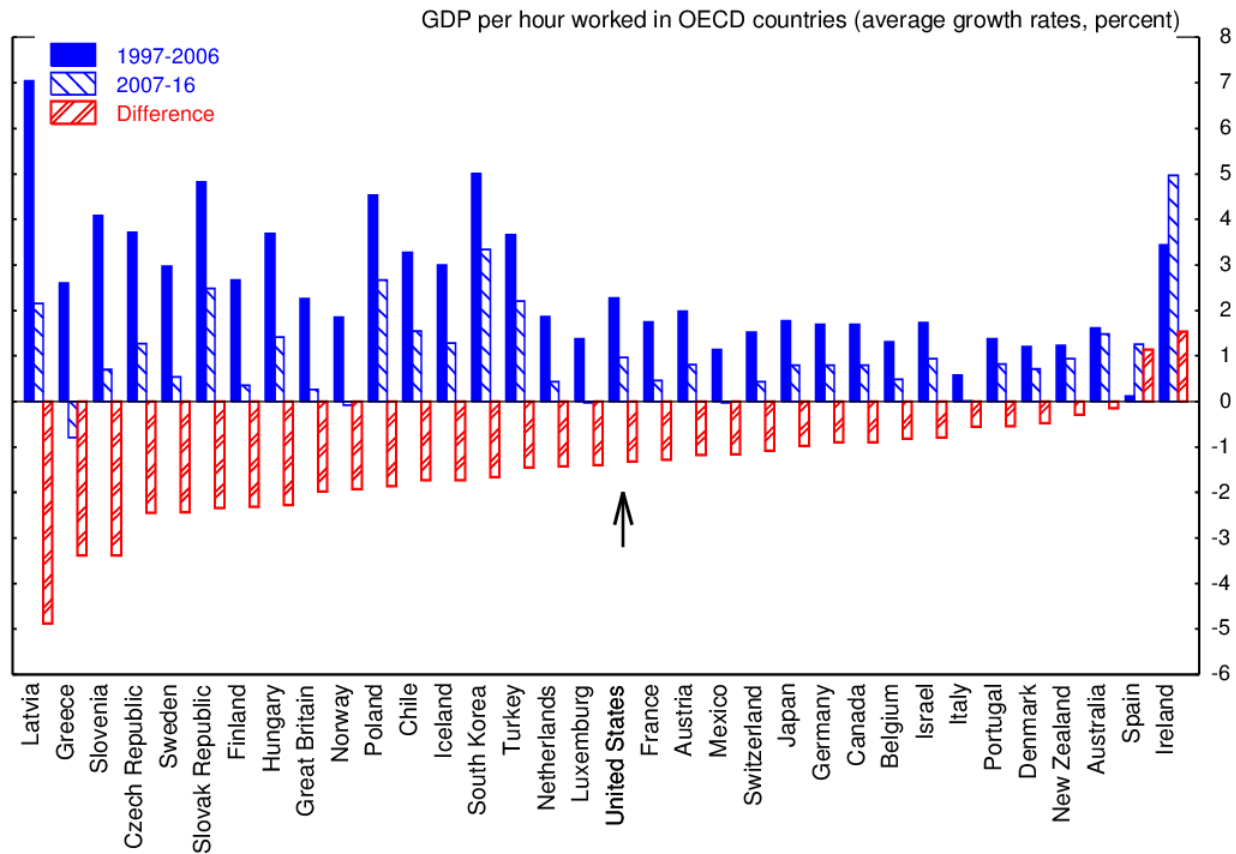
# Productivity Growth

- Some facts
- Potential explanations
- Does the slowdown pre-date the financial crisis?
- Lessons from history
- Measurement

