We See the Digital Revolution Everywhere But in GDP

Measuring and Accounting for Innovation in the 21st Century
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Charles Hulten, University of Maryland and NBER
Leonard Nakamura, Federal Reserve Bank of Philadelphia

* The views expressed today are my own and not necessarily those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.
Disclaimer:

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• The US statistical agencies are among the best in the world and are leading innovators in statistical methodology despite limited resources.
Economic Growth in the Age of the Internet

• The last three decades have seen tectonic changes in technology and structure of economy
  – profusions of new or improved goods -- internet, mobile communications, new ITC devices, medical breakthroughs
  – new modes of distribution – warehouse stores; Amazon
  – much more information about alternative choices

• These goods are hard to measure
  – intangible (units of measurement problems)
  – some are contingent on hard-to-observe factors (talent)
  – some distributed “free” or below cost

• Current measurement procedures may understate the true growth of real GDP, and overstate prices
Project Overview

• The objectives of our project are
  – To take a broader look at the potential for mismeasurement of real GDP, rather than an in-depth look at selected new economy goods
  – Understand the productivity slowdown beginning in 2000s (PS2)
  – Examine preparedness for innovations on horizon

• Background: First productivity slowdown (PS1) from 1970s
  – Many explanations, two foremost:
    • Baumol’s cost-disease in services
    • Mismasurement
      – Griliches and Greenspan doubted Baumol’s cost-disease because ICT was being used to a growing extent in hard-to-measure service industries
      – Triplett and Bosworth took up the challenge of HTMI in Brookings project on services measurement (1998-2004)
Griliches in his 1994 AEA Address distinguished:

- Readily-measurable industries (ETMI) that are quantifiable
  - Agriculture, Mining, Manufacturing, Transportation, Utilities (including information)
  - Bushels, tons, feet, ton-miles, kilowatts
  - [But digital revolution makes these harder to quantify]

- Hard-to-measure industries (HTMI) that are not
  - Most are knowledge-intensive service industries
    - FIRE, Educ. and Health, Professional and Business Services
  - Also Trade, Construction, Arts and Rec, Hotels and Restaurants, etc.

Griliches’s challenge: Can we measure the HTMI?
# GDP Shares of Hard-to-Measure vs Easier-to-Measure Industries

<table>
<thead>
<tr>
<th></th>
<th>1955</th>
<th>1985</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HTMI as Percent of GDP</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial Services and Real Estate</td>
<td>12.46%</td>
<td>17.11%</td>
<td>20.27%</td>
</tr>
<tr>
<td>Professional &amp; Business Services</td>
<td>3.78%</td>
<td>7.39%</td>
<td>12.24%</td>
</tr>
<tr>
<td>Education &amp; Health Care</td>
<td>2.21%</td>
<td>5.23%</td>
<td>8.32%</td>
</tr>
<tr>
<td><strong>TOTAL HTMI</strong></td>
<td>55.54%</td>
<td>66.87%</td>
<td>75.94%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>ETMI As Percent of GDP</strong></th>
<th>1955</th>
<th>1985</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>4.41%</td>
<td>1.77%</td>
<td>0.97%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>27.57%</td>
<td>18.53%</td>
<td>12.03%</td>
</tr>
<tr>
<td>Transportation</td>
<td>4.93%</td>
<td>3.17%</td>
<td>3.01%</td>
</tr>
<tr>
<td>Information</td>
<td>3.28%</td>
<td>4.58%</td>
<td>4.66%</td>
</tr>
<tr>
<td><strong>TOTAL ETMI</strong></td>
<td>44.46%</td>
<td>33.13%</td>
<td>24.06%</td>
</tr>
</tbody>
</table>
Bosworth-Triplett Studies

- Triplett and Bosworth took up Griliches’ challenge in a multiyear, 15 workshop study (1998-2004)
  - Their detailed studies showed MFP (relative growth of inputs vs. outputs) was a good diagnostic tool
    - Negative MFP growth was a sign of mismeasurement in an industry
  - For the period 1995 to 2001, they found services MFP growth was close to the goods MFP
    - This remained true until mid-2000s
  - Major contributors: trade and transportation, FIRE
  - Most of services not well-measured
Diagnostic: If we deflate all of GDP by the prices of ETMI, PS1 disappears.

<table>
<thead>
<tr>
<th>Period</th>
<th>ETMI prices</th>
<th>Official prices</th>
<th>Nominal GDP growth</th>
<th>Official real GDP growth</th>
<th>real GDP growth deflated by ETMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>55-85</td>
<td>4.04%</td>
<td>4.44%</td>
<td>8.05%</td>
<td>3.46%</td>
<td>3.85%</td>
</tr>
<tr>
<td>85-15</td>
<td>0.93%</td>
<td>2.20%</td>
<td>4.86%</td>
<td>2.60%</td>
<td>3.89%</td>
</tr>
<tr>
<td>55-75</td>
<td>3.14%</td>
<td>3.58%</td>
<td>7.13%</td>
<td>3.44%</td>
<td>3.83%</td>
</tr>
<tr>
<td>75-15</td>
<td>2.14%</td>
<td>3.18%</td>
<td>6.10%</td>
<td>2.82%</td>
<td>3.87%</td>
</tr>
</tbody>
</table>
MFP and Mismeasurement

• ETMI MFPG rates generally larger than HTMI rates, but suspicious in some cases
  – Manuf. MFPG is fairly robust until 2007 (~1.8 1995-2007)
    • Ex computers, manufacturing MFPG near zero
  – Autos and Chemicals MFPG near zero
  – Measuring the output of “Information” is problematic

