# MMismeasuring TFP and the myth of productivity shocks

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# Debates over Procyclical Productivity

- Well known that measured productivity is procyclical
- Productivity
  - low in recession
  - high in recoveries
- Debate over whether this is due to:
  - Productivity varying over business cycle
  - Procyclical measurement errors
- If it is measurement error, then
  - Productivity growth at something like a "trend"

# Solow Residual

- Solow Residual (Solow 1957)
  - Used to measure Total Factor Productivity (TFP)
  - Growth in GDP not explained by growth in factor inputs
  - Measure of our ignorance -Abramovitz

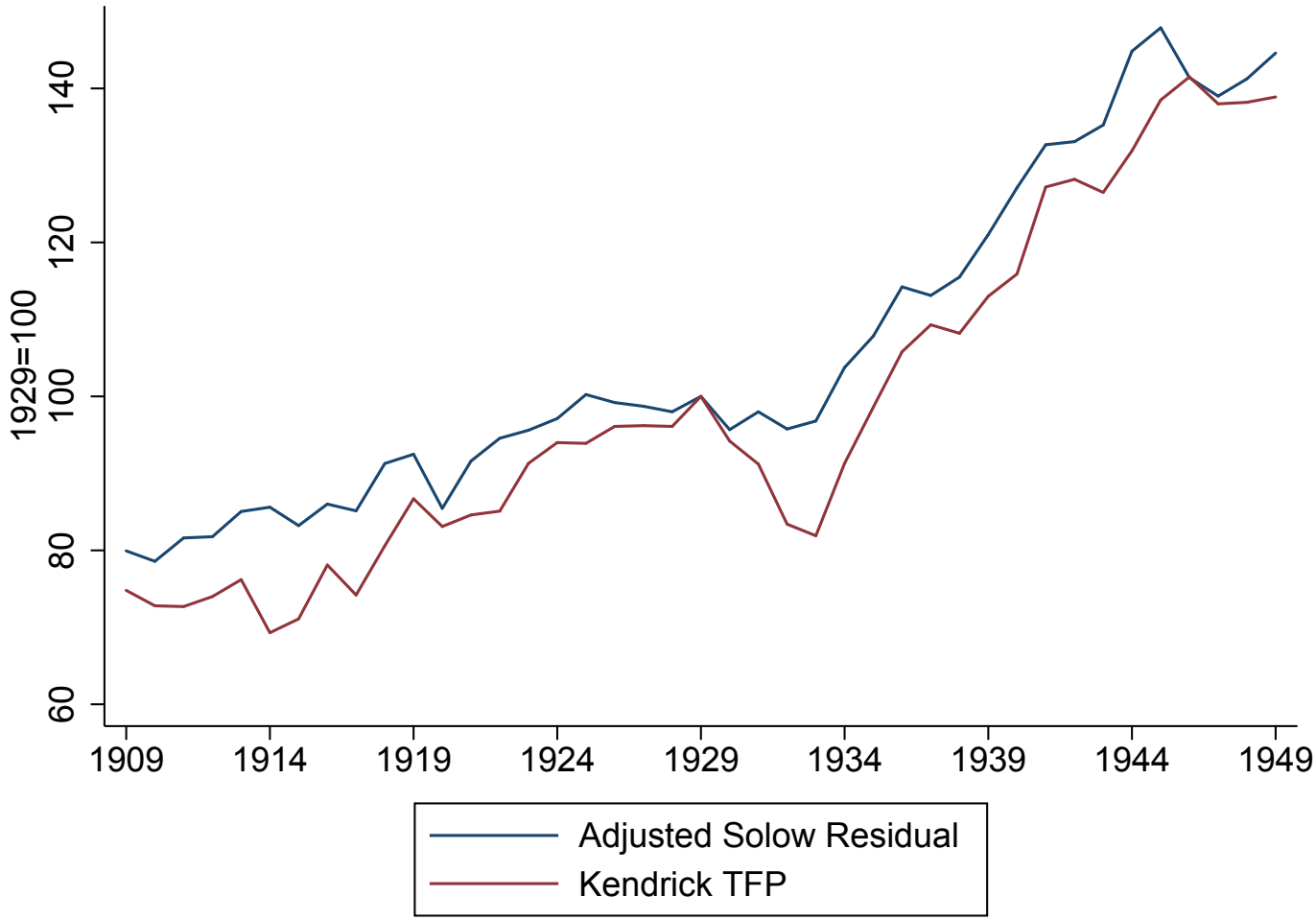
$$Y = AL^{(1-\alpha)}K^{\alpha}$$

$$\frac{dA}{A} = \frac{dY}{Y} - (1-\alpha)\frac{dL}{L} - \alpha\frac{dK}{K} \tag{1}$$

# Cyclicality of Solow Residual

- Solow Residual is Procyclical
  - Little debate about this for postwar (through at least 1980)
- Debate is whether this is due to:
  - Exogeneous Changes in TFP
    - Changes in TFP $\rightarrow$ changes in output
  - Measurement Error (Cyclical)
    - Changes in output $\rightarrow$ changes in TFP

# Historical Solow-Adjusted and Unadusted Solow Residual



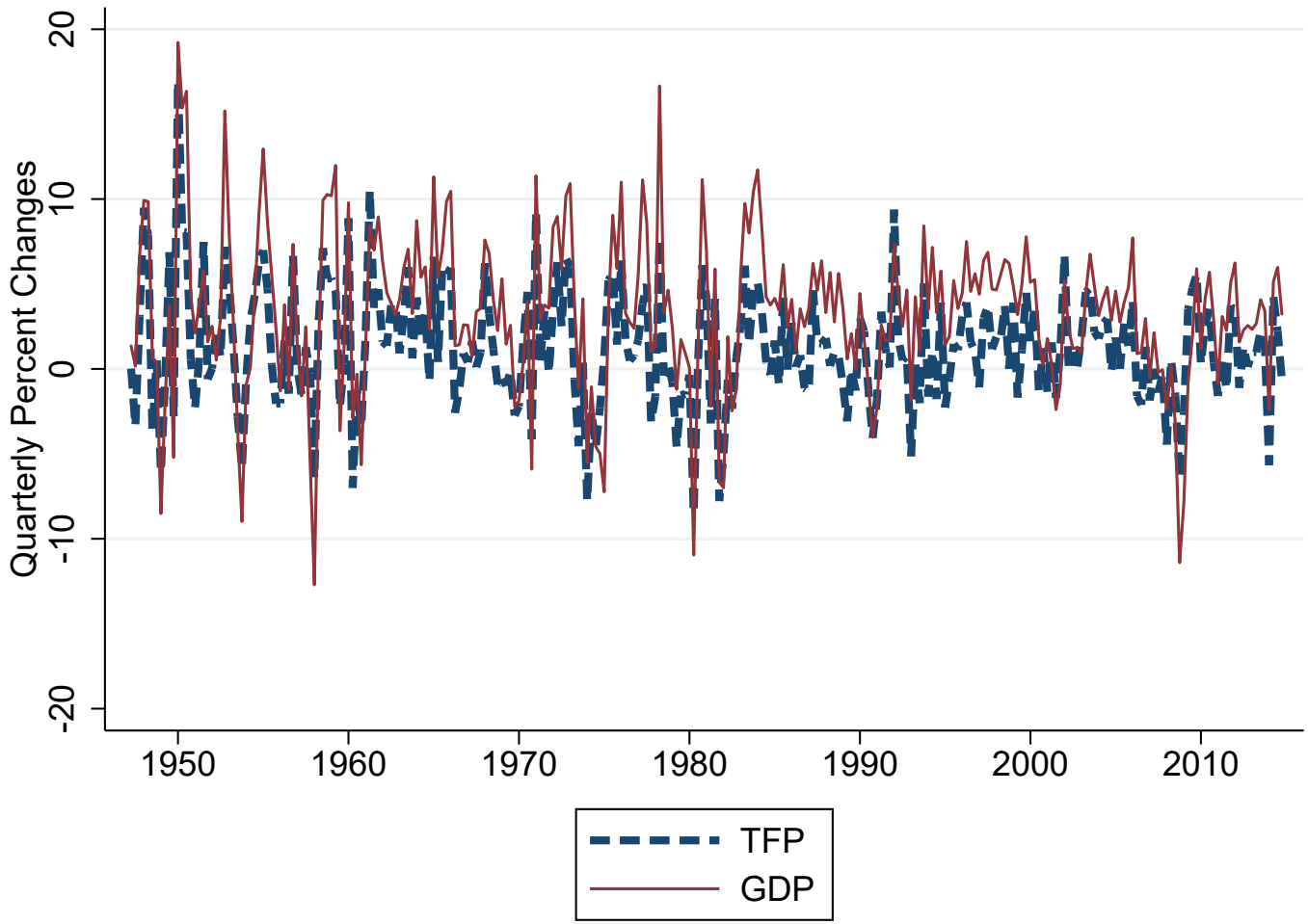
# Real Business Cycle Theory

- Real Business Cycle Theory
  - Often based on productivity shocks
  - Long and Plosser 1983, *inter alia*
- Productivity falls in recessions

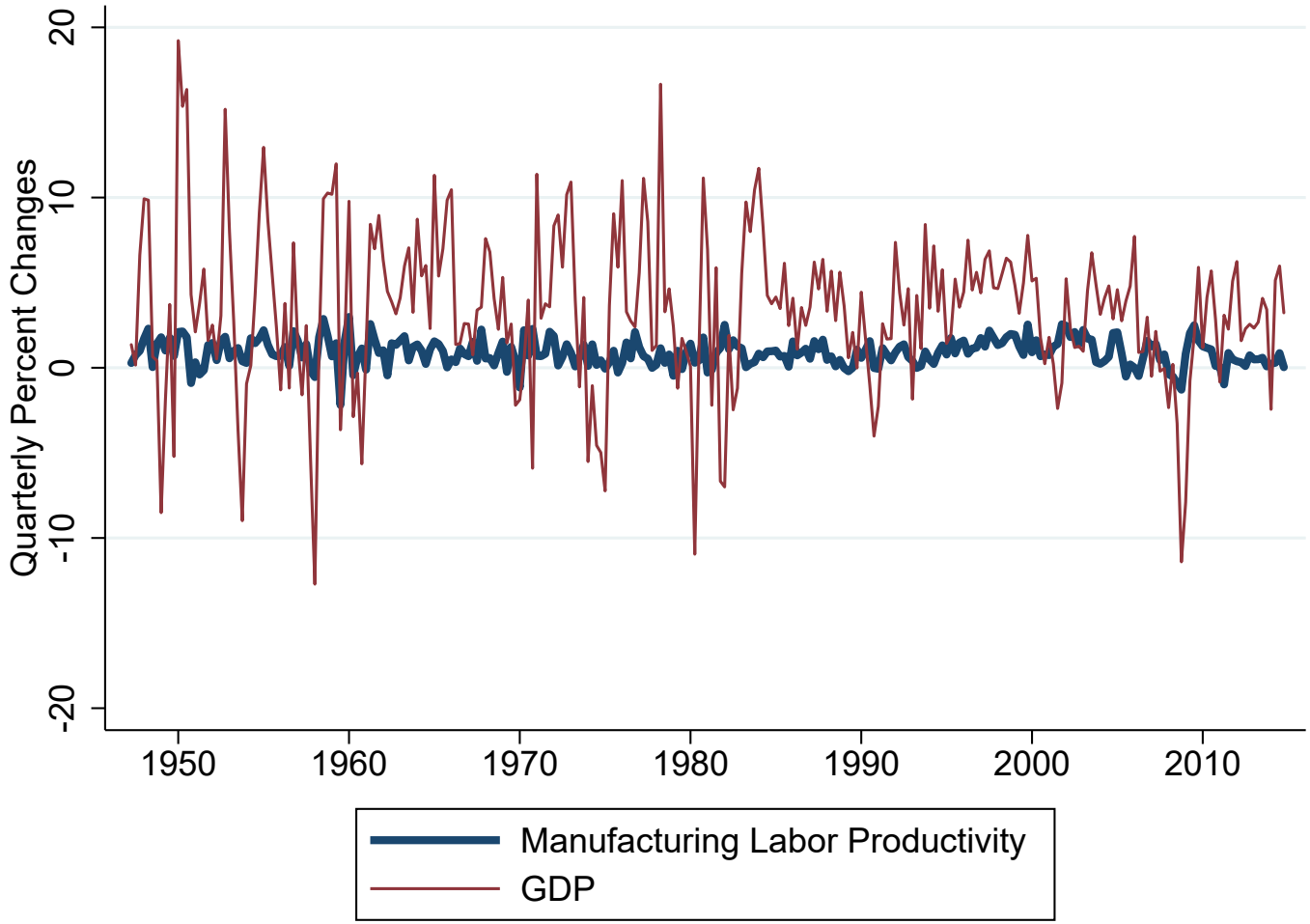
1. Marginal Product of Labor falls
   - Wages fall
     - Workers choose to work less
     - Move along labor supply curve