## Labor productivity growth has slowed



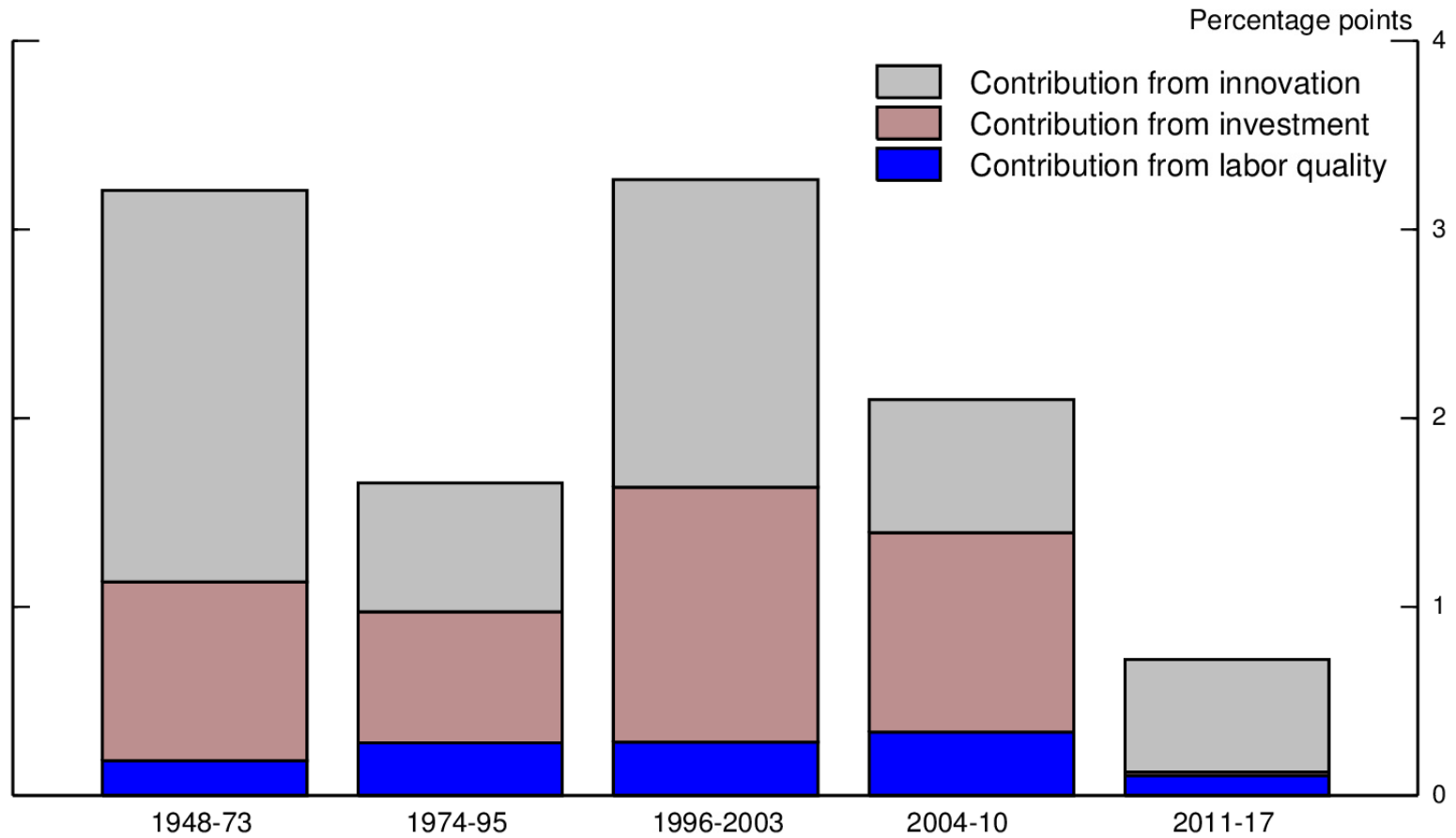
# Productivity slowdown is global



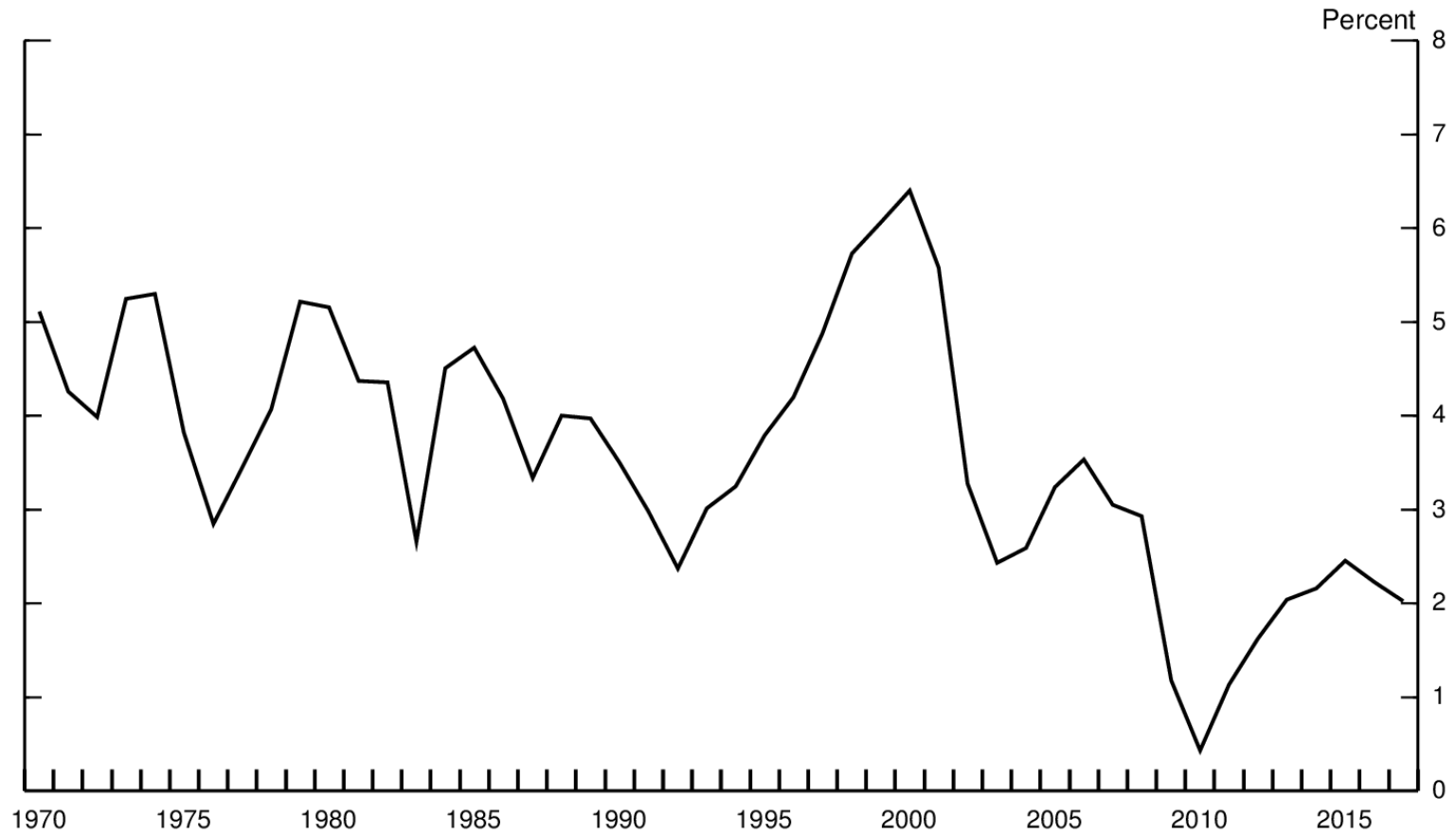
Source: Organisation for Economic Co-operation and Development (OECD), <https://data.oecd.org/lprdy/gdp-per-hour-worked.htm#indicator-chart>.



