Perspectives on the Productivity Slowdown

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Statistics Norway
Oslo
14 May 2019
References


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1. Productivity Slowdown

2. The Innovation Debate

3. Mismeasurement Hypothesis

4. Sources of Productivity Growth: Australian Industry Evidence
Trend Labour Productivity Growth in G7 Countries
Average Annual Rate, OECD Productivity Compendium 2016

Graphs showing trend labour productivity growth for Canada, France, Germany, and Italy.
Trend Labour Productivity Growth in G7 Countries
Average Annual Rate, OECD Productivity Compendium 2016

Japan

United Kingdom

United States
Labour productivity growth in emerging economies

GDP per person employed, percentage change at annual rate, OECD Productivity Compendium 2016
International Productivity Performance

Labour Productivity Growth
Real GDP per hour worked, annual average

South Korea
Spain
US
New Zealand
OECD*
Australia
Japan
Germany
Sweden
Mexico
Canada
Switzerland
France
UK
Italy
Norway

* 1995–2004 period estimated based on 28 out of 34 countries
Sources: IMF; OECD; RBA

Multifactor Productivity Levels, Australian Market Sector Industries

Data source: ABS (2018a). Note that the indicated years are fiscal years, which run from July 1 to 30 June. The plotted series are cumulated indexes, indicating the level of productivity relative to the base year of 1989-90.
Average Industry Multifactor Productivity Performance by Sub-Period

Data source: ABS (2018a). Note that the indicated years are fiscal years, which run from July 1 to 30 June. The plotted series are cumulated indexes, indicating the level of productivity relative to the base year of 1989-90.
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“Everything that can be invented has been invented.”

(Attributed to) Charles H. Duell, Commissioner of US patent office, 1899
Innovation and Economic Growth


-Drying up of big breakthroughs:

- Can economic growth be saved by Google’s driverless car?

- I am not forecasting an end to innovation, just a decline in the usefulness of future inventions in comparison with the great inventions of the past.
Innovation and Economic Growth

But what about the evidence of a decline in “inventiveness” ....?

I interpret most of the proffered evidence as reflecting the impact of reduced aggregate demand and less favourable economic prospects for inventive activity in the late 1970s, rather than as the result of technological springs running dry.

Innovation and Economic Growth

But what about the evidence of a decline in “inventiveness” ....?

I interpret most of the proffered evidence as reflecting the impact of reduced aggregate demand and less favourable economic prospects for inventive activity in the late 1970s, rather than as the result of technological springs running dry.

Alvin Hansen’s 1938 book *Full Recovery or Stagnation*?

“Hansen drew on the macroeconomic ideas of John Maynard Keynes in fearing that economic growth was over, with population growth and technological innovation exhausted.”
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“I don’t believe for a second the idea by economists who say that productivity does not grow any more. It is just badly measured! We are witnessing a tremendous increase in the quality of services at decreasing costs. A Google search that costs nothing would have been invoiced dearly twenty five years ago. If that is not productivity, what is?”

Henri de Castries, Chief Executive AXA Assurance, Les Echos 31 August 2015 (Quoted by Paul Schreyer, OECD)
And if that wasn’t enough….

Charlie Bean (2016):
“statistics have failed to keep pace with the impact of digital technology”

Hal Varian (Google):
“There’s a lack of appreciation for what’s happening in Silicon Valley, because we don’t have a good way to measure it.”

The productivity slowdown has occurred in dozens of countries, and its size is unrelated to measures of the countries’ consumption or production intensities of information and communication technologies.

Estimates from the existing research literature of the surplus created by internet-linked digital technologies fall far short of the “missing output” resulting from the productivity growth slowdown. The largest—by some distance—is less than one-third of the purportedly mismeasured GDP.
Mismeasurement of IT hardware is significant prior to the slowdown and because the domestic production of these products has fallen, the quantitative effect on productivity is larger in the 1995-2004 period than since....adjustments make the slowdown in labor productivity worse.