2. Marginal Product of Capital falls
   - Interest rates fall
     - Firms choose to invest less
     - Move along investment supply curve

# Quarterly Percent Change in Solow Residual and Real GDP



# Quarterly Percent Change in Production Labor Productivity and Real GDP



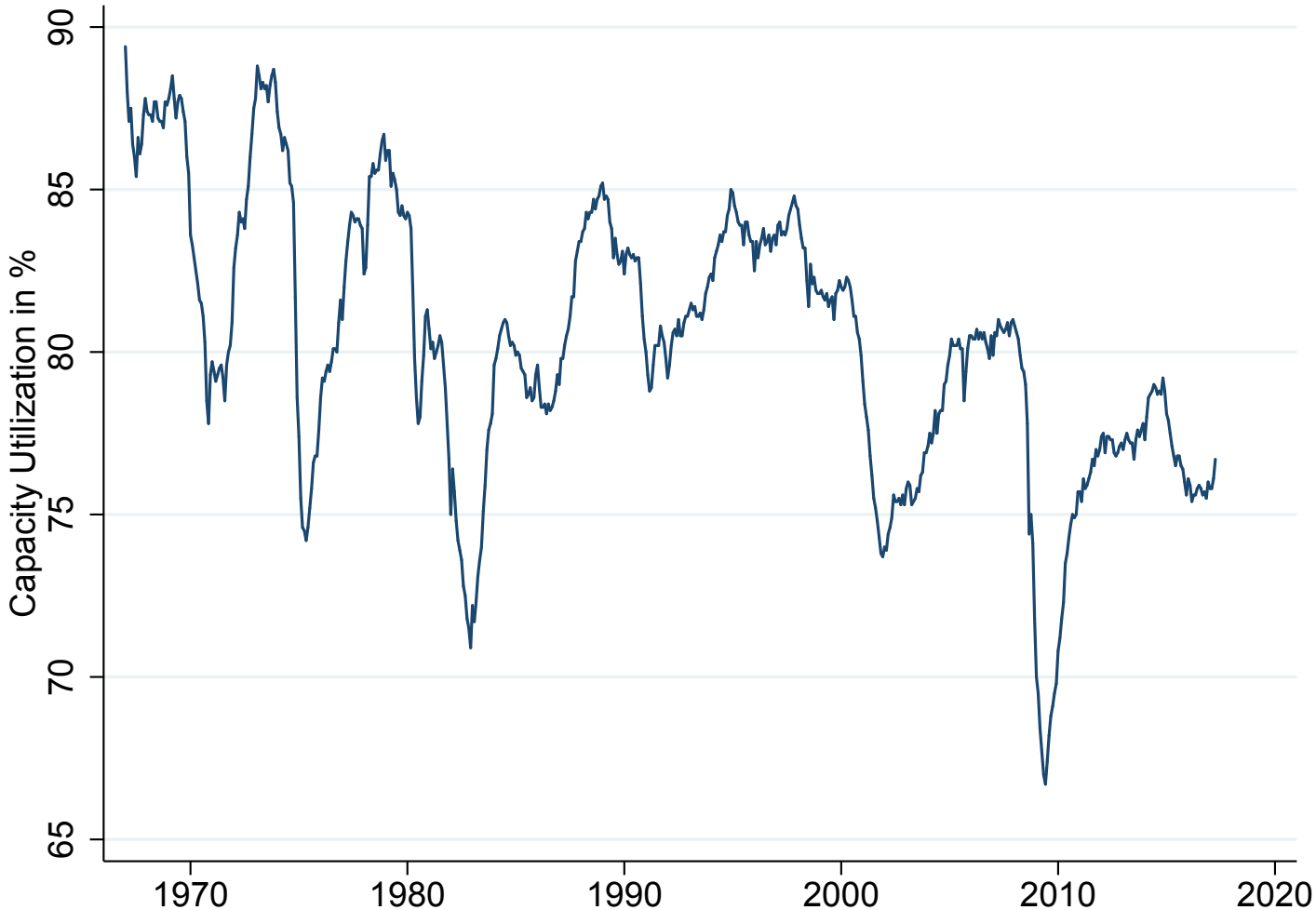
# Factor Hoarding

- Labor Hoarding
  - Don't fire workers when sales fall
  - Ready to ramp up production once sales recover
- Capital Hoarding/Irreversible Investment
  - Don't scrap factory when sales fall
  - Ready to ramp up production once sales recover
  - Ramey and Shapiro (2001), Dixit and Pindyck (1994)

# Cyclical Factor Utilization

- Labor Utilization
  - Workers work harder (less hard) when sales are high (low)
  - Accountants, Consultants, etc.
  - Christmas (Braun and Evans, 1998)
- Capital Utilization
  - Run fewer shifts to save on labor costs
  - Idle capital for maintenance / reduce depreciation

# Capacity Utilization (in industry): varies a lot!



# Overhead Factors

- Overhead Capital
  - Easier to adjust equipment investment
  - Investment in structures is "overhead" and slow to adjust
- Overhead Labor
  - Easy to adjust blue collar/production workers
  - White collar/salaried workers more inflexible
  - Costly to break up teams of engineers, restructure management, etc.

# Deviations from Standard Production Function/Competition

- Market Power
  - Market power likely procylical
  - Market power makes firms look more productive
  - Increases value of output without more inputs
- Increasing Returns to Scale
  - Many industries have increasing returns to scale (in short-run)
  - As sales $\uparrow$, measured productivity rises with returns to scale

# Literature on Mismeasurement

| Authors | Hoarding | Utilization | IRS/MP |
|---|---|---|---|
| Solow (1957)/Okun(1962) | X | X | |
| Jorgenson and Griliches (1967) | | | X |
| Hall (1988, 1990) | | | X |
| Rotemberg and Summers (1990) | X | | |
| Bernanke and Parkinson (1991) | | | X |
| Eichenbaum (1991) | X | | |
| Caballero and Lyons (1992) | | | X |
| Burnside, Eichenbaum, Rebelo (1993) | X | | |
| Basu(1997) | | | X |
| Basu and Kimball (1997) | | X | X |
| Braun and Evans (1998) | X | | X |
| Basu and Fernald (2001) | | X | X |
| Inklaar et al. (2011) | X | | |
| Fernald (2012) | | X | |

# What this paper does

- To deal with issue of mismeasurement
  - Use alternative measure of productivity
- Productivity of Production & Nonsupervisory Workers in Manufacturing
  - Make index of production worker manhours in manufacturing
    - Hours worked per week * total employment
  - Divide manufacturing output by production worker manhours
- Labor productivity has been used many times before
  - Manufacturing labor productivity behaves differently

# Benefits to using this measure

- Eliminates mismeasurement problems from TFP
- Long historical dataset
  - Annual 1899-1926
  - Monthly 1919-present
- Allows us to look at productivity in Great Depression

# Manufacturing pros and cons

- Using manufacturing data has pros and cons
- Pros:
  1. Most productivity growth in manufacturing vs. services$\rightarrow$ good sector to identify cyclicality of productivity
  2. Manufacturing is most cyclical sector vs. services/agriculture $\rightarrow$ good sector to identify cyclicality of productivity
  3. Manufacturing relatively easy to quantity
- Cons:
  1. Manufacturing is never more than 30% of GDP, about 10% now
  2. Could be there is cyclicality of productivity in the non-manufacturing sector
  3. Imported inputs become increasingly important in manufacturing $\rightarrow$ imported labor hours not measured
  4. Wage Earners/Production Workers/Production & Nonsupervisory categories slightly different

# Capital Deepening

- Difference between TFP and labor productivity is capital deepening

$$Y = AL^{(1-\alpha)}K^{\alpha}$$

$$\frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha}$$

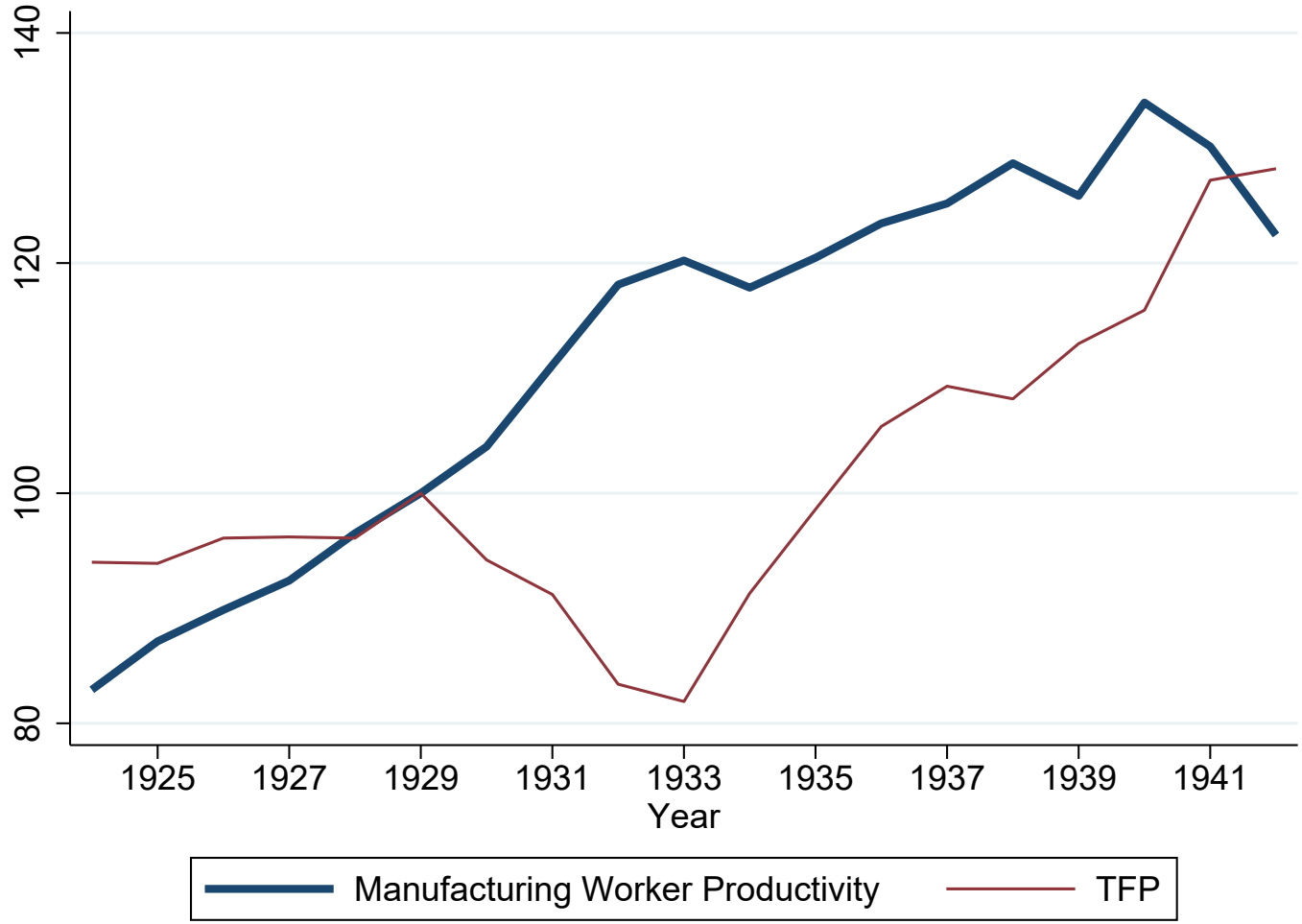
$$g\left(\frac{Y}{L}\right) - g\left(A\right) = \alpha \; g\left(\frac{K}{L}\right) \tag{2}$$