## Sources of the Slowing in U.S. Productivity Growth



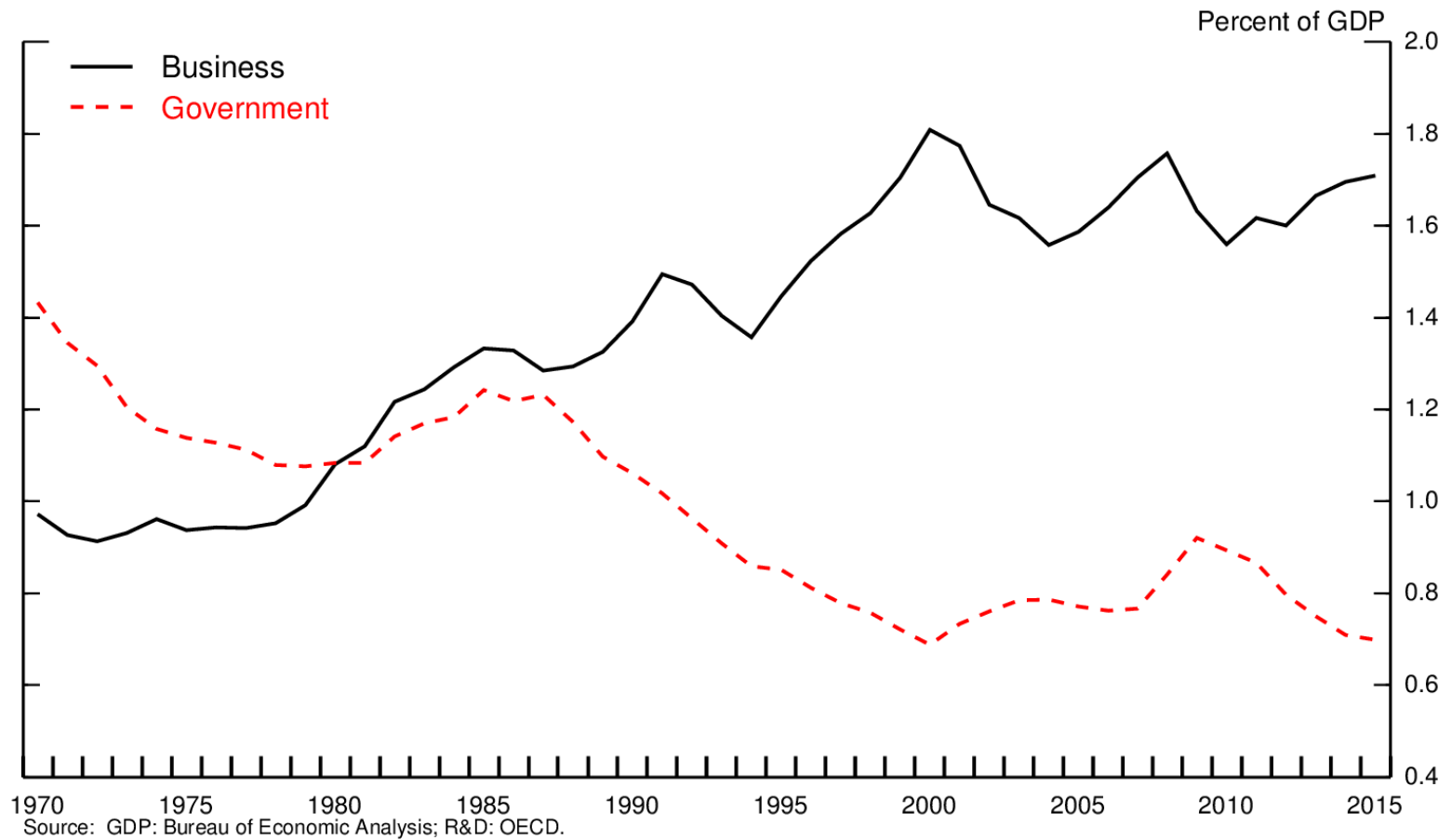
## Growth Rate of Capital Input



# A New Productivity Paradox?

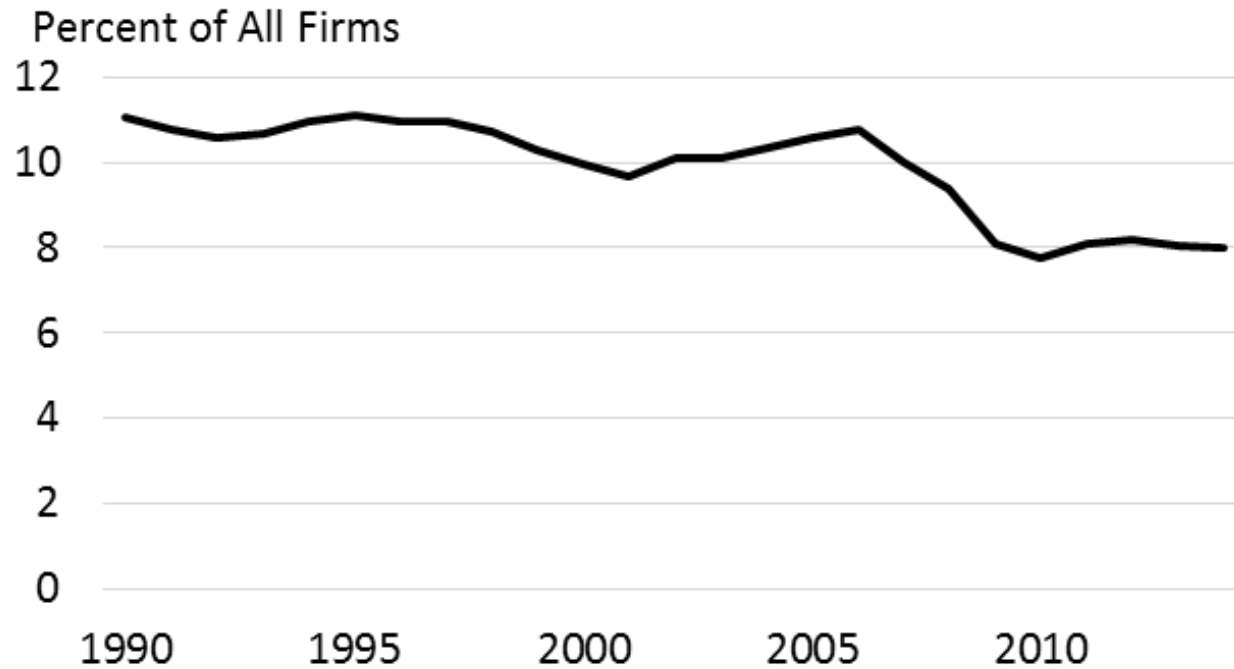
- TFP growth has slowed down markedly but technology seems to be advancing rapidly
  - Great excitement (or fear) about robots, AI etc.
  - We can see the digital revolution everywhere but in the productivity statistics
- Innovation isn't what it used to be
  - Are ideas harder to come by?
  - Have returns on innovation softened?
- The technical frontier is advancing faster than the productive frontier
  - Firms need to reorganize, retool, and retrain
  - Has diffusion slowed?