Many of the tremendous consumer benefits from smartphones, Google searches, and Facebook are, conceptually, non-market: Consumers are more productive in using their nonmarket time to produce services they value. These benefits raise consumer well-being but do not imply that market-sector production functions are shifting out more rapidly than measured.
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4. Sources of Productivity Growth: Australian Industry Evidence
Industry- and State-level Value Added and Productivity Decompositions

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Outline

1. Introduction
2. Method
3. Data
4. Industry-level decompositions
5. State-level decompositions
6. Conclusion
Diewert and Fox (2017) (DF) decompose value added into five explanatory factors:

- technical progress
- inefficiency
- input mix
- net output prices
- input quantities.

Advantages of the DF decomposition:

- Free Disposal Hull (FDH) and index number theory
- rules out technical regress
- a non-parametric approach using only observable data.
We apply the DF decomposition to Australian data at the aggregate, industry and state levels.

Focus on total factor productivity (TFP), which comprises:
- technical progress
- inefficiency
- input mix.

Our approach is simple to implement as it only requires:
- data cubes from the Australian Bureau of Statistics (ABS)
- R package: dfvad.
Defining the optimal output value

- Cost-constrained value added function:

\[ R^t(p, w, x) = \max_{y, z} \{ p \cdot y : (y, z) \in S^t; w \cdot z \leq w \cdot x \} \]

- Unit cost function:

\[ c^t(w, p) = \min_s \left\{ \frac{w \cdot x^s}{p \cdot y^s} : s = 1, \cdots, t \right\} \]
Defining the optimal output value

► Rewrite the cost-constrained value added function:

\[
R^t(p, w, x) = \max_s \left\{ \frac{p \cdot y^s \cdot w \cdot x}{w \cdot x^s} : s = 1, \cdots, t \right\} = \frac{w \cdot x}{c^t(w, p)}
\]

► A sequential approach which rules out technical regress.
Explanatory factors

- Net output price indexes:

$$\alpha(p_{t-1}^t, p^t, w, x, s) = \frac{R^s(p^t, w, x)}{R^s(p_{t-1}^{t-1}, w, x)}$$

- Input quantity indexes:

$$\beta(x_{t-1}^t, x^t, w) = \frac{w \cdot x^t}{w \cdot x_{t-1}^{t-1}}$$
Explanatory factors

- Input mix indexes:

\[
\gamma(w^{t-1}, w^t, p, x, s) = \frac{R^s(p, w^t, x)}{R^s(p, w^{t-1}, x)}
\]

- Returns to scale:

\[
\delta(x^{t-1}, x^t, p, w, s) = \frac{R^s(p, w, x^t)}{R^s(p, w, x^{t-1}) / \frac{w \cdot x^t}{w \cdot x^{t-1}}} = 1
\]
Explanatory factors

- Growth in value added efficiency:

\[ e^t = \frac{p^t \cdot y^t}{R^t(p^t, w^t, x^t)} \leq 1 \]

\[ \varepsilon^t = \frac{e^t}{e^{t-1}} \]

- Technical progress:

\[ \tau(t - 1, t, p, w, x) = \frac{R^t(p, w, x)}{R^{t-1}(p, w, x)} \]
Straightforward decomposition

- **Value added growth decomposition:**

\[
\frac{p^t \cdot y^t}{p^{t-1} \cdot y^{t-1}} = \alpha^t \cdot \beta^t \cdot \gamma^t \cdot \varepsilon^t \cdot \tau^t
\]

- **TFP growth decomposition:**

\[
TFPG^t = \frac{p^t \cdot y^t / p^{t-1} \cdot y^{t-1}}{\alpha^t \cdot \beta^t} = \gamma^t \cdot \varepsilon^t \cdot \tau^t
\]
A weighted average industry approach

- Törnqvist explanatory factors: \( \lambda \in \{ \alpha, \beta, \gamma, \varepsilon, \tau \} \)

\[
\ln \lambda^{t \bullet} = \sum_{k=1}^{K} \frac{1}{2} (s^{kt} + s^{k,t-1}) \ln \lambda^{kt}
\]

