UNSW Business School
Centre for Applied Economic Research

Perspectives on the Productivity Slowdown

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Oslo
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References

Fox, K.J. (2018), "What Do We Know About the Productivity Slowdown? Evidence from Australian Industry Data," *International Productivity Monitor Number* 35, Fall, 149–156.

Diewert, W.E. and K.J. Fox (2019), "Productivity Indexes and National Statistics: Theory, Methods and Challenges," in W. Greene and T. ten Raa (eds.), *Handbook of Economic Performance Analysis*, Palgrave, Chapter 18, forthcoming.

Zeng, S., S. Parsons, W.E. Diewert and K.J. Fox (2019), "Industry and State Level Value Added and Productivity Decompositions," forthcoming manuscript.

Diewert, W.E. and K.J. Fox (2018), "Decomposing Value Added Growth into Explanatory Factors," in E. Grifell-Tatjé, C.A.K. Lovell and R. Sickles (eds.), *The Oxford Handbook of Productivity Analysis*, Oxford University Press: New York, NY, Chapter 19, 625–662.

Plan

1. Productivity Slowdown

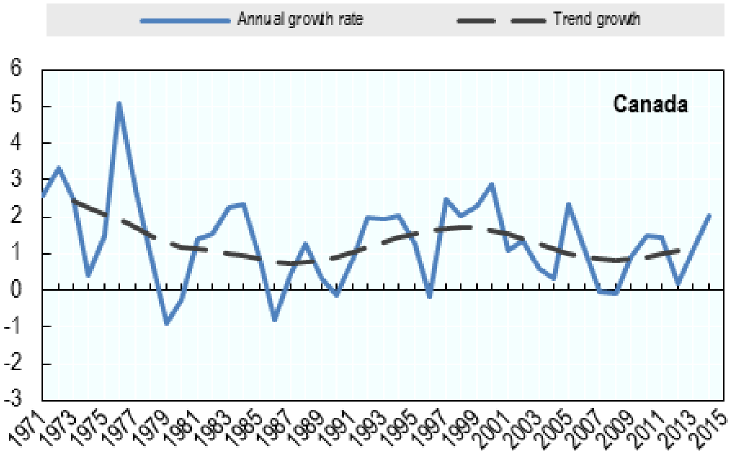
2. The Innovation Debate

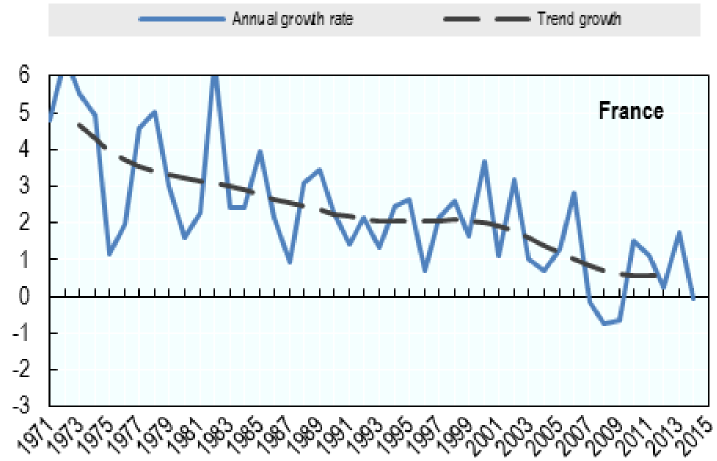
3. Mismeasurement Hypothesis

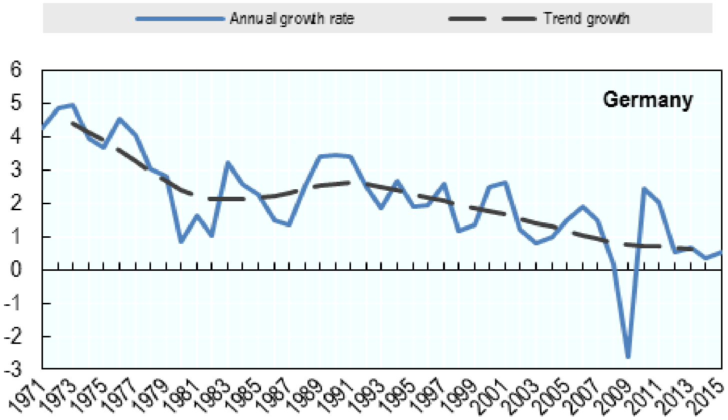
4. Sources of Productivity Growth: Australian Industry Evidence

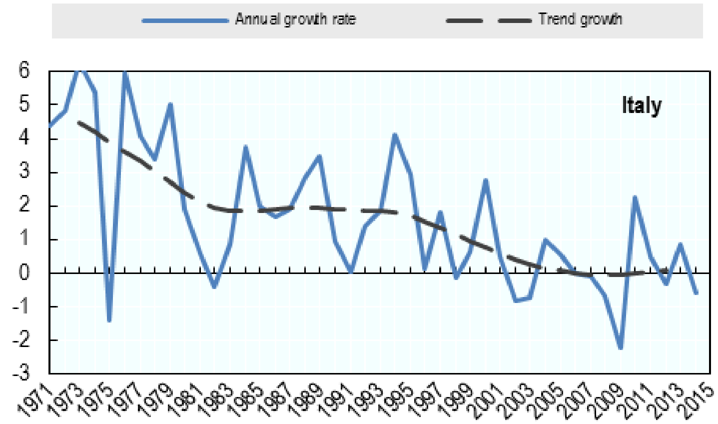
Trend Labour Productivity Growth in G7 Countries

Average Annual Rate, OECD Productivity Compendium 2016









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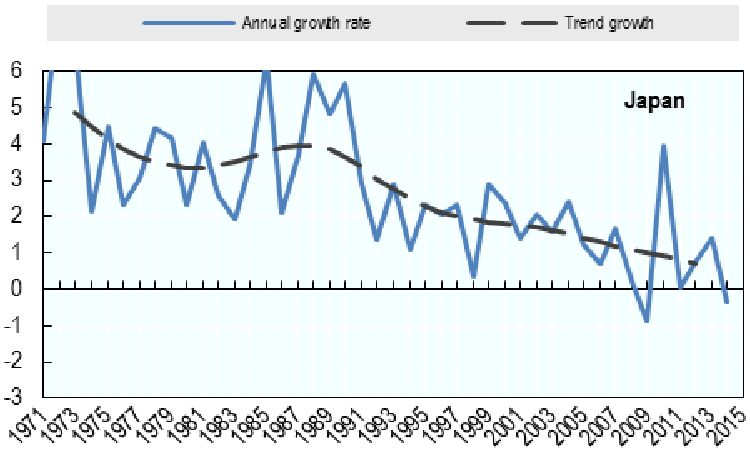