## U.S. Research and Development Spending



# New Business Formation Has Fallen

## *Firms < 1 year Old*

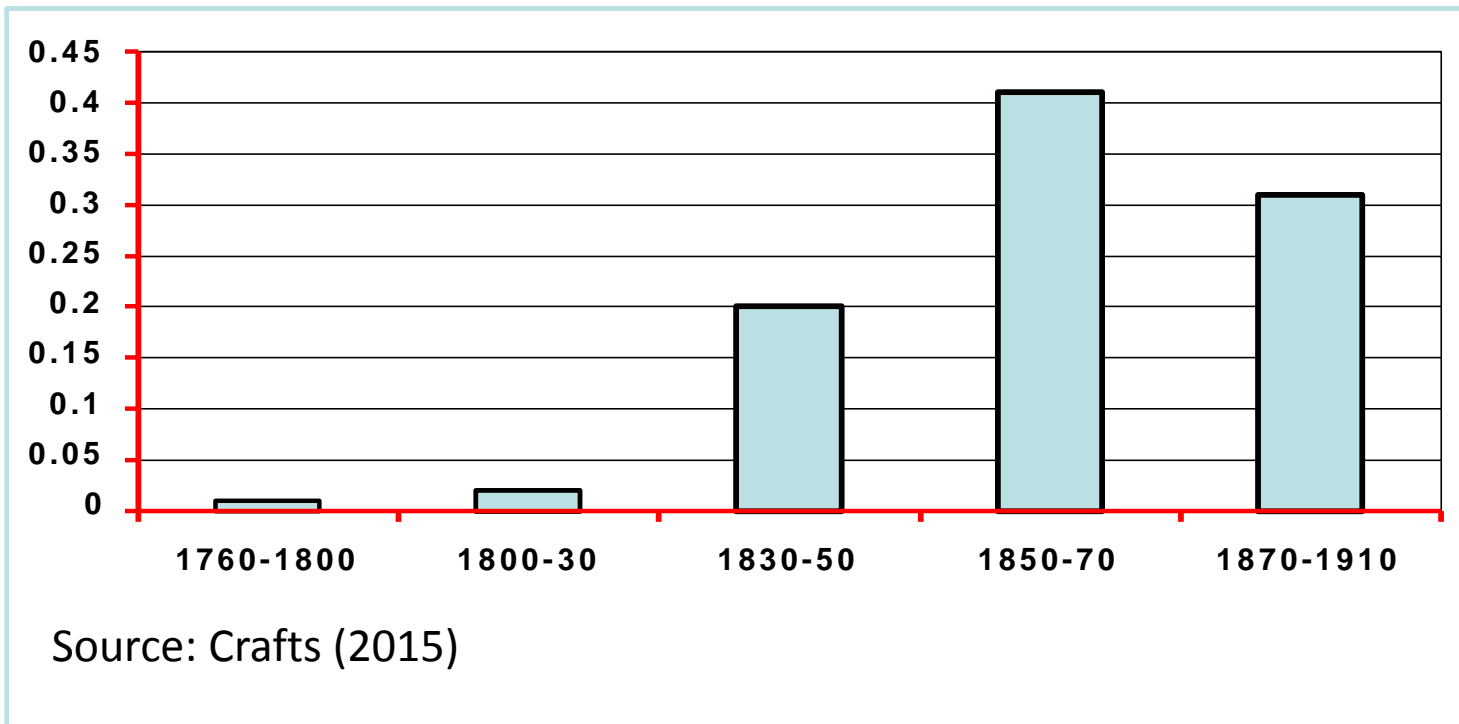


Source. Census Bureau. Business Dynamics Statistics.

## **General Purpose Technologies (GPTs)**

- Aggregate productivity effects typically modest initially: took time to realize full potential
- Possible that GPTs can have big cumulative effect but never raise the aggregate productivity growth rate very much

# Total Steam Contribution to Growth of Labor Productivity (% per year)



# Contributions to Labor Productivity Growth

(per year)

|                          | <i>K/L</i> | <i>TFP</i> | <i>Total</i> |
|--------------------------|------------|------------|--------------|
| <b>Steam (UK)</b>        |            |            |              |
| 1760-1830                | 0.011      | 0.003      | 0.014        |
| 1830-1870                | 0.18       | 0.12       | 0.30         |
| 1870-1910                | 0.15       | 0.16       | 0.31         |
| <b>Electricity (USA)</b> |            |            |              |
| 1899-1919                | 0.34       | 0.06       | 0.40         |
| 1919-1929                | 0.23       | 0.05       | 0.28         |
| 1919-1929 + spillovers   | 0.23       | 0.41       | 0.64         |
| <b>ICT (USA)</b>         |            |            |              |
| 1974-1995                | 0.41       | 0.36       | 0.77         |
| 1995-2004                | 0.78       | 0.72       | 1.50         |
| 2004-2012                | 0.36       | 0.28       | 0.64         |

Source: Crafts (2015)



## General Purpose Technologies (GPTs)

- Aggregate productivity effects typically modest initially: took time to realize full potential
- Possible that GPTs can have big cumulative effect but never raise the aggregate productivity growth rate very much
- ICT had strong and relatively rapid impact, but other GPTs did not

# Contributions to Labor Productivity Growth

(per year)