- As we will see, two measures behave differently over the business cycle
  - Must be from the capital deepening term (mechanically)
- But capital deepening in practice has little cyclicality
  - Suggestive of mismeasurement issues instead

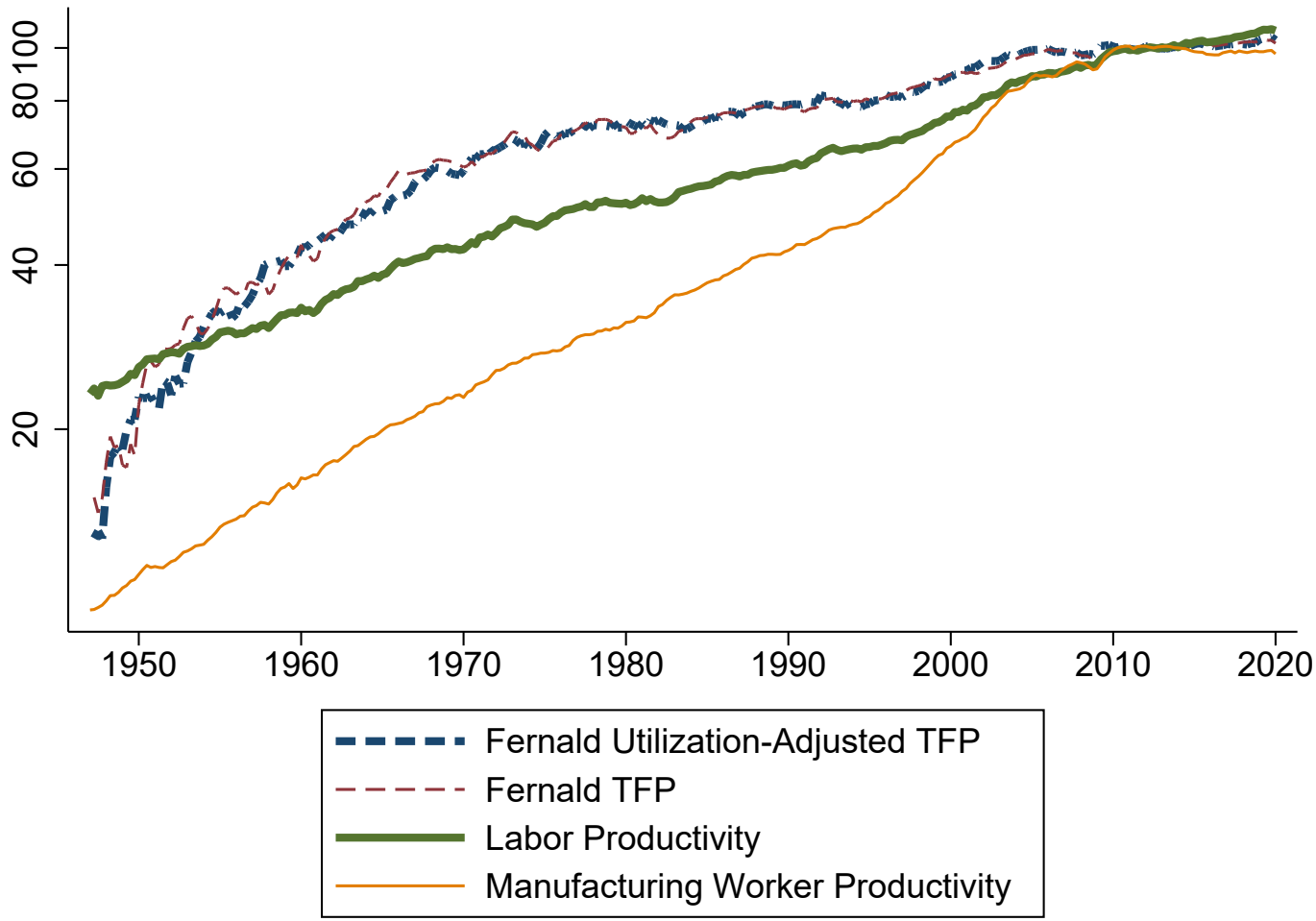
# Solow Residual versus Production Labor Productivity

- Why else might the two productivity measures diverge?
  - Change in share of manufacturing in GDP
  - Change in share of labor in manufacturing
- But this doesn't vary much, especially over business cycle
  - Even Great Depression
- Field (2003) finds TFP growth from 1929-1941 is 2.6%
  - I find 2.51% over same period for production labor productivity
- Graphs show close correspondence between trends of two measures of productivity

# Solow Residual and Production Labor Productivity 1924-1942



# Solow Residual, Production Labor Productivity, and Utilization Adjusted TFP



# Preview of Results

- This paper finds that:
  - Cyclicality of productivity is due primarily to measurement issues with Solow Residual
  - Correcting for these measurement issues yields largely smooth series for productivity
  - Changes in GDP $\Rightarrow$ changes in measured Productivity
  - Changes in actual productivity $\not\Rightarrow$ changes in GDP
- Changes in productivity can not matter much for business cycles

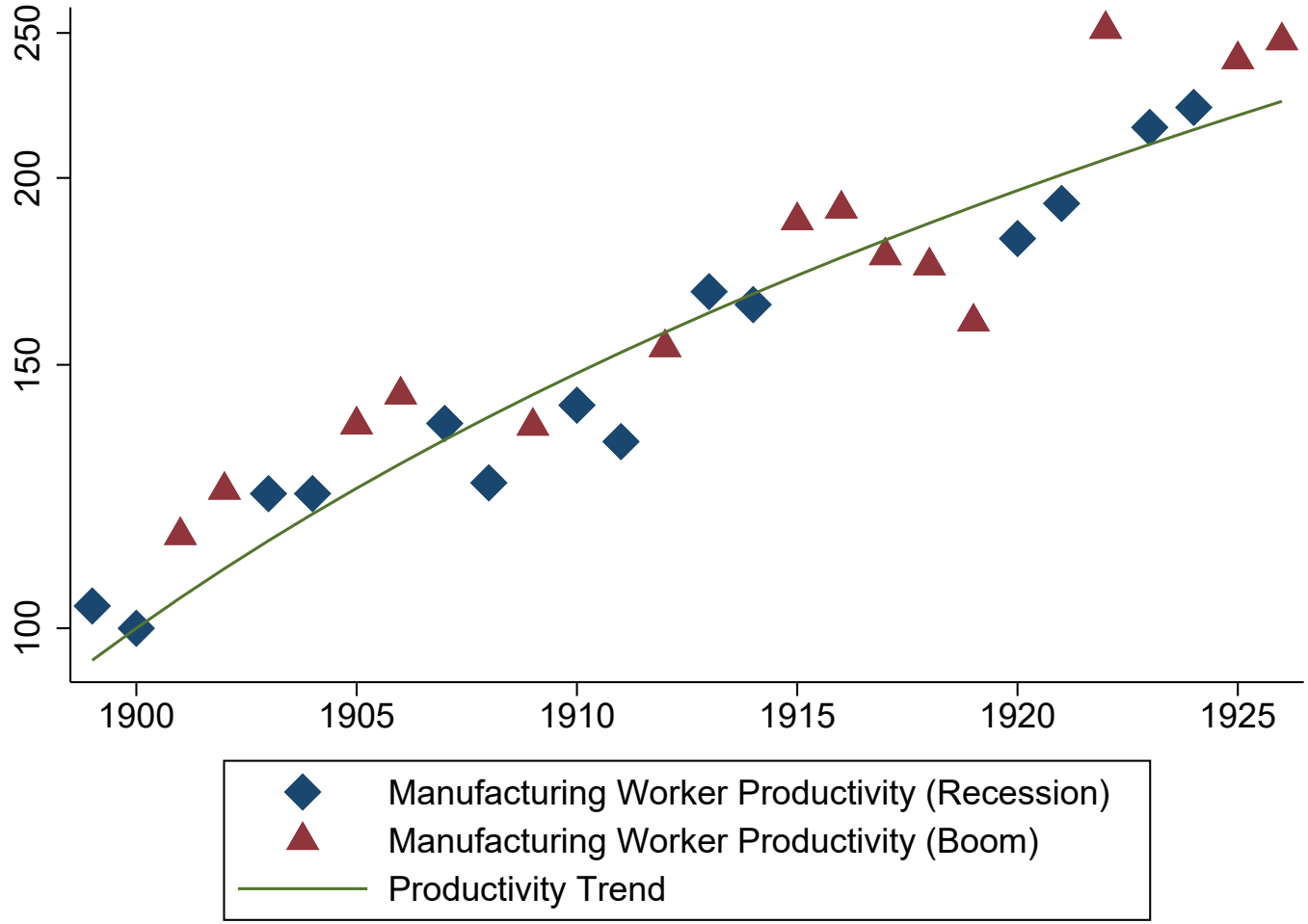
# Solow Residual versus Production Labor Productivity Productivity

| Avoids Mismeasurement | Solow Residual | Production Labor Productivity |
|---|---|---|
| Labor Hoarding | - | - |
| Capital Hoarding | - | ✓ |
| Labor Utilization | - | - |
| Capital Utilization | - | ✓ |
| Overhead Labor | - | ✓ |
| Overhead Capital | - | ✓ |
| Market Power | - | - |
| Increasing Returns to Scale | - | - |

# Fabricant Data

- *Employment in Manufacturing, 1899-1939: An Analysis of Its Relation to the Volume of Production* (Fabricant, 1942)
  - Annual Data
  - 1899-1926 for the series I consider
  - Derived from Census of Manufactures
- Wage Earners in Manufacturing
- Average Hours of Work per Week per Wage Earner
- Index of Physical Output (Manufacturing)

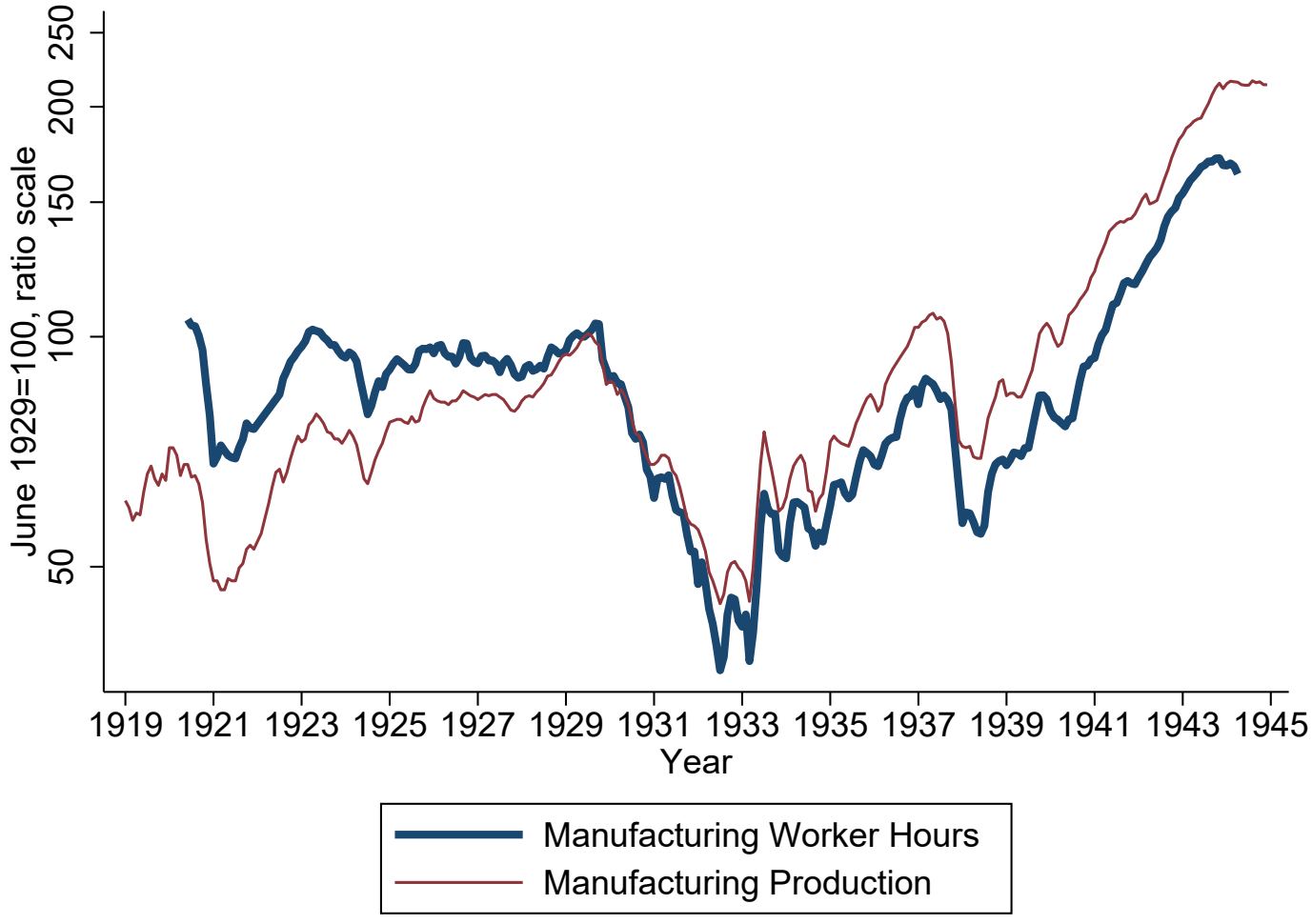
# Manufacturing Worker Labor Productivity in Recessions and Booms: 1899-1926



