Mismeasuring 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

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

\[ \frac{dA}{A} = \frac{dY}{Y} - (1 - \alpha) \frac{dL}{L} - \alpha \frac{dK}{K} \]  \hspace{1cm} (1)
Cyclicality of Solow Residual

- Solow Residual is Pro-cyclical
  - Little debate about this for postwar (through at least 1980)

- Debate is whether this is due to:
  - Exogenuous 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 procyclical
  - 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 ↑, measured productivity rises with returns to scale
## Literature on Mismeasurement

<table>
<thead>
<tr>
<th>Authors</th>
<th>Hoarding</th>
<th>Utilization</th>
<th>IRS/MP</th>
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<tbody>
<tr>
<td>Solow (1957)/Okun (1962)</td>
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<td>Jorgenson and Griliches (1967)</td>
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<td>Hall (1988, 1990)</td>
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<td>Rotemberg and Summers (1990)</td>
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<td>Bernanke and Parkinson (1991)</td>
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<td>Eichenbaum (1991)</td>
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<td>Caballero and Lyons (1992)</td>
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<td>Burnside, Eichenbaum, Rebelo (1993)</td>
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<td>Basu (1997)</td>
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<td>Inklaar et al. (2011)</td>
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<td>Fernald (2012)</td>
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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 → good sector to identify cyclicality of productivity
  2. Manufacturing is most cyclical sector vs. services/agriculture → 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 → 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

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

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

\[ g \left( \frac{Y}{L} \right) - g \left( A \right) = \alpha \ g \left( \frac{K}{L} \right) \]  \hspace{1cm} (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:
  - Cyclical 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

<table>
<thead>
<tr>
<th>Avoids Mismeasurement</th>
<th>Solow Residual</th>
<th>Production Labor Productivity</th>
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<tbody>
<tr>
<td>Labor Hoarding</td>
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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

Manufacturing Worker Productivity (Recession)

Manufacturing Worker Productivity (Boom)

Productivity Trend
“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
Production Labor Productivity in Recessions and Booms: 1920-1944

![Graph showing manufacturing worker productivity]

- **Diamonds** represent manufacturing worker productivity during recessions.
- **Triangles** represent manufacturing worker productivity during booms.
- **Green line** shows the HP trend of manufacturing worker productivity.

Year: 1919 to 1945

Manufacturing Worker Productivity (Recessions)
Manufacturing Worker Productivity (Boom)
HP trend of Manufacturing Worker Productivity
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

The graph shows the trend of manufacturing worker hours (blue line) and manufacturing production (red line) from 1940 to 2010. The y-axis represents the ratio scale, with 'July 1973 = 100'. The graph indicates a generally increasing trend in both metrics, with fluctuations over time.
Production Labor Productivity and Manufacturing Production: 1939-2017

![Graph showing the trend of production labor productivity and manufacturing production from 1939 to 2017. The x-axis represents the years from 1940 to 2010, and the y-axis represents manufacturing worker hours and manufacturing production, both on a ratio scale with July 1973 set at 100. The graph shows a general increase in both metrics over the years.]
Production Labor Productivity in Recessions and Booms: 1939-2017

- Manufacturing Worker Productivity (Recessions)
- Manufacturing Worker Productivity (Boom)
- HP trend of Manufacturing Worker Productivity
Quarterly Percent Change in Solow Residual and Real GDP: 1947-2017
Quarterly Percent Change in Production Labor Productivity and Real GDP: 1947-2017
Correlations between Productivity Measures and Real GDP

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

<table>
<thead>
<tr>
<th>Period</th>
<th>Solow Residual</th>
<th>Production Labor Productivity</th>
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<tr>
<td>1921-1943</td>
<td>0.8797</td>
<td>-0.6965</td>
</tr>
<tr>
<td>1921-29, 1935-1941</td>
<td>0.8687</td>
<td>0.0079</td>
</tr>
<tr>
<td>1947Q2-2013Q1</td>
<td>0.8039</td>
<td>0.0152</td>
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</tbody>
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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)
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

The graph illustrates the percent deviation from trend for various economic predictions and actual GDP from 1930 to 1940. The predictions include:

- GDP Predicted by Manufacturing Worker Productivity
- GDP Predicted by Solow Residual
- GDP Predicted by Kendrick Labor Productivity
- Actual GDP

The years 1930 to 1940 are shown on the x-axis, and the percent deviation from trend is on the y-axis.

Legend:
- Blue line: GDP Predicted by Manufacturing Worker Productivity
- Maroon line: GDP Predicted by Solow Residual
- Green line: GDP Predicted by Kendrick Labor Productivity
- Orange line: Actual GDP
Mismeasurement in Production Worker Productivity

- Capital, once installed, largely irreversible
  - Ramey and Shapiro (2001)

- During Depression, capital stock falls through depreciation
  - Without irreversibility constraint/costs, capital stock would likely fall more
Mismeasurement in Production Worker Productivity

- Capital, once installed, largely irreversible
  - Ramey and Shapiro (2001)

- 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

- 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

- 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
Conclusion I

- Labor Hoarding, Labor Utilization (Production Workers)
  - 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
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 (Recession)
- Real Wages (Boom)
- HP Trend Real Wages
Real Wages (CPI): 1939-2017