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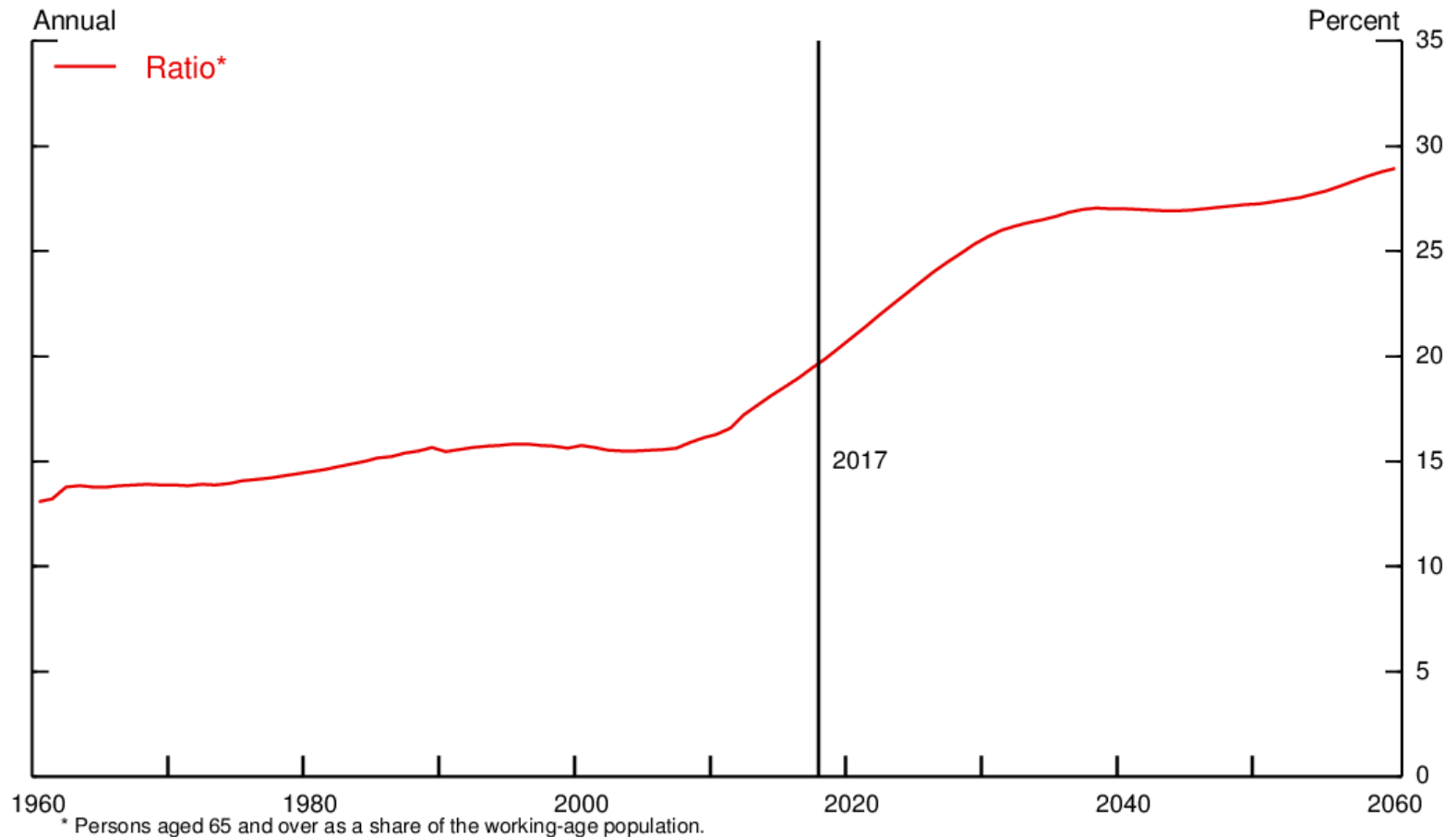
# Overall Assessment

- Can't be certain, but the GFC likely accounts for some the slower growth of potential output.
  - Mostly in labor productivity.
  - Counterfactual unclear
- But it would be too much to assert that all of it was demand driven
  - Demographics important contributor to LFPR trend
  - Long-running decline in LFPR's for prime-age men
  - Evidence that productivity gains from IT slowed before GFC
  - Delayed contributions from GPTs an historical regularity