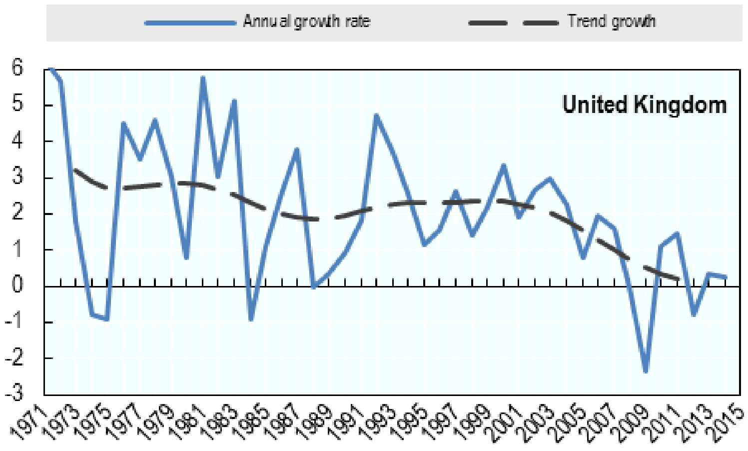

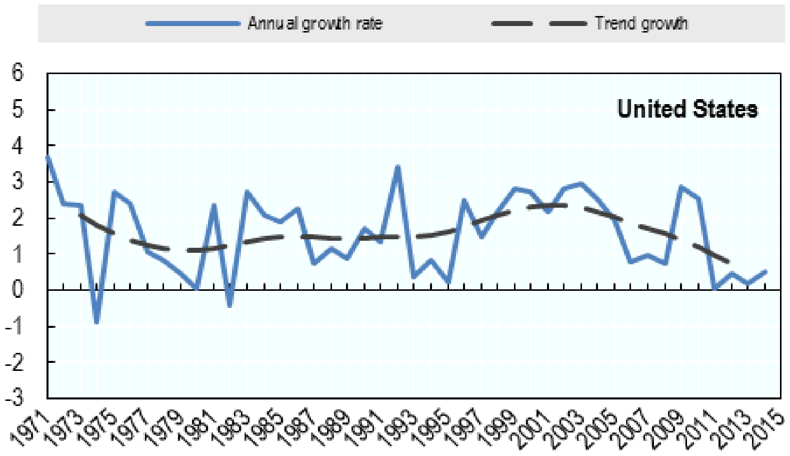

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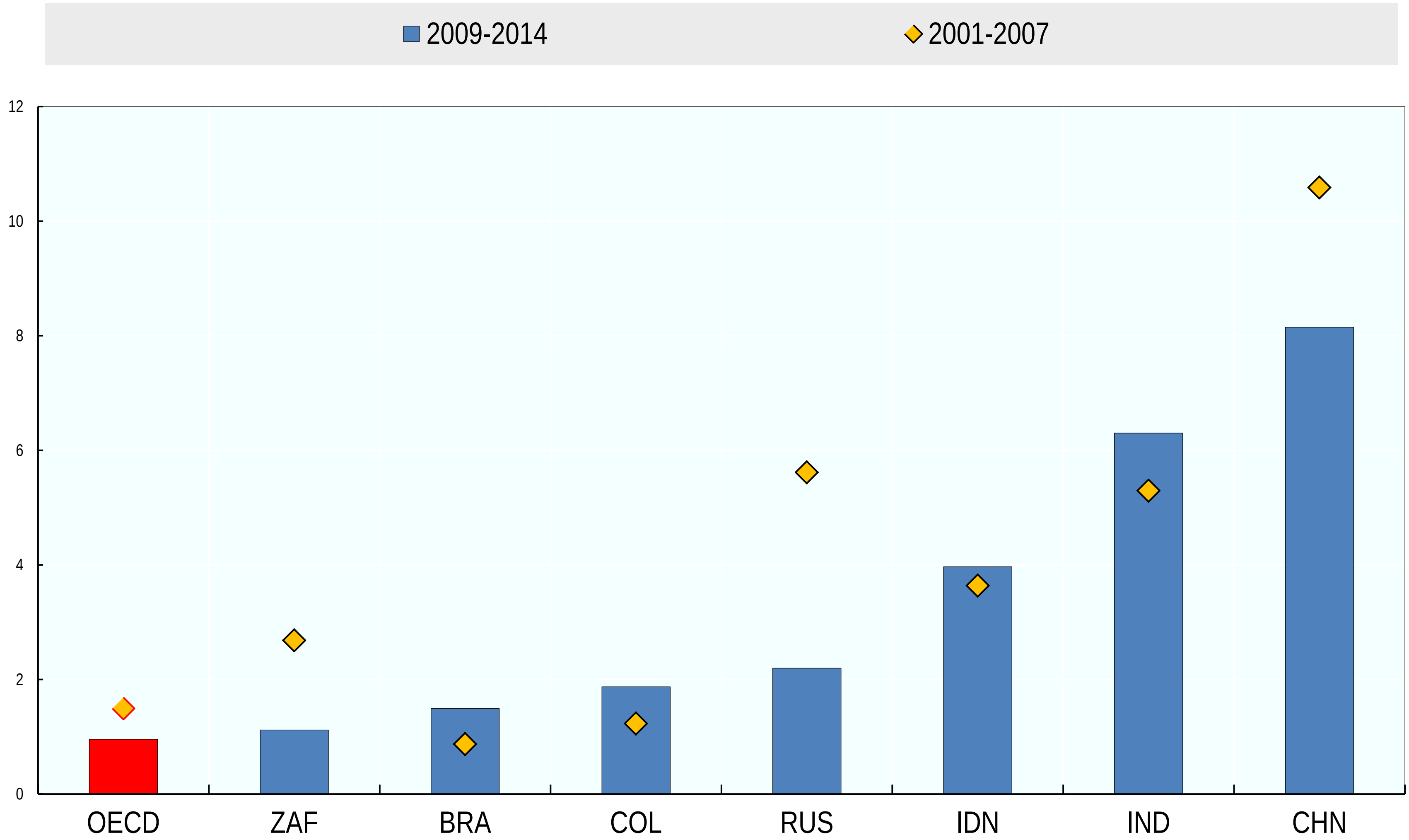
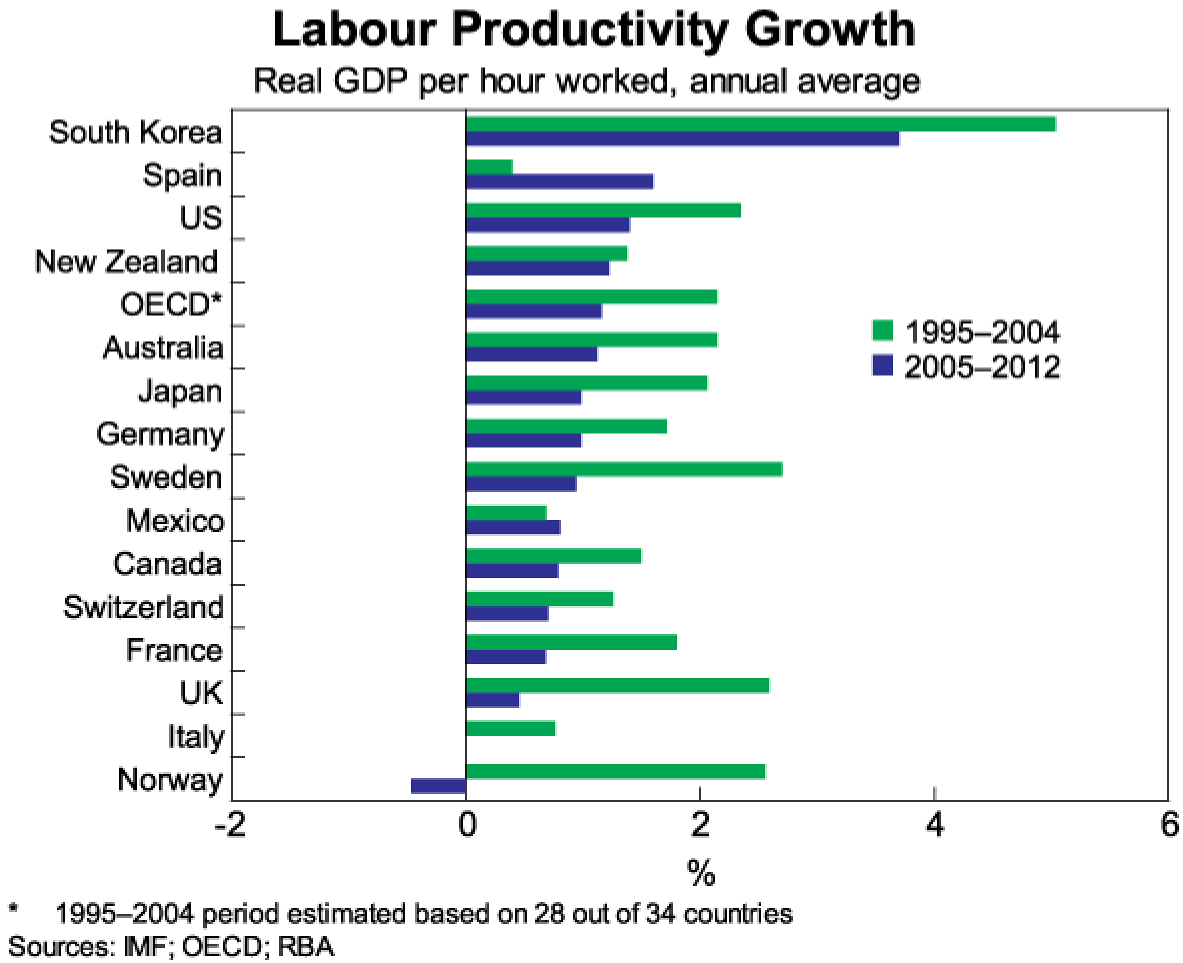
Labour productivity growth in emerging economies