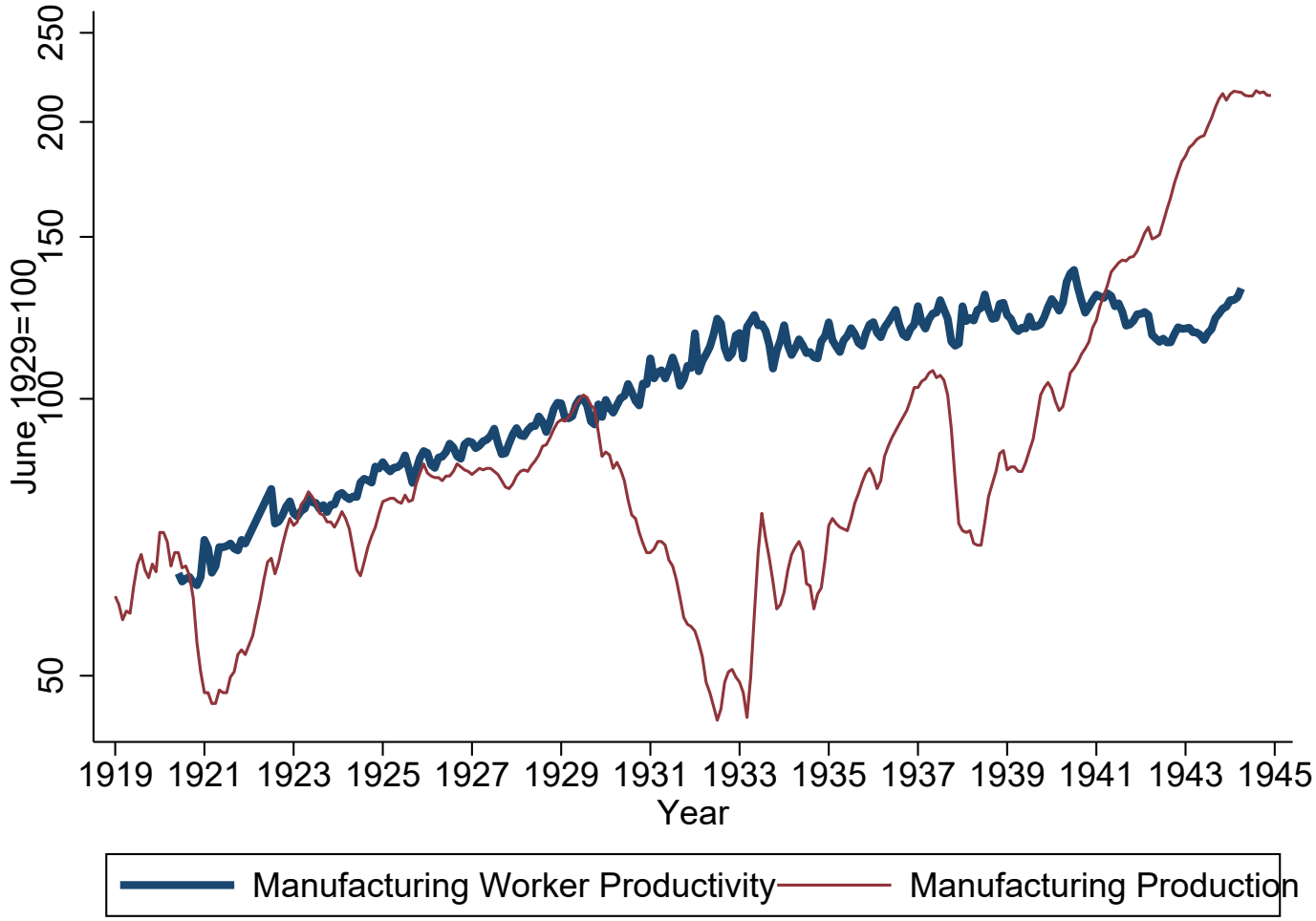
# "Historical Data"

- Monthly Data, 1919-1944 with some monthly missing in 1920-1921
- Industrial Production: Manufacturing (SIC), 1919-present (SA) [Fed Board]
- Production Worker Employment, Manufacturing, Total for United States, 1919-1969 (NSA) [BLS]
- Average Hours of Work Per Week Per Wage Earner, All Male, Twenty-Five Manufacturing Industries for United States, 06/1920-12/1921, 07/1922-07/1948 [Conference Board]

# Manufacturing Output and Manufacturing Production Hours Worked: 1920-1944



# Manufacturing Output and Manufacturing Production Labor Productivity: 1920-1944



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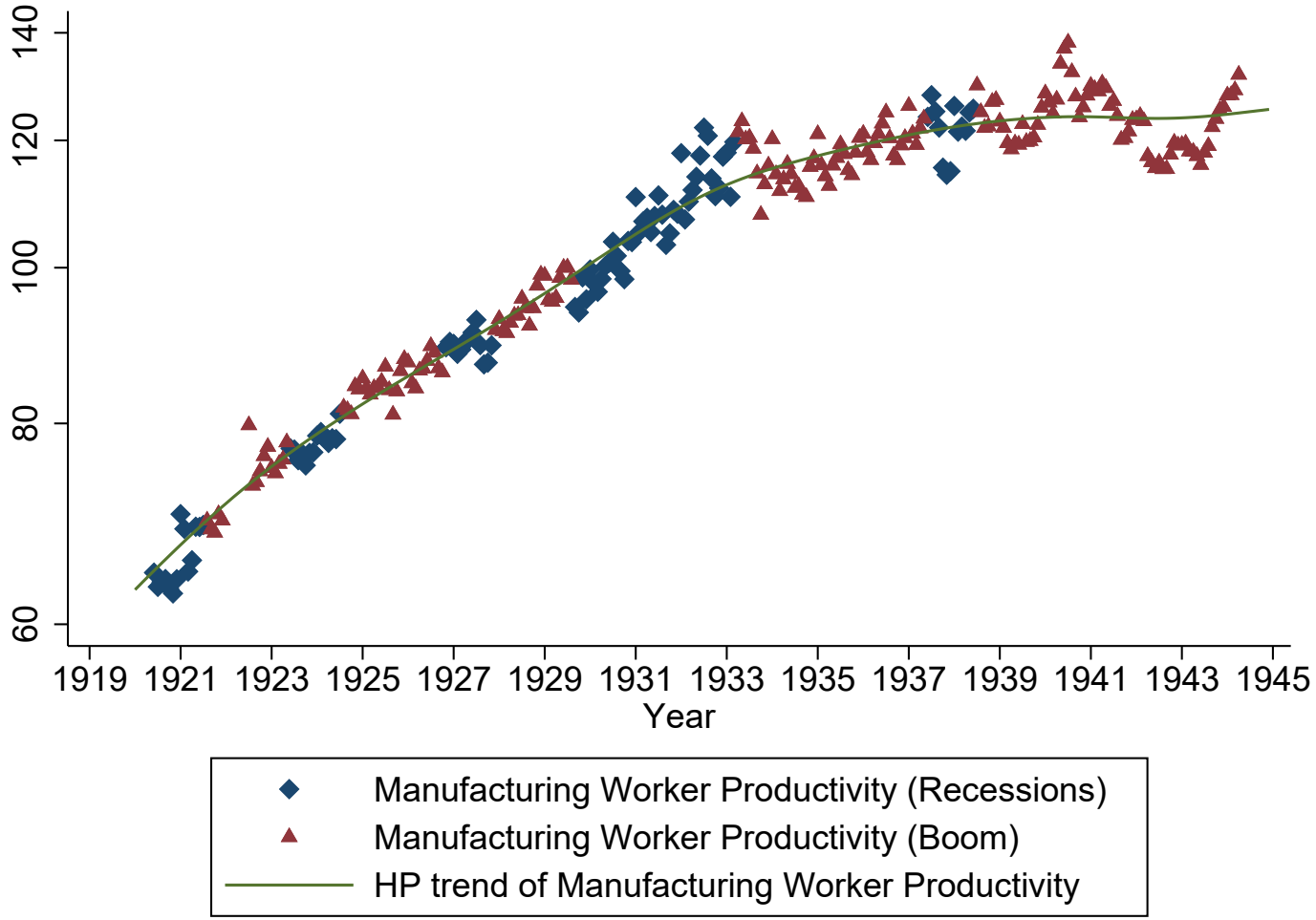
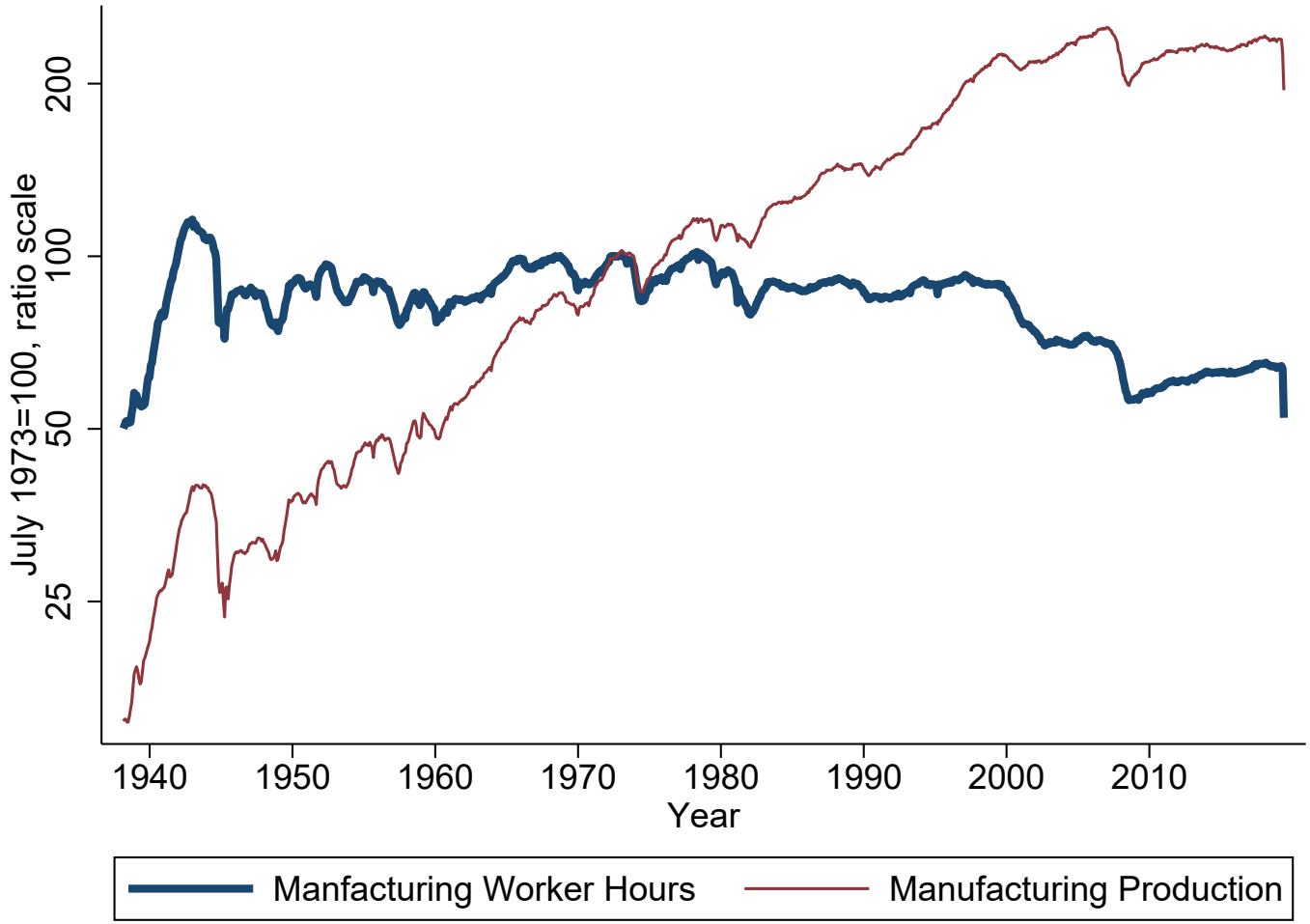