- Approximation of value relatives:

\[
\ln \left( \frac{v^{t}}{v^{t-1}} \right) \approx \sum_{k=1}^{K} \frac{1}{2} (s^{kt} + s^{k,t-1}) \ln \left( \frac{v^{kt}}{v^{k,t-1}} \right)
\]

\[
= \sum_{k=1}^{K} \frac{1}{2} (s^{kt} + s^{k,t-1}) \ln \left( \alpha^{kt} \beta^{kt} \gamma^{kt} \varepsilon^{kt} \tau^{kt} \right)
\]

\[
= \ln \alpha^{t \bullet} + \ln \beta^{t \bullet} + \ln \gamma^{t \bullet} + \ln \varepsilon^{t \bullet} + \ln \tau^{t \bullet}
\]
Establishing a benchmark

▶ $t = 1$:

\[ A^1 = 1, B^1 = 1, C^1 = 1, E^1 = 1, T^1 = 1 \]

▶ $t > 1$:

\[ A^t = \alpha^t A^{t-1}, \quad B^t = \beta^t B^{t-1}, \quad C^t = \gamma^t C^{t-1} \]
\[ E^t = \varepsilon^t E^{t-1}, \quad T^t = \tau^t T^{t-1} \]

▶ Level value of productivity:

\[ TFP^t = \frac{p^t \cdot y^t}{p^1 \cdot y^1 \cdot A^t \cdot B^t} \]
\[ = C^t E^t T^t \]
Australian market sector

- Two definitions:
  - 16 industries with productivity data available 1994/95–2016/17 (July–June years)
  - 12 industries with productivity data available 1989/90–2016/17 (July–June years).

- Concerns about measurement problems and research periods.
### Australian market sector

**Table 1: Industry classification of the market sector in Australia**

<table>
<thead>
<tr>
<th>Division</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Agriculture, Forestry and Fishing</td>
</tr>
<tr>
<td>B</td>
<td>Mining</td>
</tr>
<tr>
<td>C</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>D</td>
<td>Electricity, Gas, Water and Waste Services</td>
</tr>
<tr>
<td>E</td>
<td>Construction</td>
</tr>
<tr>
<td>F</td>
<td>Wholesale Trade</td>
</tr>
<tr>
<td>G</td>
<td>Retail Trade</td>
</tr>
<tr>
<td>H</td>
<td>Accommodation and Food Services</td>
</tr>
<tr>
<td>I</td>
<td>Transport, Postal and Warehousing</td>
</tr>
<tr>
<td>J</td>
<td>Information, Media and Telecommunications</td>
</tr>
<tr>
<td>K</td>
<td>Financial and Insurance Services</td>
</tr>
<tr>
<td>L</td>
<td>Rental, Hiring and Real Estate Services</td>
</tr>
<tr>
<td>M</td>
<td>Professional, Scientific and Technical Services</td>
</tr>
<tr>
<td>N</td>
<td>Administrative and Support Services</td>
</tr>
<tr>
<td>R</td>
<td>Arts and Recreation Services</td>
</tr>
<tr>
<td>S</td>
<td>Other Services</td>
</tr>
</tbody>
</table>
Industry-level decompositions

TFP – 12 Selected Industries
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – DF Method with ABS Aggregates
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Industry-level decompositions

TFP Decomposition – Weighted Industry Aggregation Method
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)

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Value added decomposition
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Large efficiency losses in mining and utilities

TFP Decompositions by Industry
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Since 2004, tech progress concentrated in four industries

TFP Decompositions by Industry
1989/90 = 0, log scale, financial years

Agriculture

Wholesale

Retail

Financial

TFP Technical progress Inefficiency Input mix

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Industry Contributions to Value Added

Financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Industry contribution: aggregation

- The weighted average industry approach:

\[
\ln \lambda^{t\bullet} = \sum_k \frac{1}{2} (s^{kt} + s^{k,t-1}) \ln \lambda^{kt}
\]