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

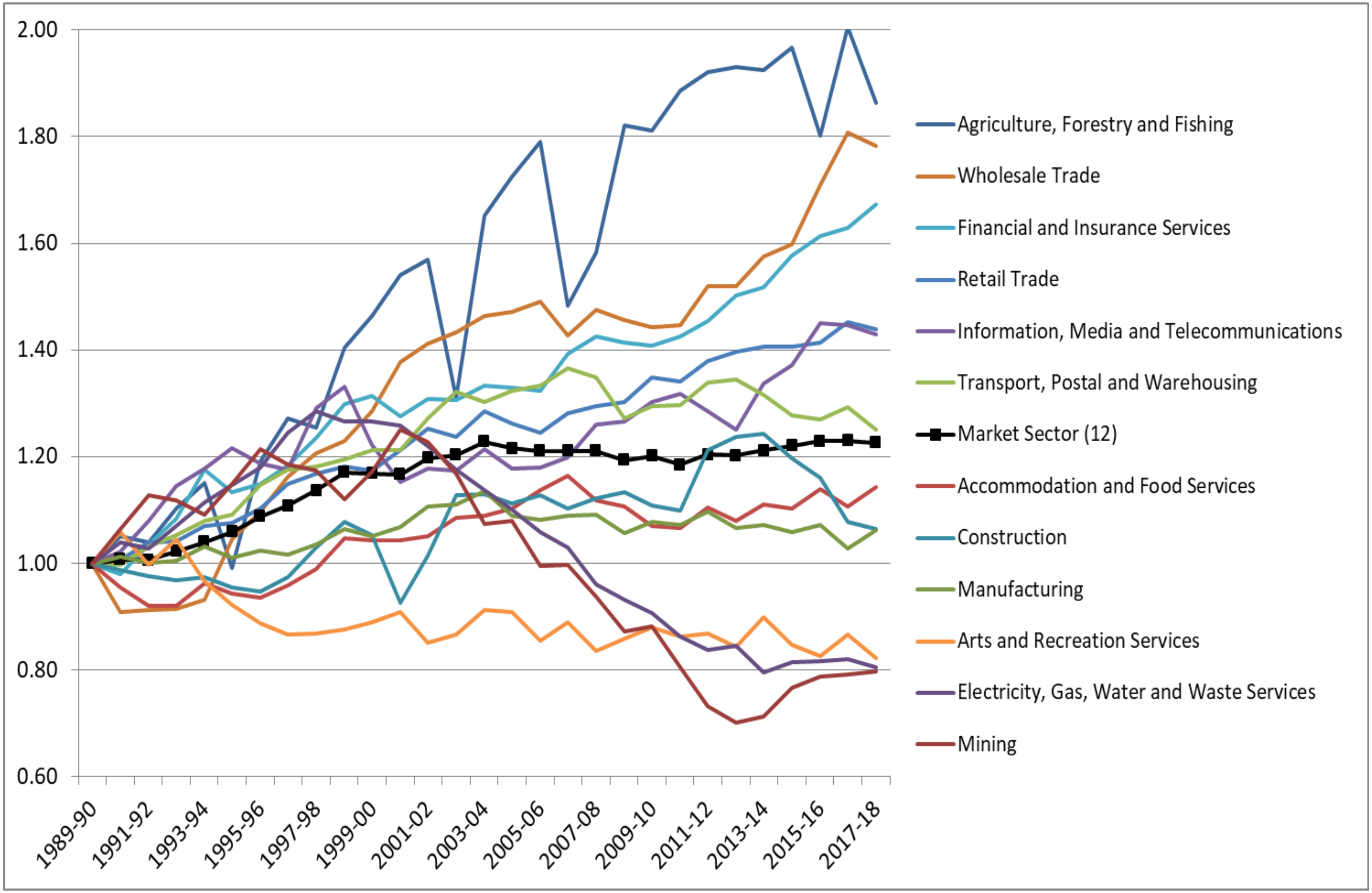


International Productivity Performance



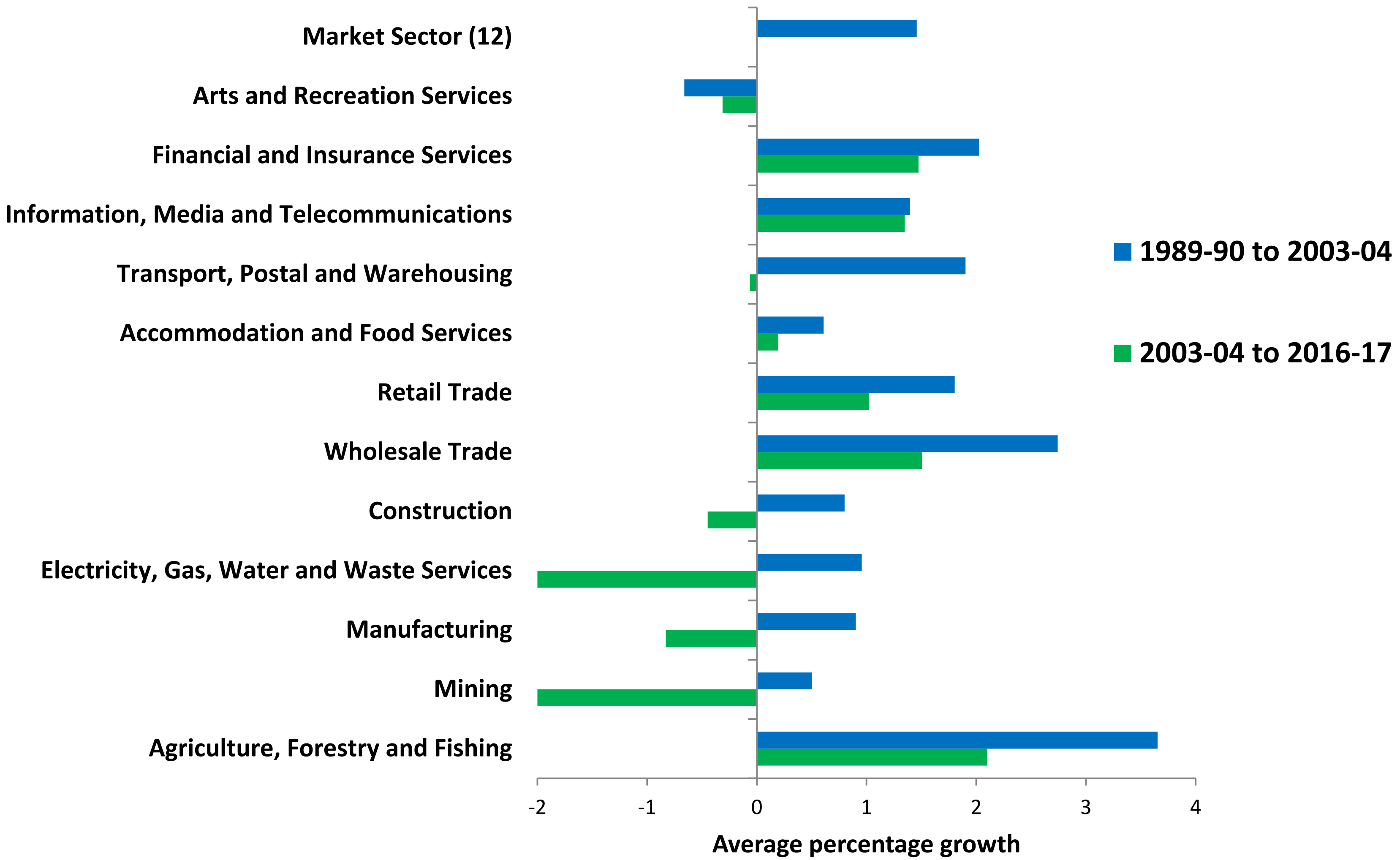
From a speech by Dr. Phillip Lowe, Deputy Governor, Reserve Bank of Australia: "Demographics, Productivity and Innovation," The Sydney Institute, Sydney, 12 March 2014. http://www.rba.gov.au/speeches/2014/sp-dg-120314.html

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



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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

Robert Gordon: "Why Innovation Won't Save Us" (Wall Street Journal, 22-23 Dec. 2012)

-**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.

Griliches (1988): "Productivity Puzzles and R&D: Another Nonexplanation," ***Journal of Economic Perspectives*** **2(4), 9 – 21.**

Innovation and Economic Growth

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Griliches (1988): "Productivity Puzzles and R&D: Another Nonexplanation," *Journal of Economic Perspectives* 2(4), 9 – 21.

“The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?”

Joel Mokyr, Chris Vickers, and Nicolas L. Ziebarth (2015), *Journal of Economic Perspectives 29(3), 31–50*.

Alvin Hansen’s1938 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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A Typical View From Industry

"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 Wall Street Journal (2015): Silicon Valley Doesn't Believe U.S. Productivity is Down

Chad Syverson (2017) “Challenges to Mismeasurement Explanations for the U.S. Productivity Slowdown”

Journal of Economic Perspectives 31, 165-186.

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.

Byrne, Reinsdorf, Fernald (2016)
"Does the United States have a Productivity Slowdown or a Measurement Problem?"

in J. Eberly and J. Stock (eds.), *Brookings Papers on Economic Activity: Spring 2016*, Washington, D.C.: Brookings Institute..