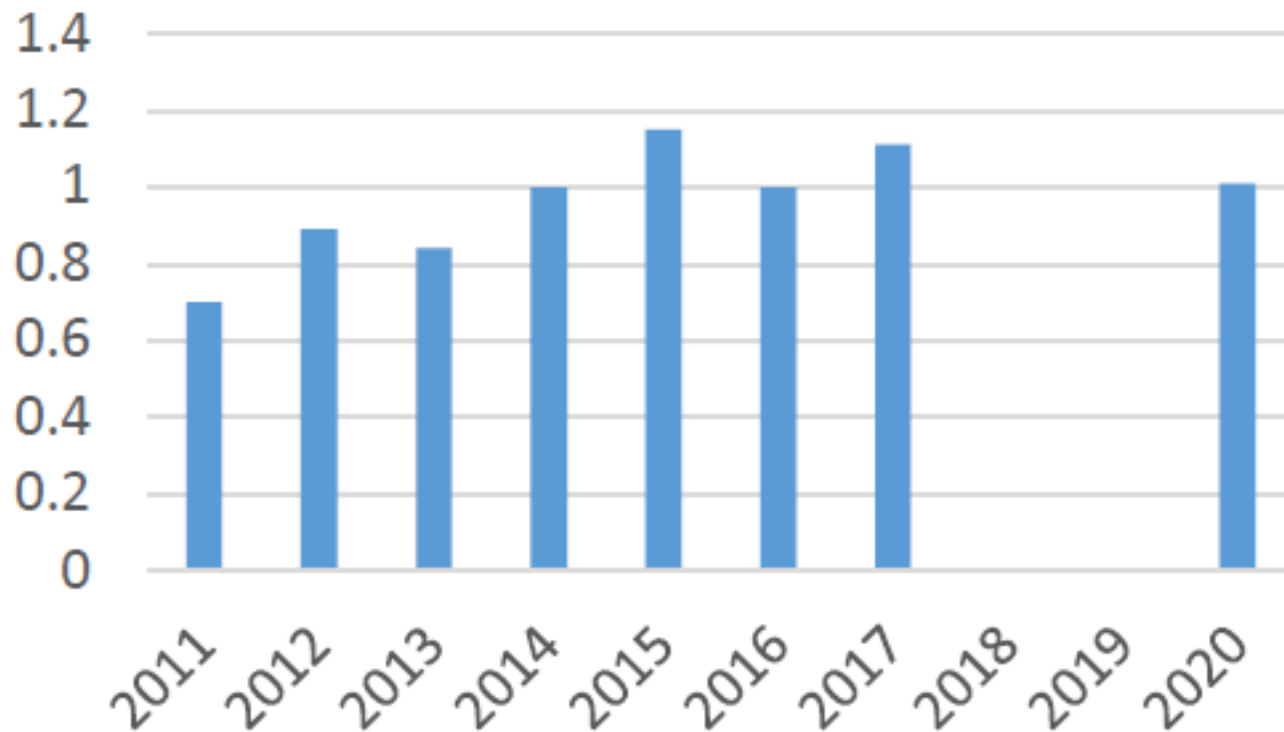
# What should we expect going forward?

- Outlook for labor force growth not particularly favorable
  - Aging of the population will continue
  - Not a clear reason to expect the long downtrend for prime-age men to end (although might see some positive hysteresis from tight labor market?)
  - Could see offsets from rising participation among older individuals due to improved health
  - In contrast, immigration policy seems likely to be more restrictive (immigration currently accounts for half of labor force growth)

# Population Aging Expected to Continue



## Net Immigration (millions).



# What should we expect going forward?

- Outlook for productivity much more uncertain
  - Very wide range of projections for medium-term TFP growth among technology pundits
    - Gordon (2016): 0.4% per year
    - Brynjolffson and McAfee (2014): 2.0% per year
  - Delayed impact of new GPT is a quite plausible explanation of productivity paradox
- The productivity slowdown is not necessarily permanent

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