- From growth value to level value:

\[
\ln \Lambda^{t\bullet} = \sum_t \sum_k \frac{1}{2} (s^{kt} + s^{k,t-1}) \ln \lambda^{kt}
\]

\[
= \sum_k \ln \Lambda^{kt}
\]
Industry Contributions to TFP
1989/90 = 0, log scale, financial years

Industry Contributions to TFP
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)

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Industry Contributions to Inefficiency

1989/90 = 0, log scale, financial years

- Arts & recreation
- Financial
- Info, media & telecom
- Transport
- Accom & food
- Retail
- Wholesale
- Manufacturing
- Mining
- Agriculture
- Total

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Industry Contributions to Technical Progress
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Thoughts on the industry results

▶ Industry performance contributes to the aggregate level according to value added shares.

▶ Efficiency:
  - Unweighted: electricity, gas, water and waste services.
  - Weighted: mining.

▶ Technical progress:
  - Unweighted: agriculture, forestry and fishing.
  - Weighted: financial and insurance services.
State-level data

- Data for eight states and territories available 1994/95–2017/18 (July–June years).

- TFP data cover 12 selected industries and are still *experimental*.
  - State × industry breakdown not publically available.

- Less-populated states more prone to measurement error and volatility.
State-level decompositions

Tech progress strongest in non-mining states...

TFP Decompositions – Non-mining States
1994/95 = 0, log scale, financial years

New South Wales
Victoria
Australian Capital Territory
Tasmania

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
...while inefficiency has weighed on TFP in mining states

TFP Decompositions – Mining States
1994/95 = 0, log scale, financial years

Queensland

Western Australia

South Australia

Northern Territory

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
We have applied the DF decomposition to Australian data.

Inefficiency explains much of the weakness in TFP growth in many industries and states.
- This result could be more reasonable than interpreting negative TFP growth as technical regress.
- But mismeasurement may be exaggerating the role of inefficiency.

Our method is easily implementable by national statistical offices and provides policy-relevant information on growth and productivity.
References

Spares – Industry TFP Decompositions

TFP Decompositions by Industry
1989/90 = 0, log scale, financial years

Agriculture Agriculture
0.0
0.6

Mining Mining
0.0
0.6

Manufacturing Manufacturing
-0.6
0.0

Utilities Utilities
-0.6
0.0

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decompositions by Industry

1989/90 = 0, log scale, financial years

Construction

Wholesale

Retail

Accom & food

TFP Technical progress Inefficiency Input mix

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Spares – Industry TFP Decompositions

TFP Decompositions by Industry
1989/90 = 0, log scale, financial years

Transport

Info, media & telecom

Financial

Arts & recreation

TFP Technical progress
Inefficiency
Input mix

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Agriculture
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Mining

1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Manufacturing
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Spares – Industry TFP Decompositions

TFP Decomposition – Utilities
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Spares – Industry TFP Decompositions

TFP Decomposition – Construction
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Wholesale

1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Retail

1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Accom & Food
1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Transport

1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Info, Media & Telecom
1989/90 = 0, log scale, financial years

index

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Financial

1989/90 = 0, log scale, financial years

TFP Technical progress Inefficiency Input mix

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Arts & Recreation

1989/90 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Spares – State TFP Decompositions

TFP Decomposition – NSW
1994/95 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Victoria
1994/95 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Queensland
1994/95 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
Spares – State TFP Decompositions

TFP Decomposition – SA
1994/95 = 0, log scale, financial years

TFP Technical progress
Inefficiency
Input mix

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – WA
1994/95 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – Tasmania

1994/95 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – NT
1994/95 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Decomposition – ACT

1994/95 = 0, log scale, financial years

Sources: ABS; Authors' calculations; Diewert and Fox (2017)
TFP Growth by Industry

Year-ended December 2018

Source: ABS
TFP Growth by State

Year-ended December 2018

Source: ABS

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