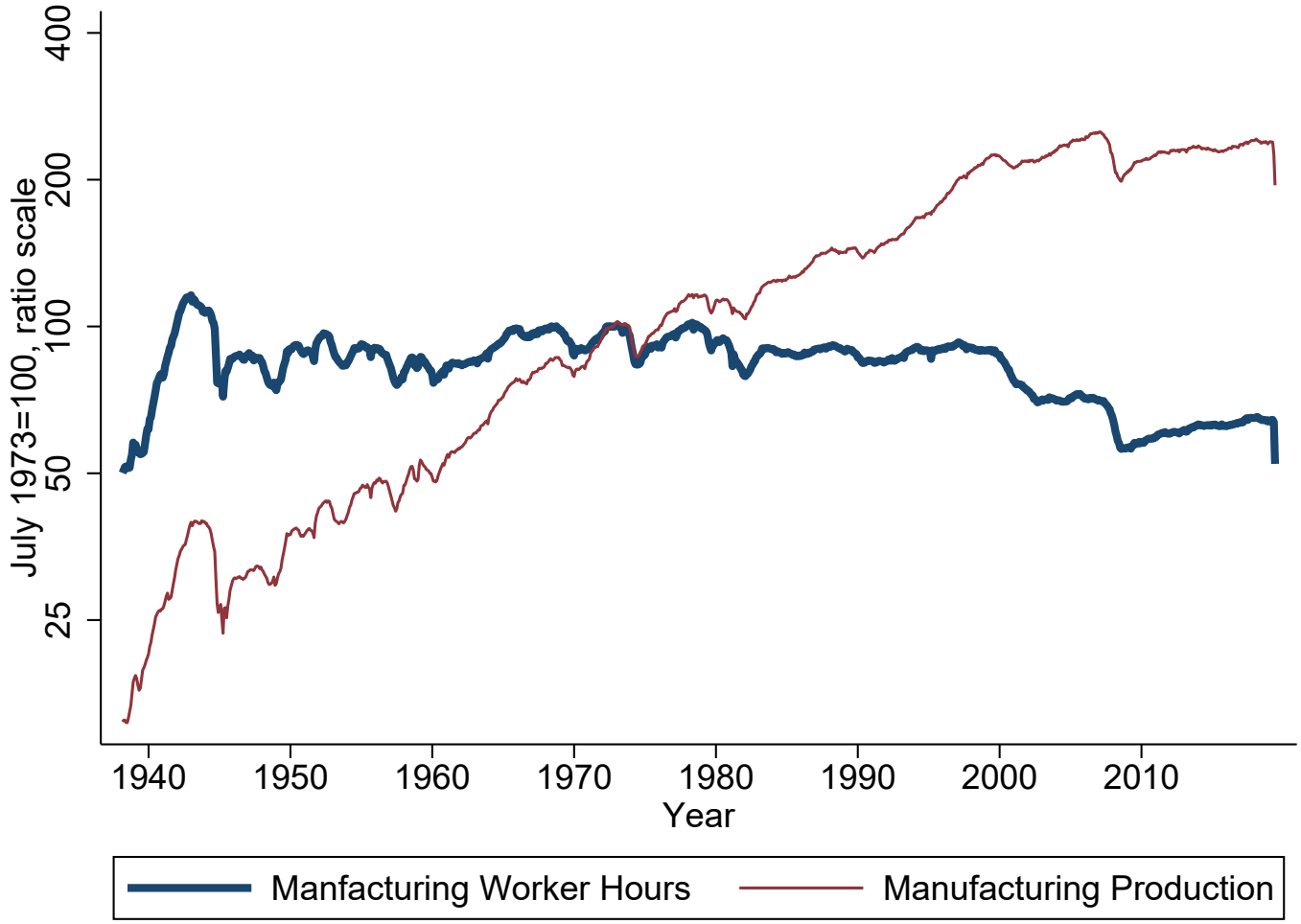
# Modern Data

- 1939-2017, monthly through present
- Industrial Production: Manufacturing (SIC), 1919-present (SA) [Fed Board]
- Production and Nonsupervisory Employees: Manufacturing, 1939-present (SA) [BLS]
- Average Weekly Hours of Production and Nonsupervisory Employees: Manufacturing, 1939-present SA [BLS]

# Manufacturing Production Labor Hours and Manufacturing Production: 1939-2017



# Production Labor Productivity and Manufacturing Production: 1939-2017



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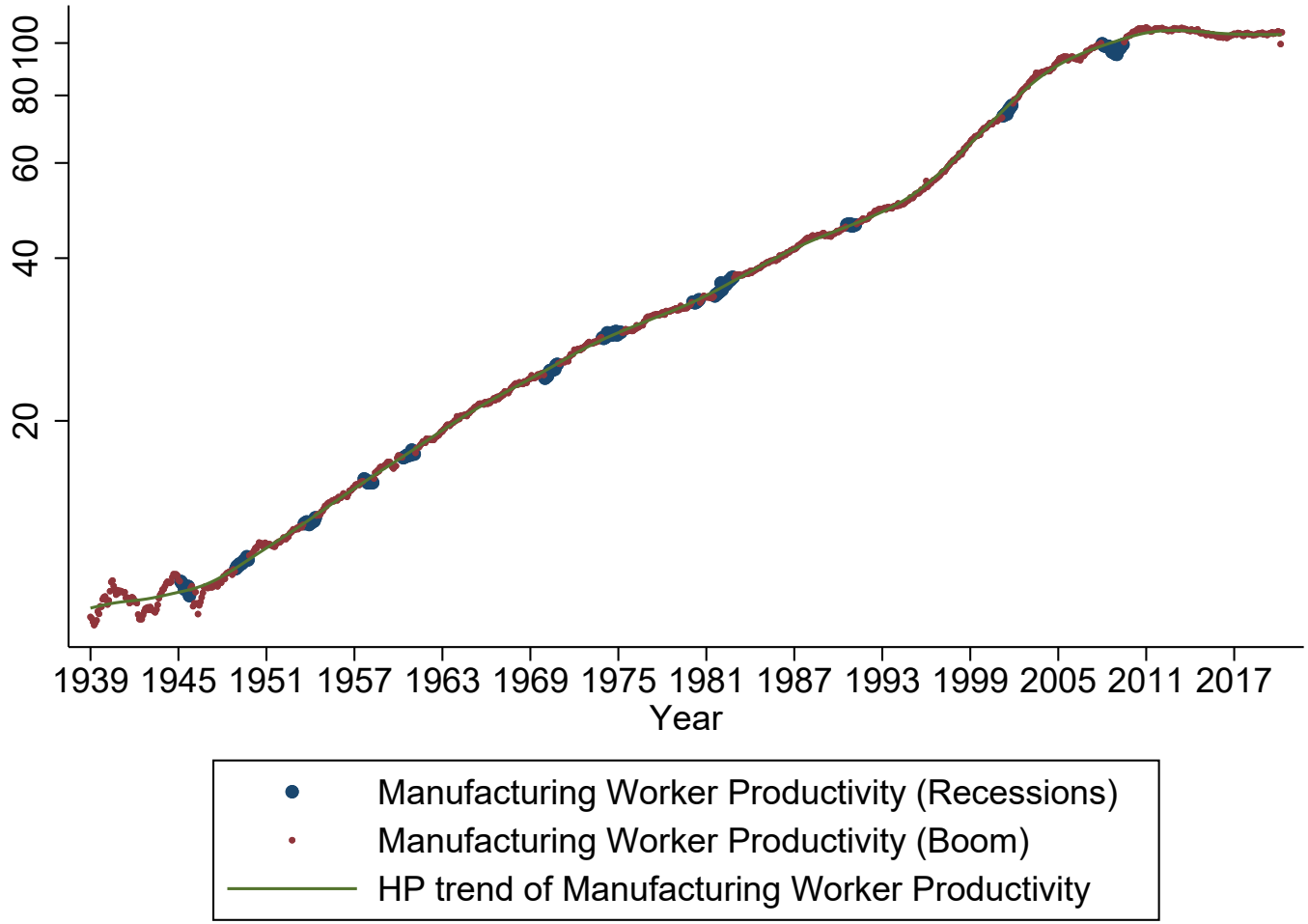
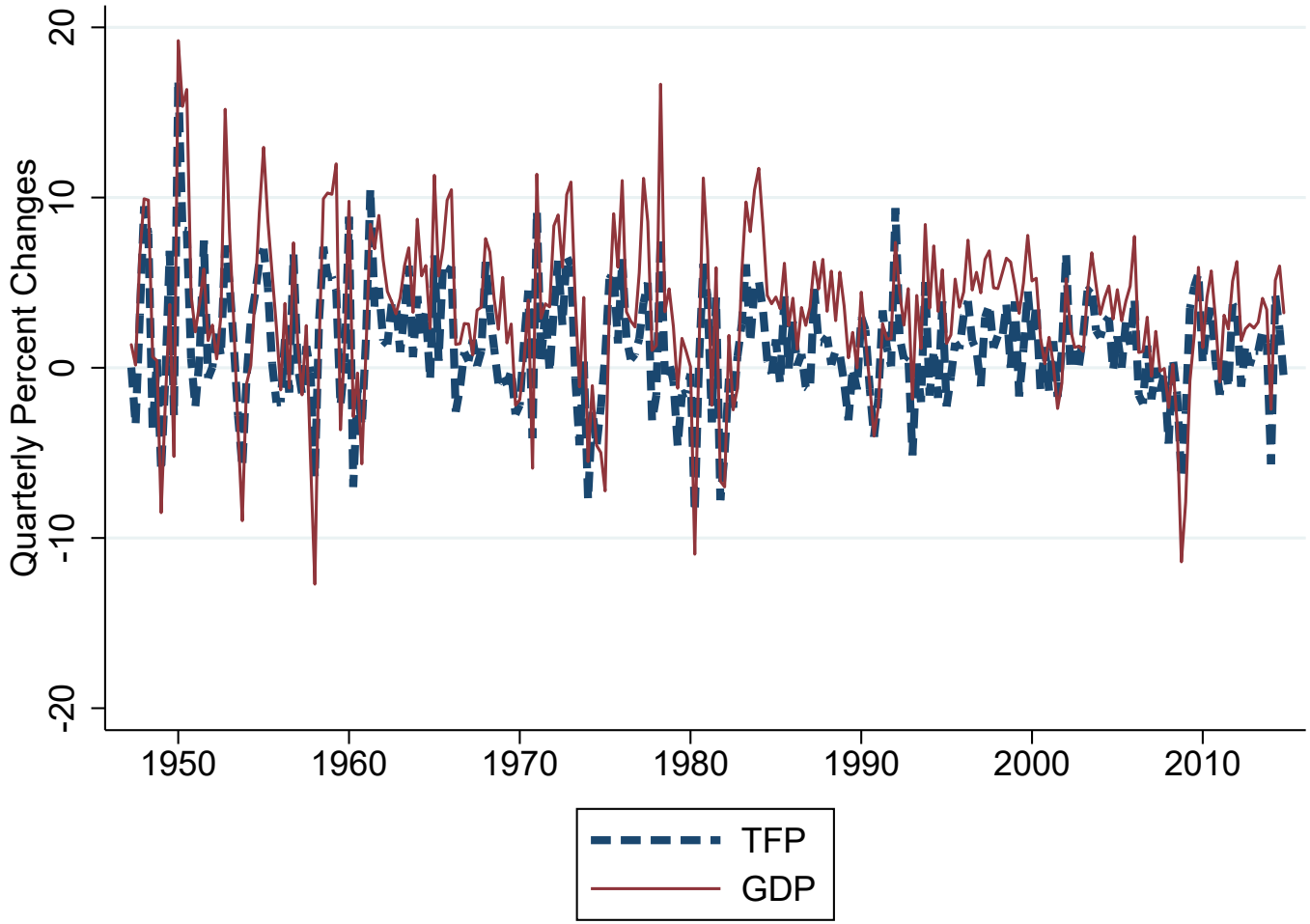