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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Industry- and State-level Value Added and Productivity Decompositions

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16 May 2019

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Outline

1. Introduction
2. Method
3. Data
4. Industry-level decompositions
5. State-level decompositions
6. Conclusion

Value added decomposition

- 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.

Value added decomposition

- 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:

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

- 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:

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

- A sequential approach which rules out technical regress.

Explanatory factors

- Net output price indexes:

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

- Input quantity indexes:

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

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:

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

Explanatory factors

- Growth in value added efficiency:

$$e^t = \frac{p^t \cdot y^t}{R^t(p^t, w^t, x^t)} \leqslant 1$$

$$\varepsilon^t = \frac{e^t}{e^{t-1}}$$

- 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:

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

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

$$= \ln \alpha^{t\bullet} + \ln \beta^{t\bullet} + \ln \gamma^{t\bullet} + \ln \varepsilon^{t\bullet} + \ln \tau^{t\bullet}$$

Establishing a benchmark

- $t = 1$:

$$A^1 = 1, B^1 = 1, C^1 = 1, E^1 = 1, T^1 = 1$$

- $t > 1$:

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

- Level value of productivity:

$$\begin{aligned} TFP^t &= \frac{p^t \cdot y^t}{p^1 \cdot y^1 \cdot A^t \cdot B^t} \\ &= C^t E^t T^t \end{aligned}$$

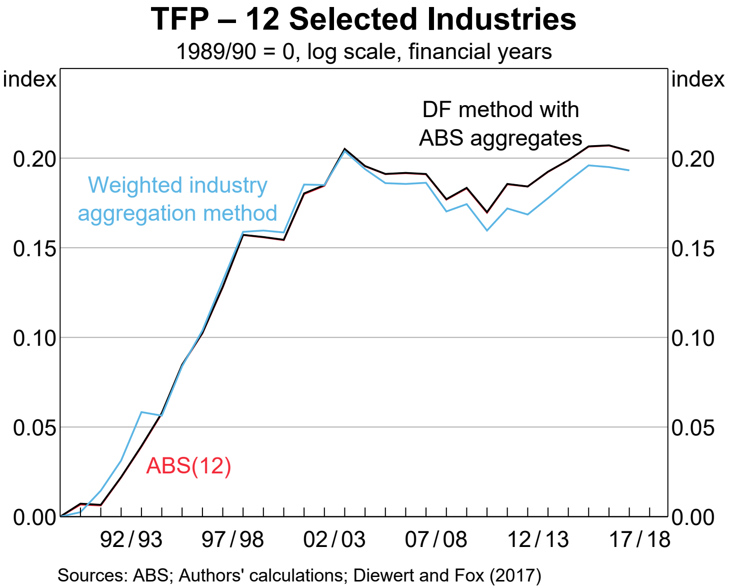
Australian market sector

- 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

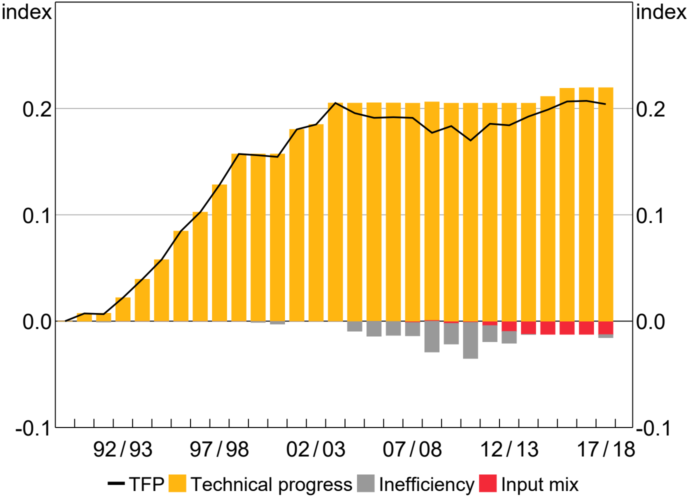
Table 1: Industry classification of the market sector in Australia