• HTMI MFPG in services
  – NAICs services 54-81 (expert industries) near zero MFPG
    • Value added in this sector was 25% of GDP in 2015
    • If sector MFP were 100 bp higher, GDP increases by ~40 bp
### Suspicious Signs of MFP mismeasurement

<table>
<thead>
<tr>
<th>MFP Growth Rates</th>
<th>87 to 95</th>
<th>95 to 05</th>
<th>05 to 14</th>
<th>87 to 14</th>
<th>2005 VA weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRE</td>
<td>-0.34%</td>
<td>0.38%</td>
<td>0.76%</td>
<td>0.29%</td>
<td>23.2%</td>
</tr>
<tr>
<td>Other Services</td>
<td>-0.83%</td>
<td>0.32%</td>
<td>-0.08%</td>
<td>-0.16%</td>
<td>28.0%</td>
</tr>
<tr>
<td>Education</td>
<td>-0.33%</td>
<td>-0.88%</td>
<td>-0.60%</td>
<td>-0.62%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Doctor offices</td>
<td>-2.11%</td>
<td>0.04%</td>
<td>-0.16%</td>
<td>-0.67%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Hospitals</td>
<td>-1.30%</td>
<td>-0.70%</td>
<td>-0.16%</td>
<td>-0.70%</td>
<td>3.1%</td>
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<th>87 to 14</th>
<th>2005 VA weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>0.76%</td>
<td>1.85%</td>
<td>-0.05%</td>
<td>0.89%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>-0.99%</td>
<td>-0.14%</td>
<td>-1.24%</td>
<td>-0.76%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Transportation Equip</td>
<td>-0.72%</td>
<td>0.78%</td>
<td>0.48%</td>
<td>0.23%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Computers</td>
<td>8.27%</td>
<td>10.96%</td>
<td>3.37%</td>
<td>7.59%</td>
<td>1.9%</td>
</tr>
</tbody>
</table>
Case Studies

Here we focus on:

- Smart phones and Internet access and telecommunications
- Autos
- Health
Smartphones

- Smartphones are only $18 billion in PCE
  - 0.15% of PCE: electronic revolutions are cheap

- Globalization
  - Smartphones are all imported (not in GDP)
  - Intellectual property exports not reported

- When the iPhone was introduced in 2007, no apparent impact on prices

- Personal online hours were 6 hours per week in 2007, now 14 hours per week
Hal Varian, 2016:
- A **mobile phone is a substitute** for a camera, a GPS, a landline, a game machine, an ebook reader, a computer, a movie player, an audio player, a map, a password generator, a fitness monitor, an alarm clock, a web browser, a calculator, a recording device, video camera, etc.

- Smartphones use broadband and cellular network
  - Often sold as part of bundle

- Smartphones use free apps (Nakamura et al, 2016)
  - Value these at resource cost or user utility?
Internet Access and Cellular Networks

• Smartphones use broadband and cellular networks
  – Internet + cell serv = 1.8 % of PCE (12 x smartphones)

• Speed has risen 1000-50,000 x in 27 years
  – Speed rises 30 to 50 % a year; deflators -2 % a year 2005-2015
  – PPI initiated hedonic index for broadband Jan 2017; 30 % speed increase implies - 9 % in price

• Cord-cutting: wireless replaces wired phones
  – Wired phone service has fallen from 1.7 % to 0.3 % of PCE, 1988-2015
• Autos now have sensors and computer power for safety and to improve cruise control, parking, backup vision
  – Devices and software too inexpensive to make a difference
• Also hybrid and all-electric technology
  – Hybrids and all-electrics no impact on prices at introduction
• Real value per car was nearly flat 2005 to 2015
  – $14.3 K 2005, $14.5 K 2015
• Near-self-driving cars are on the road!
Challenge: Self-driving cars

- If it reduces accidents, should that be included in GDP?
- Suppose it reduces consumer work and increases leisure, should that be included in GDP?
- If the car is made self-driving by a free download, should that be included in GDP?
• BEA has put substantial resources into the measurement of health care
  – Exceptionally difficult project
  – Medical deflators still grow faster than input cost

• Real health care per capita rose 2% annually, 1985-2015
  – Real health spending rose about $3000
  – Lifespans rose 5 years in 30 years
    • If 1/3 of increased longevity due to health care, value of extra year of life $2000?
    • Note: recently life spans not increasing
Challenge: Alzheimer’s Vaccine

• One downside to a long life: dementia
  – Current prevalence for 65+: 8.8 %

• What would the value of an Alzheimer’s vaccine be?
  – Its resource cost?
  – 19 year life expectancy at age 65: add 1+ years of disability free life?
  – Non-disabled retired persons have highest self-reported happiness

• If Alzheimer’s disappears
  – We no longer have expenses for care facilities and caregivers (paid and voluntary)
Conclusion

• The revolution in technology has produced many new goods, processes, modes of distribution. They have made it harder to estimate GDP.

• The statistical system is struggling to keep up with some of the new problems posed by the tech revolution.
  – Many advances (capitalization of intangibles, industry accounts, health care, satellite, tech goods initiative at BEA)
  – Old problems remain (service sector output, new goods and the class-imputation method). Some have gotten harder.

• The floods of virtually free and readily accessible information is a game changer (Hulten and Nakamura (2017))

• Current measurement procedures probably understate GDP, certainly understate gains in the standard of living
Suggestions for future work

• Need a national innovation account supported across statistical agencies
• Need to think more about what is a “good” and the “bundling” issue; value of information
• Need to know more about how much of a new or improved good is consumption rather than an investment
• Need to think about how consumer surplus fits into GDP framework when consumer surplus is large vis-a-vis resource costs
• Need to deal with household production and consumption