# Quarterly Percent Change in Solow Residual and Real GDP: 1947-2017



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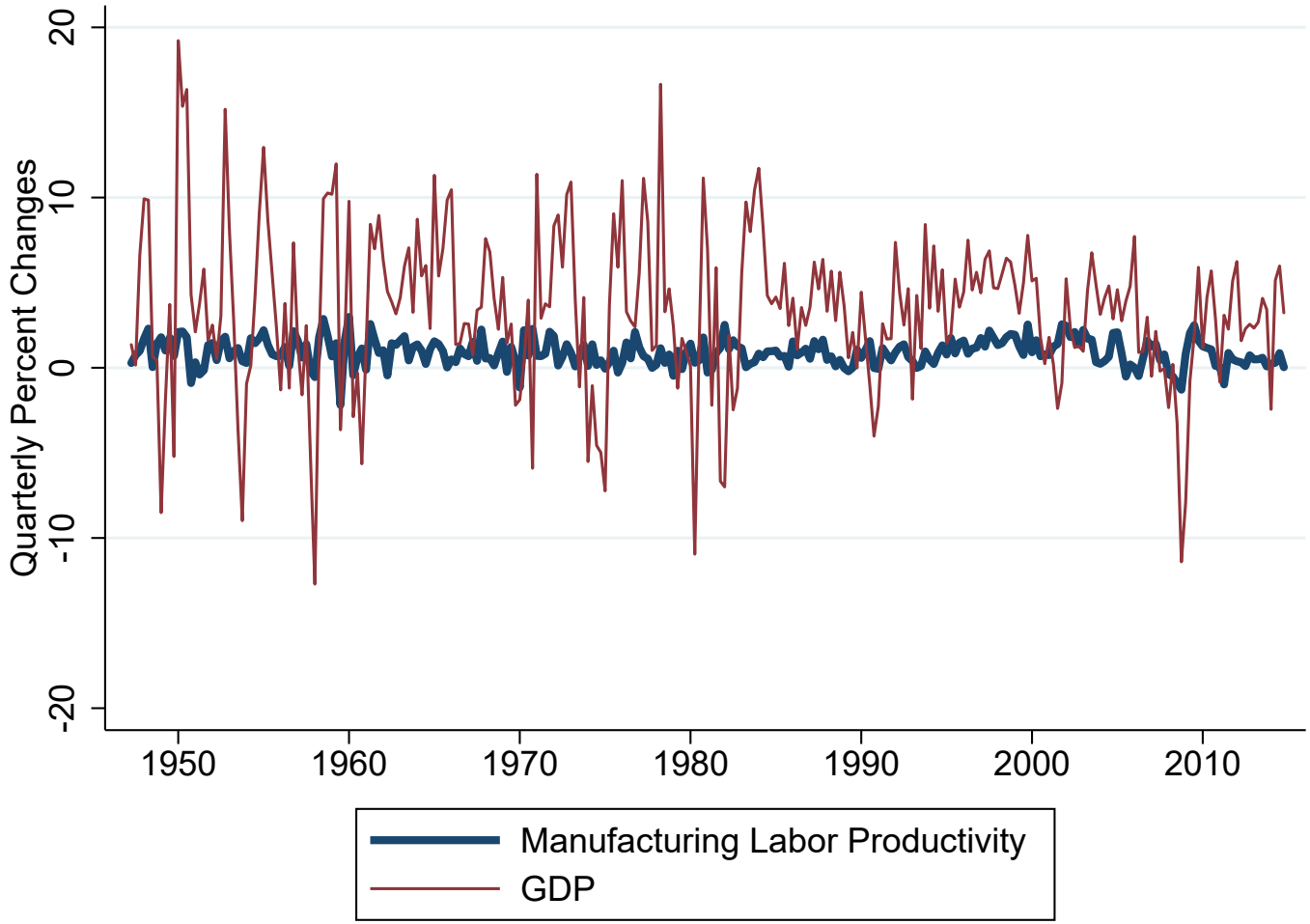
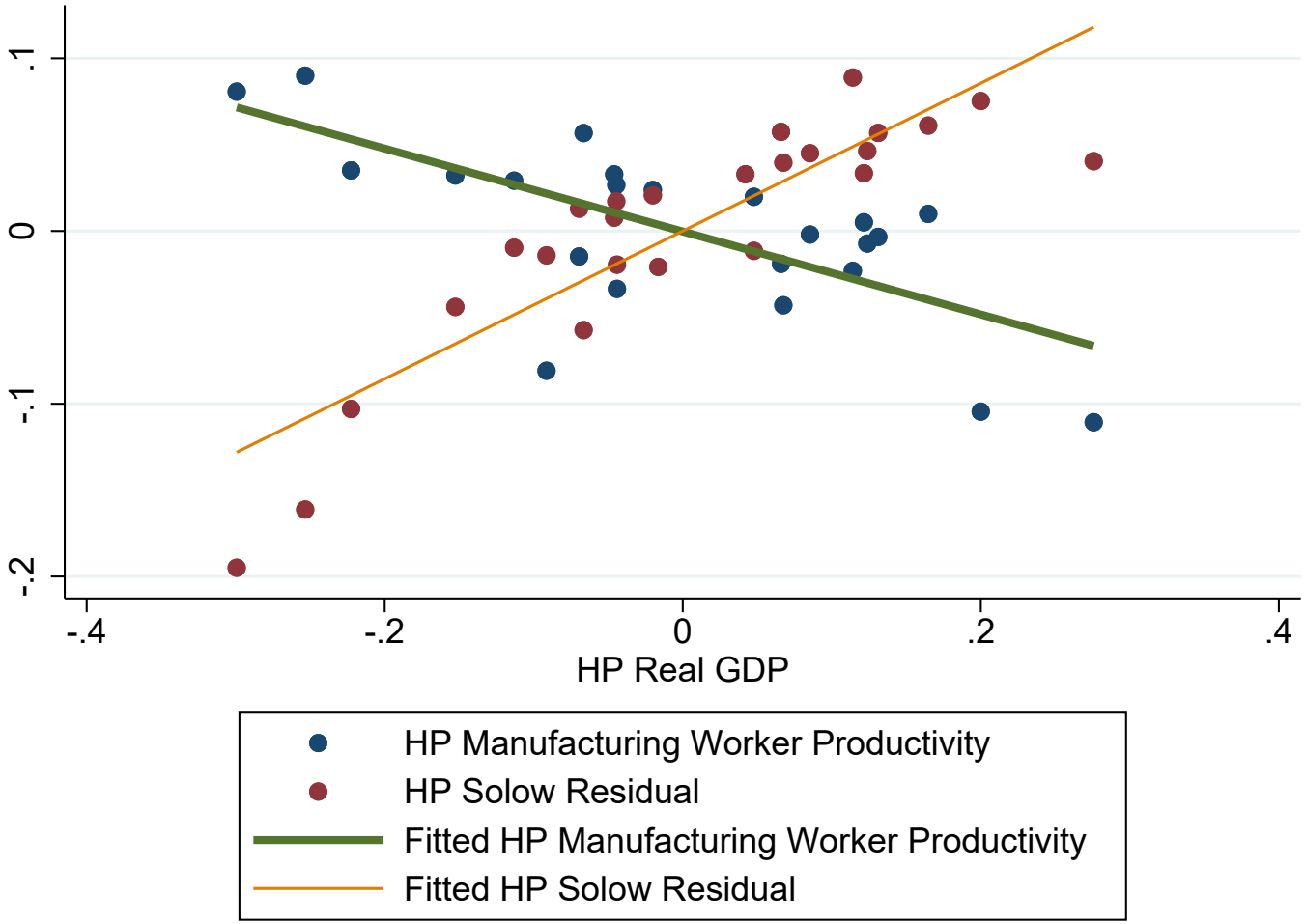


# Correlations between Productivity Measures and Real GDP

Table: Correlation of HP-filtered Productivity Measure with HP-filtered Real GDP (smoothing parameter 6.25/1600)

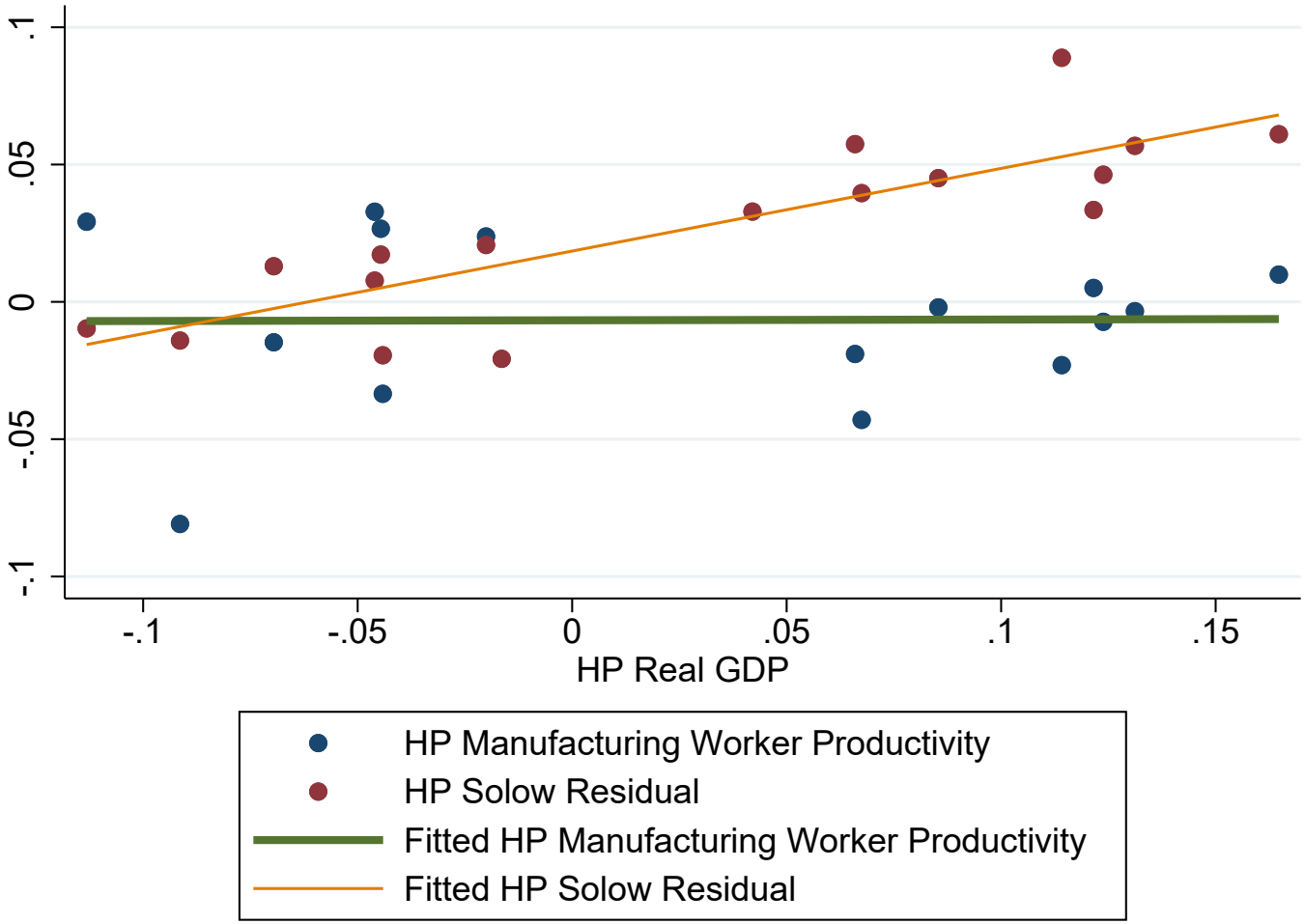
| Period | Solow Residual | Production Labor Productivity |
|---|---|---|
| 1921-1943 | 0.8797 | -0.6965 |
| 1921-29,1935-1941 | 0.8687 | 0.0079 |
| 1947Q2-2013Q1 | 0.8039 | 0.0152 |