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

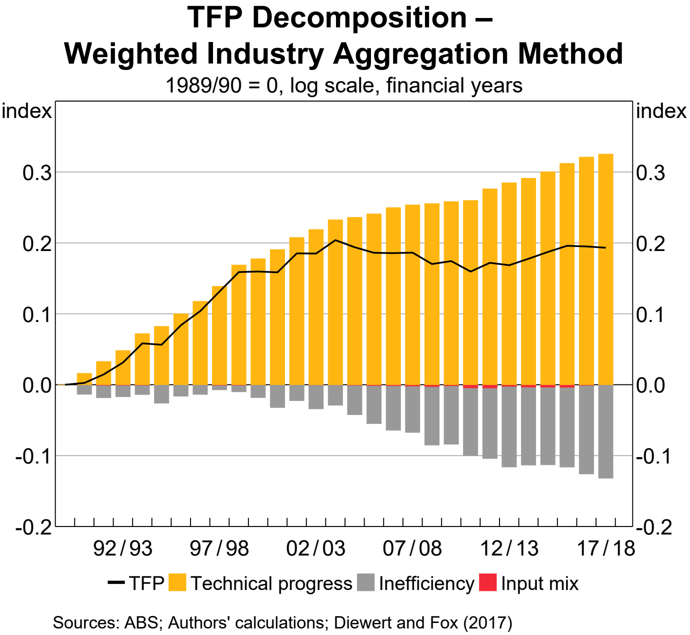

TFP – 12 Selected Industries
1989/90 = 0, log scale, financial years
index
index
DF method with
ABS aggregates
Weighted industry
aggregation method
ABS(12)
0.20
0.15
0.10
0.05
0.00
92/93
97/98
02/03
07/08
12/13
17/18
Sources: ABS; Authors' calculations; Diewert and Fox (2017)

TFP Decomposition – DF Method with ABS Aggregates

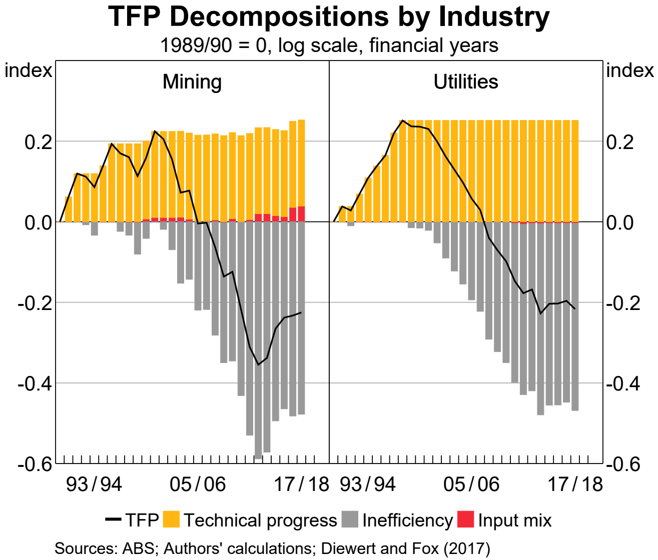
1989/90 = 0, log scale, financial years



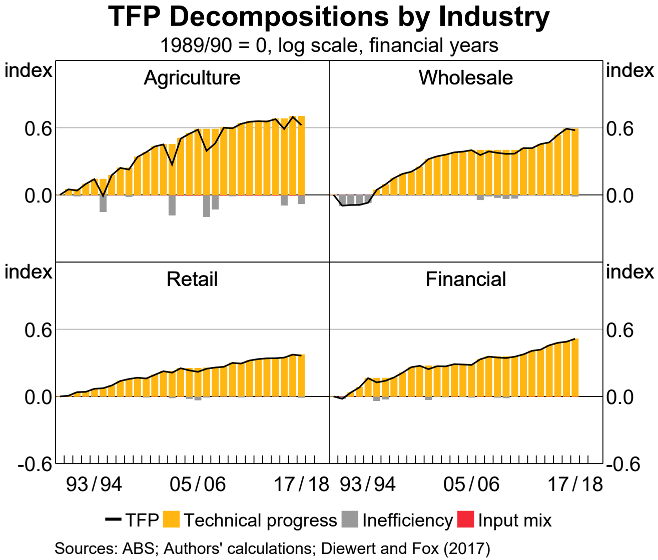
Sources: ABS; Authors' calculations; Diewert and Fox (2017)


TFP Decomposition –
Weighted Industry Aggregation Method
1989/90 = 0, log scale, financial years
index
index
0.3
0.2
0.1
0.0
-0.1
-0.2
92/93
97/98
02/03
07/08
12/13
17/18
TFP
Technical progress
Inefficiency
Input mix
Sources: ABS; Authors' calculations; Diewert and Fox (2017)