# Scatterplot of Productivity Measures versus Real GDP I



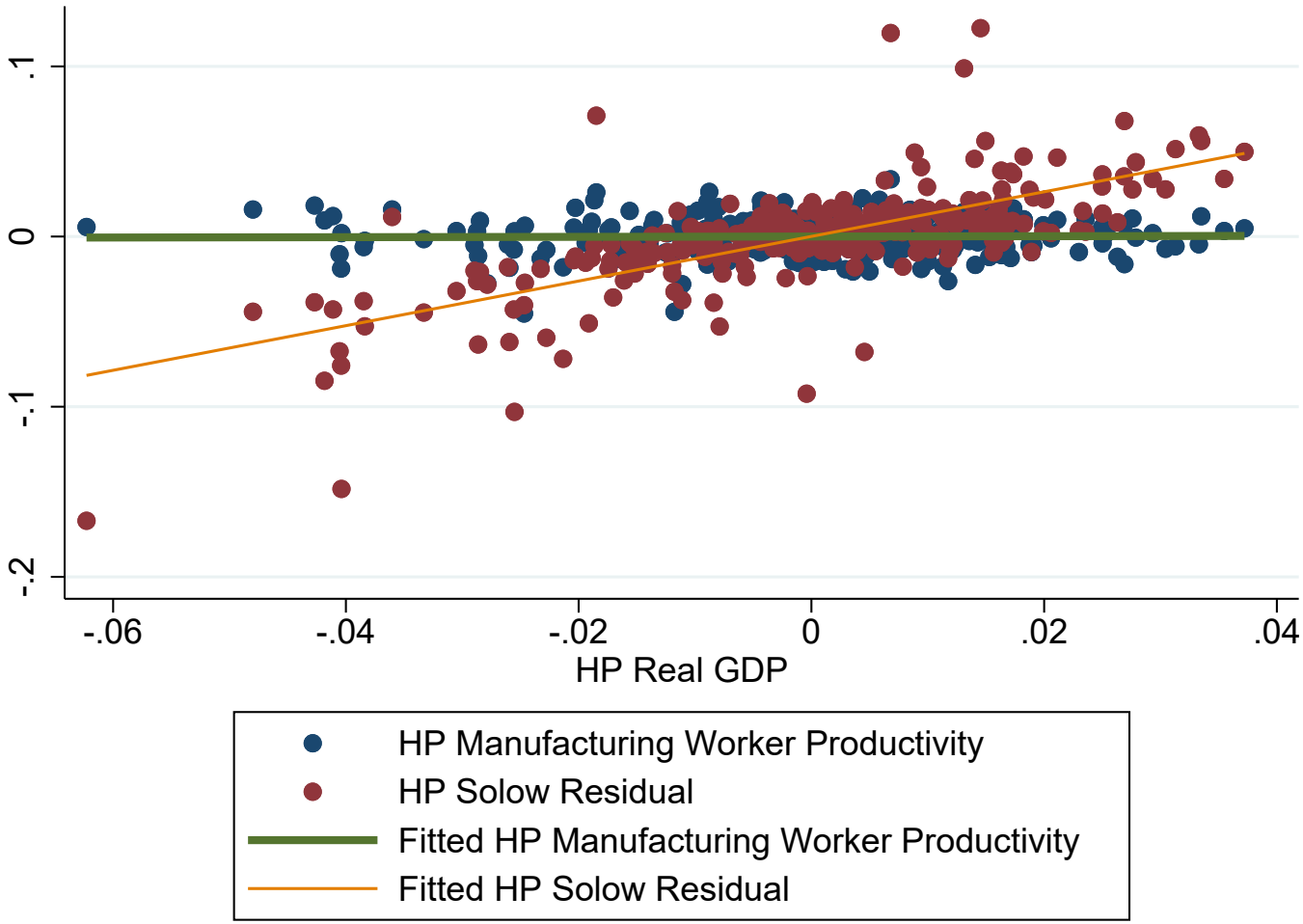

Notes: HP-filtered logged variables with smoothing parameter 6.25, annual data from 1921-1941.

# Scatterplot of Productivity Measures versus Real GDP II




Notes: HP-filtered logged variables with smoothing parameter 6.25, annual data from 1921-1941 excluding 1930-1934.

# Scatterplot of Productivity Measures versus Real GDP III




Notes: HP-filter to logged variables applied with smoothing parameter 1600, quarterly data from 1947Q2-2013Q1.

# Procyclical Productivity and Great Depression

- Productivity falls $\sim$ 18 % in Depression (Ohanian 2001)
- Solow (1957), Bernanke and Parkinson (1991), Inklaar et al. (2011)
- RBC theorists initial avoid Great Depression
  - Prescott (2002): taboo
- *Great depressions of the 20th century*
  - Kehoe and Prescott (2002)
- Misallocation helps explain drop in productivity
  - Ziebarth (2011)

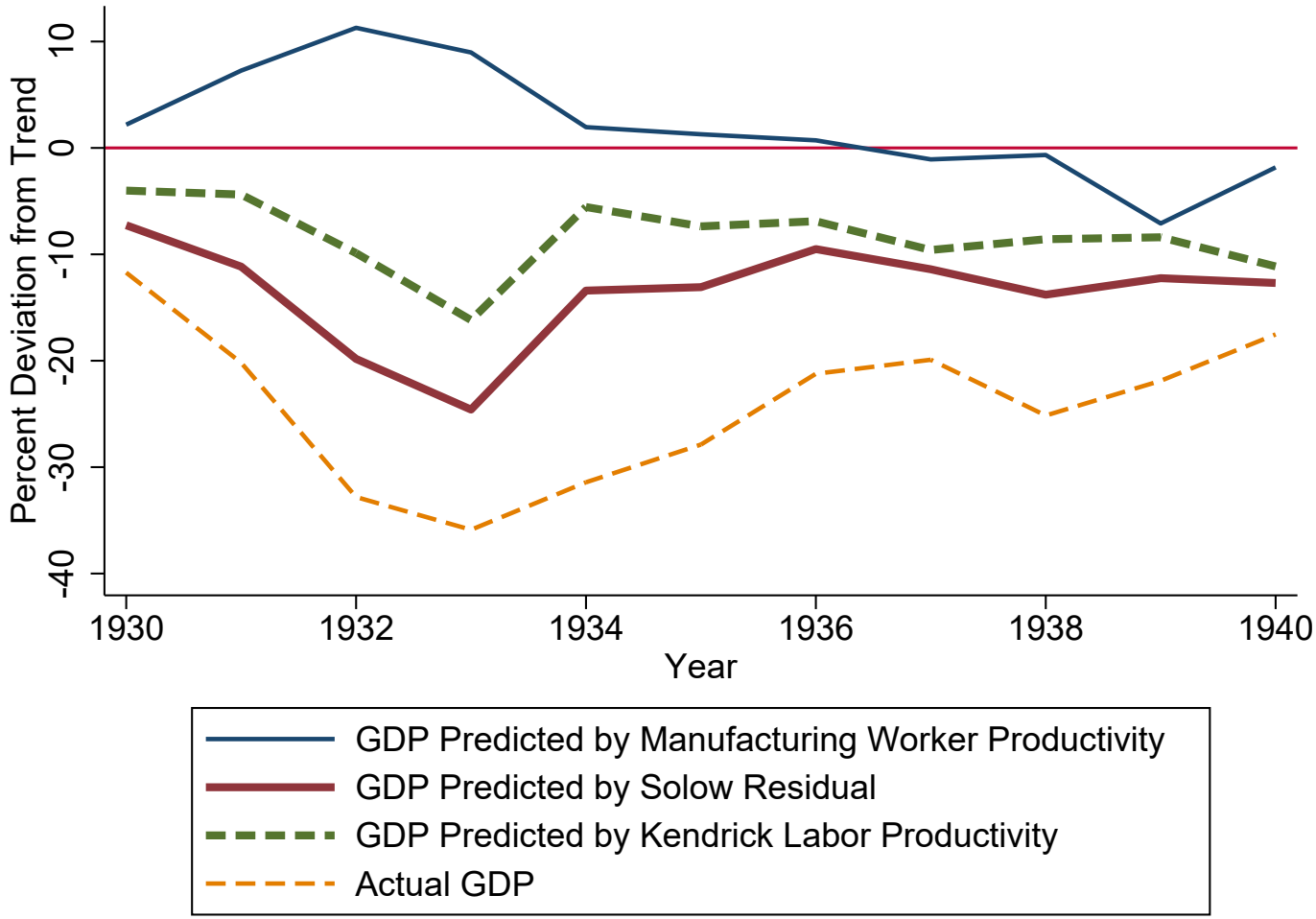
# RBC Model of Great Depression II

- Follows King et al. (1988), p. 215-218
- Based on Long and Plosser (1983)
  - 100% depreciation
  - Closed-form solution

$$\hat{k}_{t+1} = (1 - \alpha)\hat{k}_t + \hat{A}_t. \tag{3}$$

$$\hat{y}_t = (1 - \alpha)\hat{k}_t + \hat{A}_t. \tag{4}$$

# RBC simulations of Great Depression II



# Mismeasurement in Production Worker Productivity

- Capital, once installed, largely irreversible
  - Ramey and Shapiro (2001)
- During Depression, capital stock falls through depreciation
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# Mismeasurement in Production Worker Productivity

- Capital, once installed, largely irreversible
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- During Depression, capital stock falls through depreciation
  - Without irreversibility constraint/costs, capital stock would likely fall more
- This increases labor productivity measures like production worker productivity
- Capital utilization falls massively in Great Depression
  - Solow residual falls in Great Depression
  - Production Labor Productivity rises in Great Depression

# Great Depression and Production Worker Productivity

- Capital stock falls from 1931 to 1935, but recovery starts in 1933
  - Suggest capital stock still too large during 1933-1935 recovery
- Note this countercyclical capital effect on labor productivity is small elsewhere however
  - Productivity is nearly acyclical