Large efficiency losses in mining and utilities

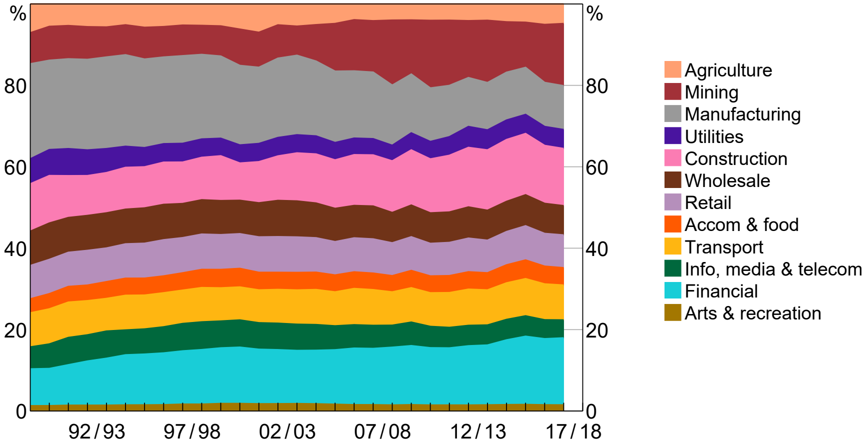


Since 2004, tech progress concentrated in four industries



Industry Contributions to Value Added

Financial years



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

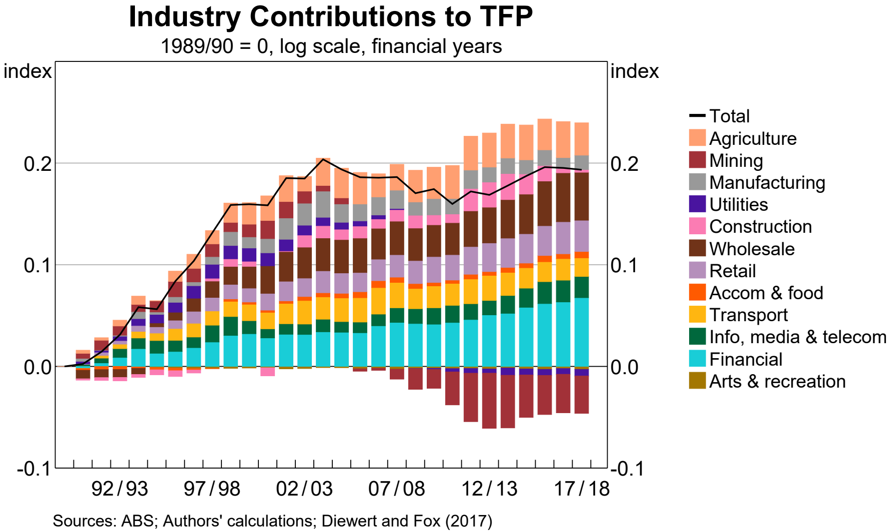
Industry contribution: aggregation

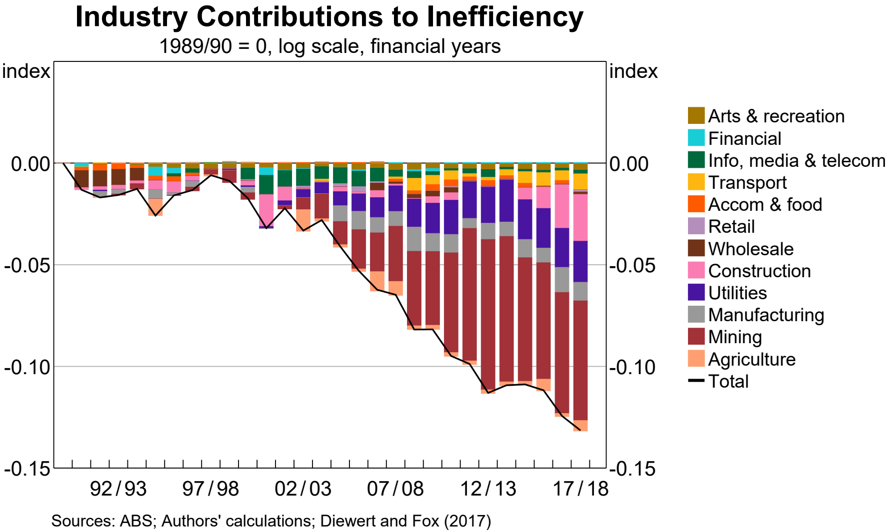
- The weighted average industry approach:

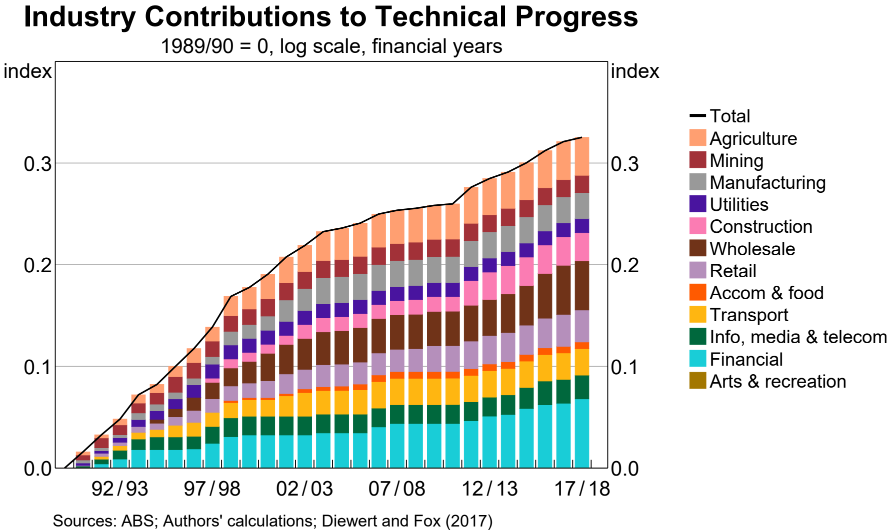
$$\ln \lambda^{t\bullet} = \sum_k \frac{1}{2}(s^{kt} + s^{k,t-1}) \ln \lambda^{kt}$$

- From growth value to level value:

$$\begin{aligned}
\ln \Lambda^{t\bullet} &= \sum_t \sum_k \frac{1}{2}(s^{kt} + s^{k,t-1}) \ln \lambda^{kt} \\
&= \sum_k \sum_t \frac{1}{2}(s^{kt} + s^{k,t-1}) \ln \lambda^{kt} \\
&= \sum_k \ln \Lambda^{kt}
\end{aligned}$$


Industry Contributions to TFP
1989/90 = 0, log scale, financial years
index
index
0.2
0.1
0.0
-0.1
92/93
97/98
02/03
07/08
12/13
17/18
Total
Agriculture
Mining
Manufacturing
Utilities
Construction
Wholesale
Retail
Accom & food
Transport
Info, media & telecom
Financial
Arts & recreation
Sources: ABS; Authors' calculations; Diewert and Fox (2017)


Industry Contributions to Inefficiency
1989/90 = 0, log scale, financial years
index
index
0.00
-0.05
-0.10
-0.15
92/93
97/98
02/03
07/08
12/13
17/18
Arts & recreation
Financial
Info, media & telecom
Transport
Accom & food
Retail
Wholesale
Construction
Utilities
Manufacturing
Mining
Agriculture
Total
Sources: ABS; Authors' calculations; Diewert and Fox (2017)


Industry Contributions to Technical Progress
1989/90 = 0, log scale, financial years
index
index
0.3
0.2
0.1
0.0
92/93
97/98
02/03
07/08
12/13
17/18
Total
Agriculture
Mining
Manufacturing
Utilities
Construction
Wholesale
Retail
Accom & food
Transport
Info, media & telecom
Financial
Arts & recreation
Sources: ABS; Authors' calculations; Diewert and Fox (2017)

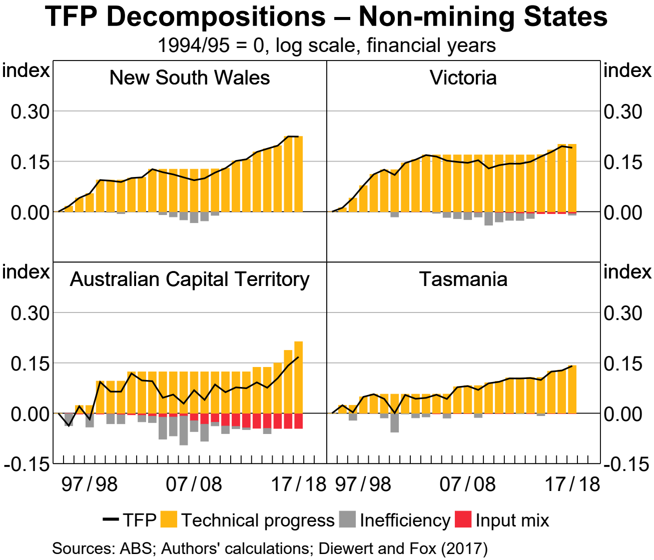
Thoughts on the industry results

- 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.