# Great Depression and Production Worker Productivity

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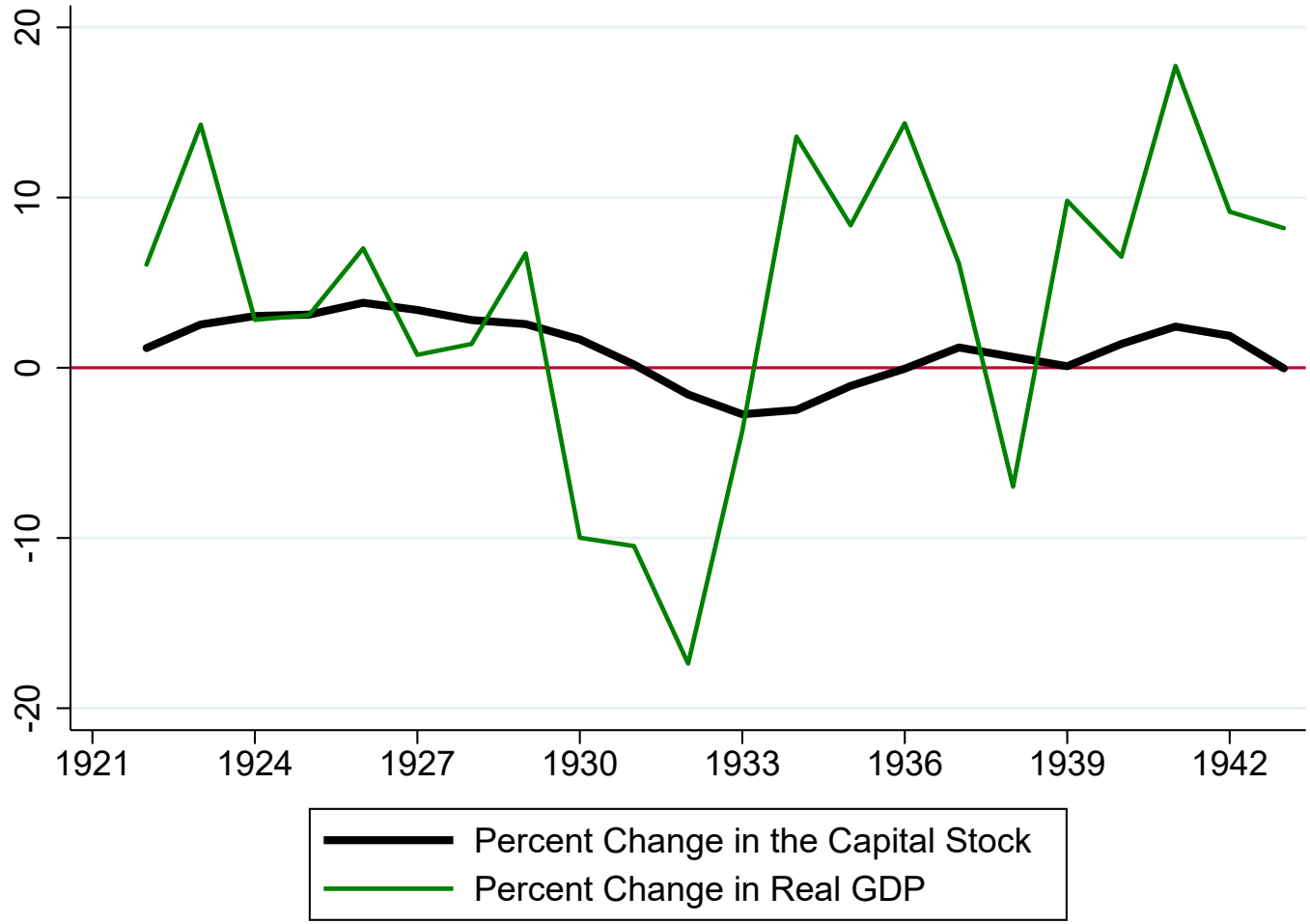
  - Suggest capital stock still too large during 1933-1935 recovery
- Note this countercyclical capital effect on labor productivity is small elsewhere however
  - Productivity is nearly acyclical
- Seems to suggest that some capital is fully idled in normal recessions
  - Does little boost to labor productivity
- In Great Depression, suggestive that:
  - Depreciation not enough to reduce capital stock then
  - Abundant overhead capital increases labor productivity

# Annual Percent Change in Capital Stock and Real GDP: 1921-1943



# Conclusion I

- Labor Hoarding, Labor Utilization (Production Workers)
  - Insignificant
- Labor Hoarding, Labor Utilization (Nonproduction Workers/Overhead labor/Management)
  - Significant

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  - Insignificant
- Labor Hoarding, Labor Utilization (Nonproduction Workers/Overhead labor/Management)
  - Significant
- Capital Hoarding, Capital Utilization
  - Important (especially in Depression)
- Increasing Returns to Scale, Market Power (Production Workers)
  - Insignificant

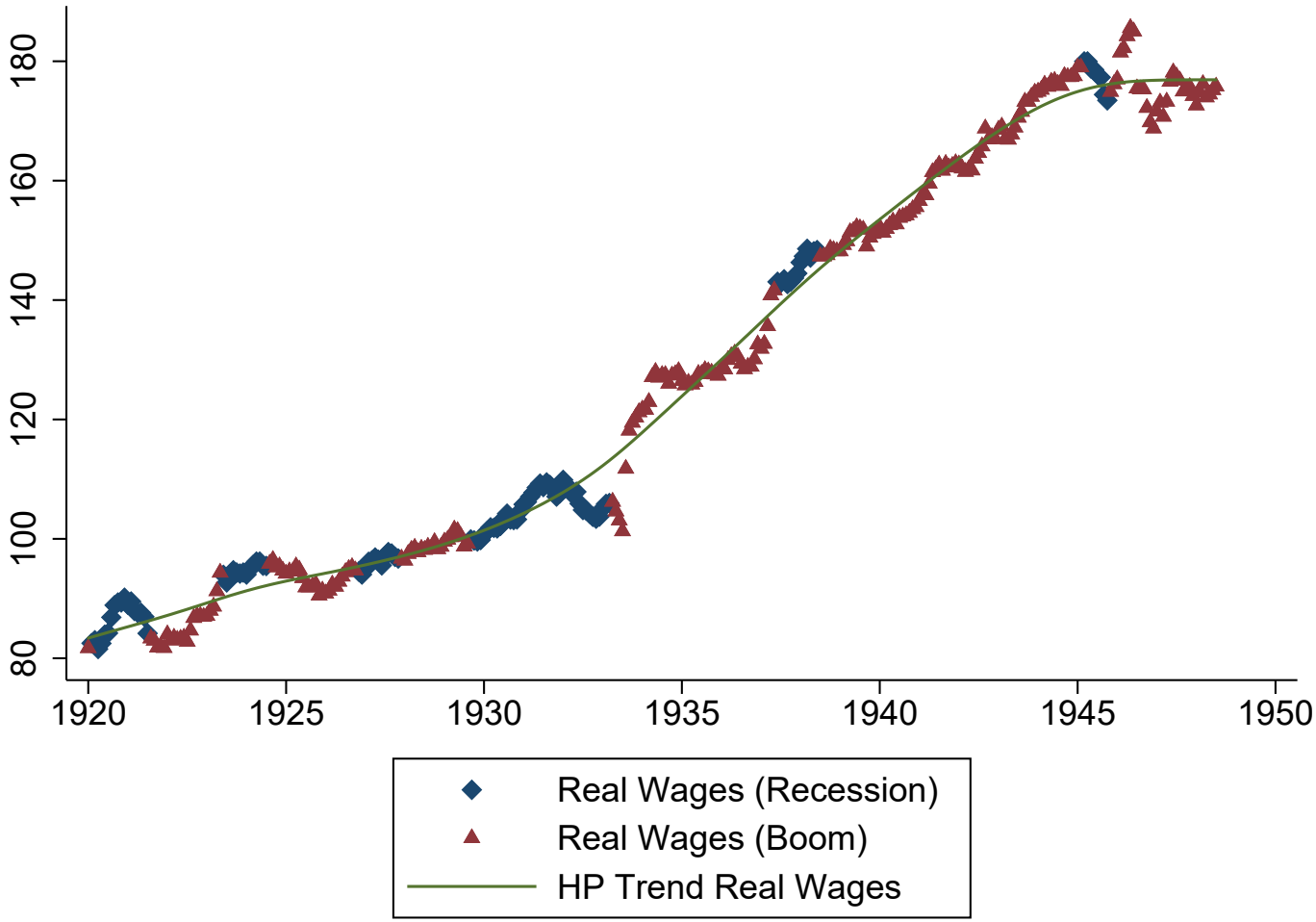
# Conclusion II

- Exogeneous productivity shocks generating business cycles
  - Little supportive evidence here
  - Especially not for Great Depression.....
- Productivity shocks have basically no explanatory power for the American business cycle
- Suggestive that other theories of the business cycle will be more fruitful approaches
  - Nominal shocks
    - Monetary policy shocks
  - Other real shocks
  - Something else

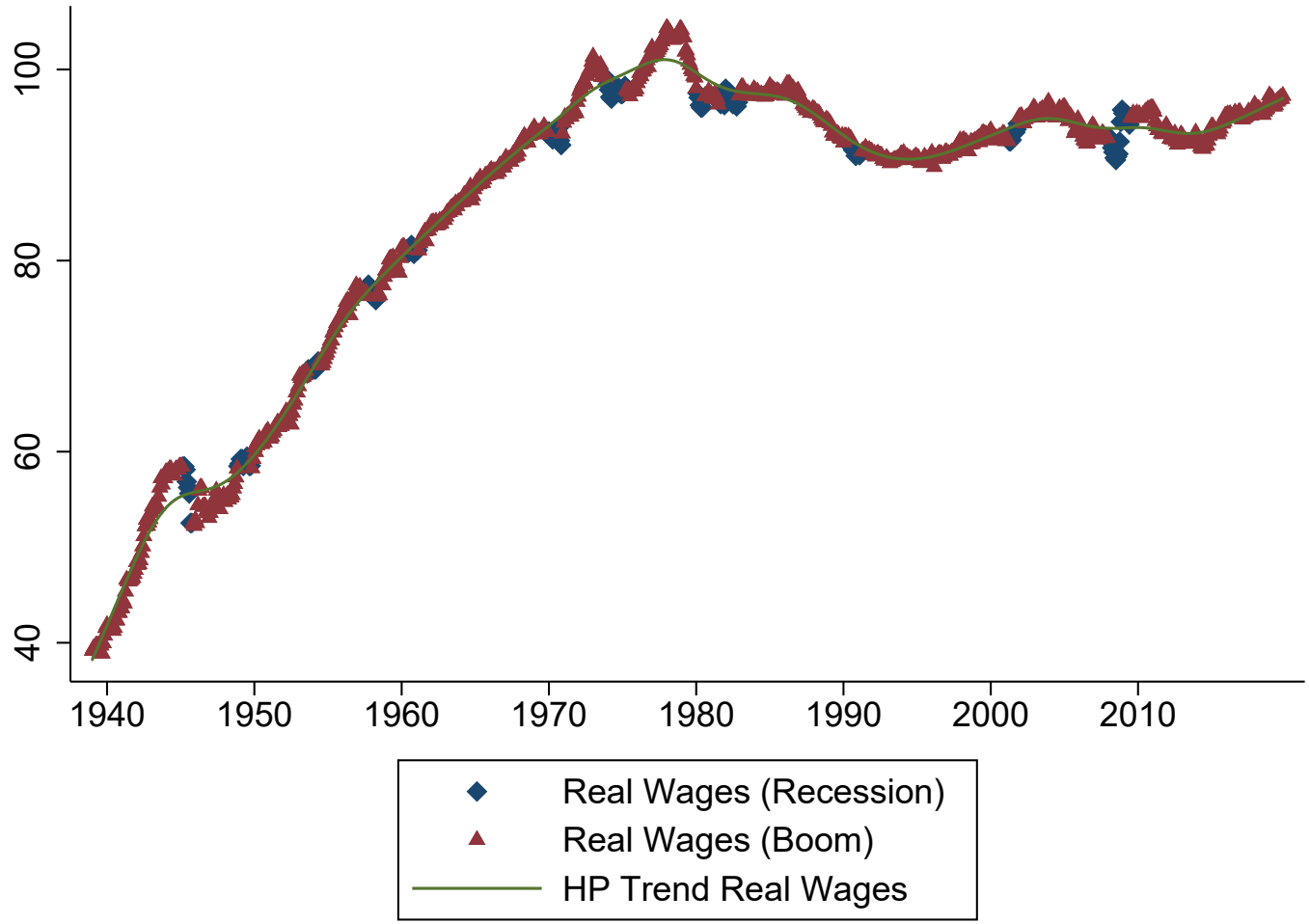
# Real Wage Cyclicality

- Another Puzzle:
  - Why aren't real wage very cyclical
- This is a puzzle if you think that productivity is cyclical
  - However....
- If Labor Productivity is acyclical
  - Then, in a neo-classical model...
- Real Wages should also be acyclical
  - So acyclical productivity helps explain weak cyclicality in real wages

# Real Wages (CPI): 1919-1947



# Real Wages (CPI): 1939-2017



# Real Wages (PCE): 1939-2017