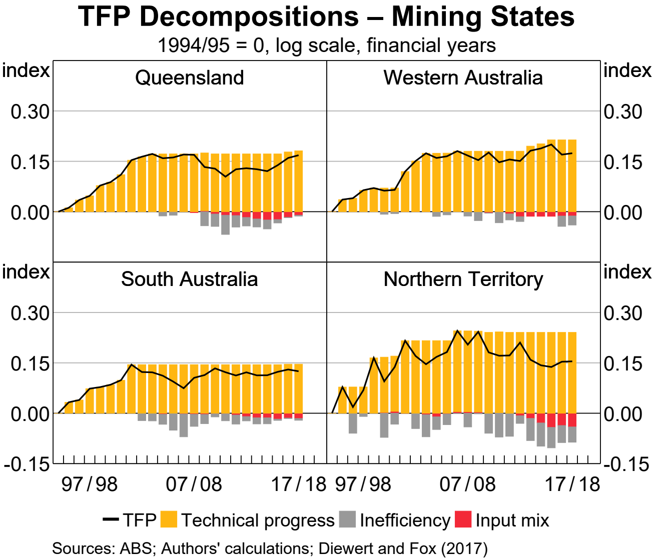
State-level data

- 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 $\times$ industry breakdown not publically available.
- Less-populated states more prone to measurement error and volatility.

Tech progress strongest in non-mining states...



...while inefficiency has weighed on TFP in mining states



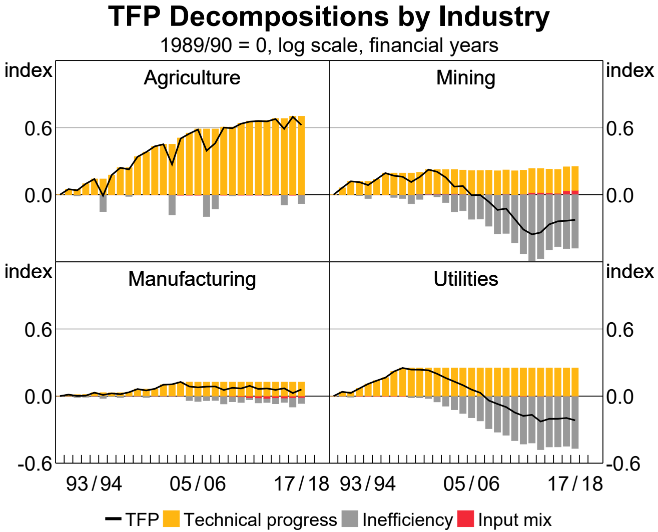
Conclusion

- 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

- Diewert WE and KJ Fox (2017), 'Decomposing Value Added Growth into Explanatory Factors', UNSW Business School Research Paper No 2017 ECON 02.

Spares – Industry TFP Decompositions



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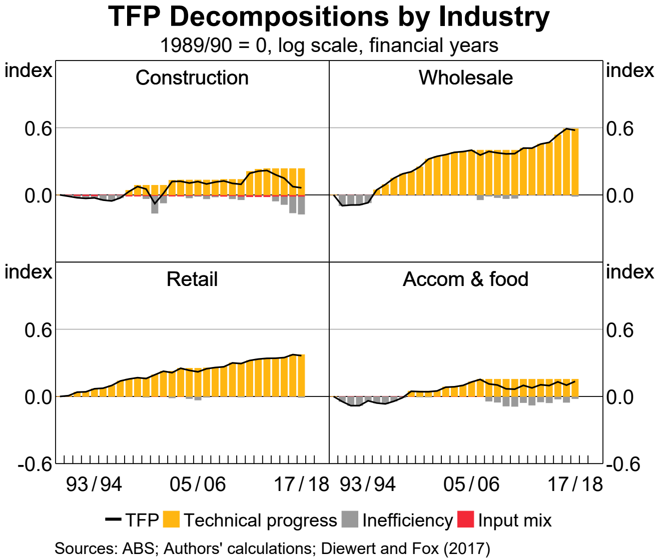

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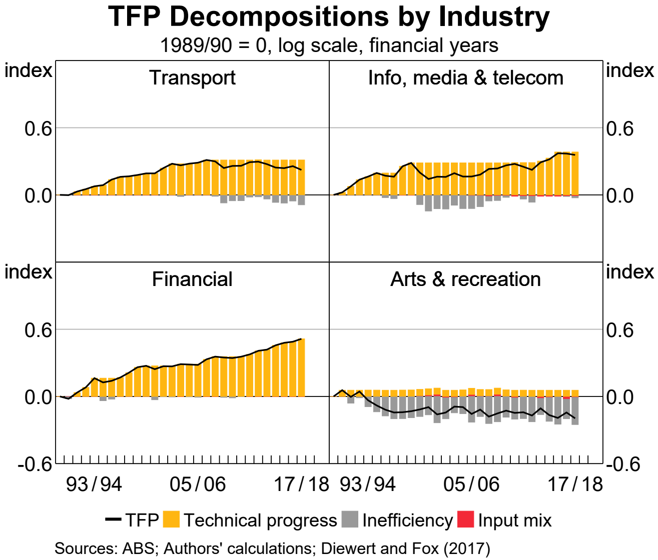

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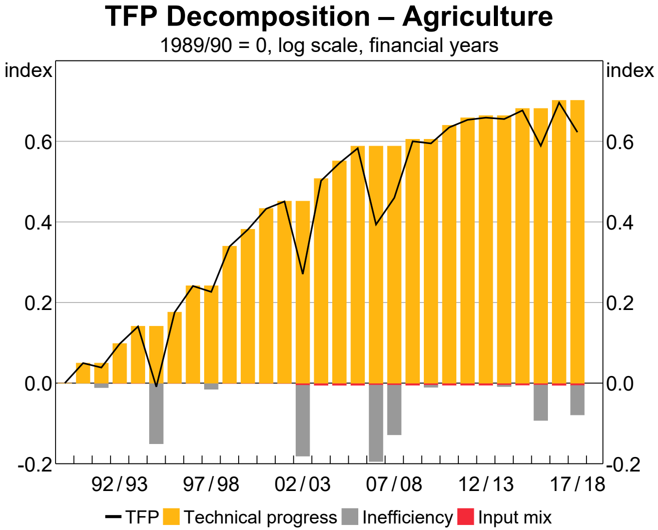

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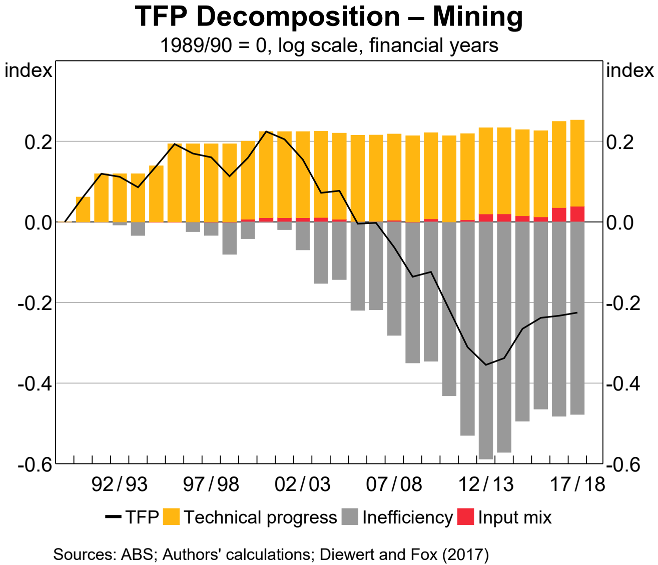

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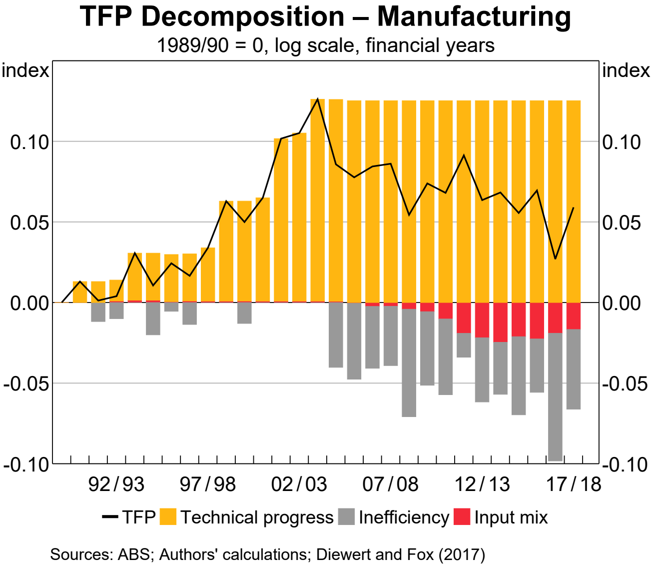

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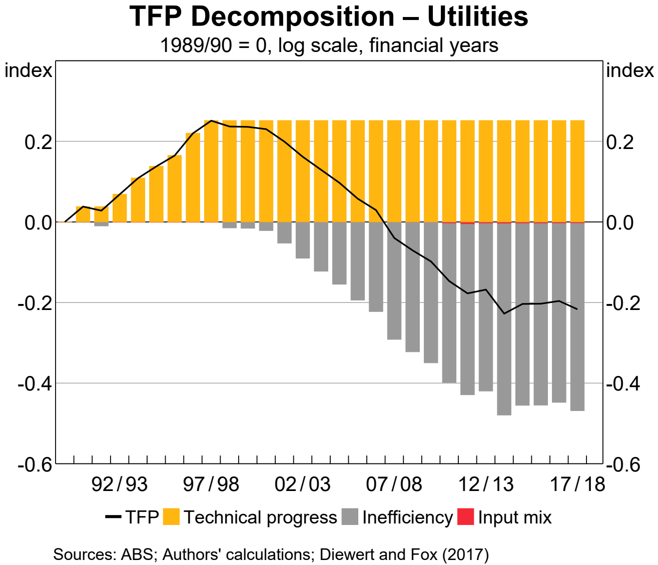
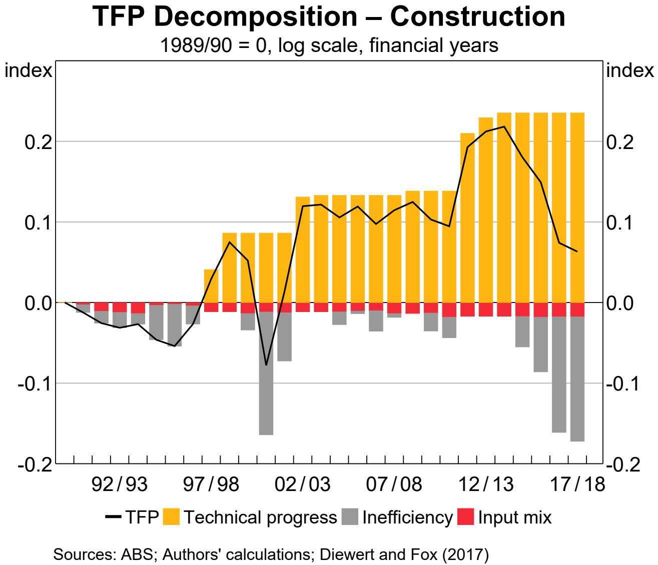


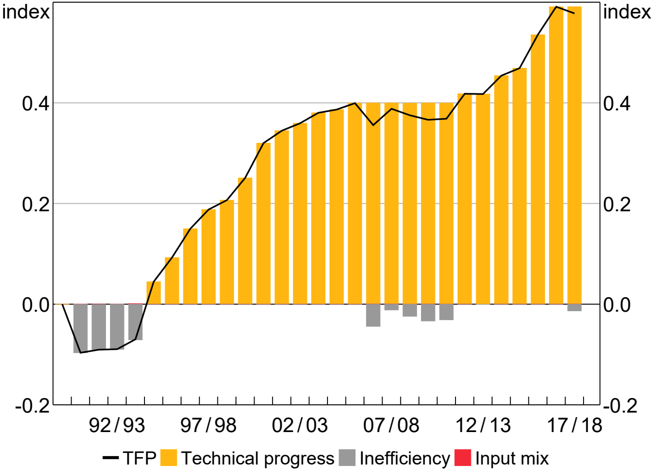
Spares – Industry TFP Decompositions



Spares – Industry TFP Decompositions

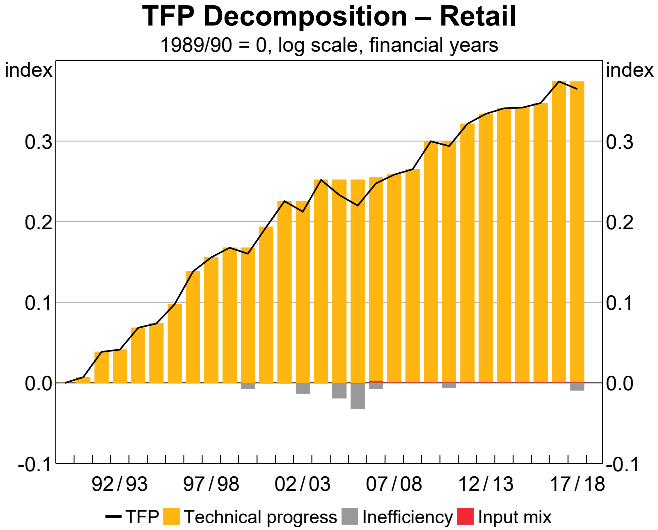
TFP Decomposition – Wholesale

1989/90 = 0, log scale, financial years



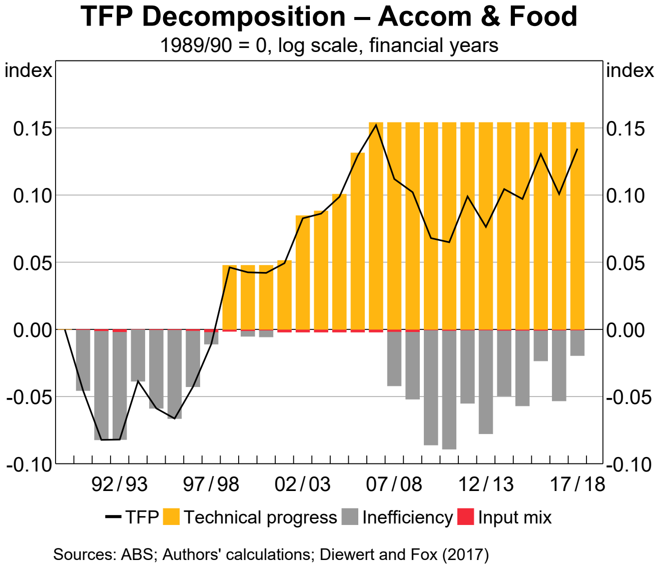
Sources: ABS; Authors' calculations; Diewert and Fox (2017)

Spares – Industry TFP Decompositions



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

Spares – Industry TFP Decompositions



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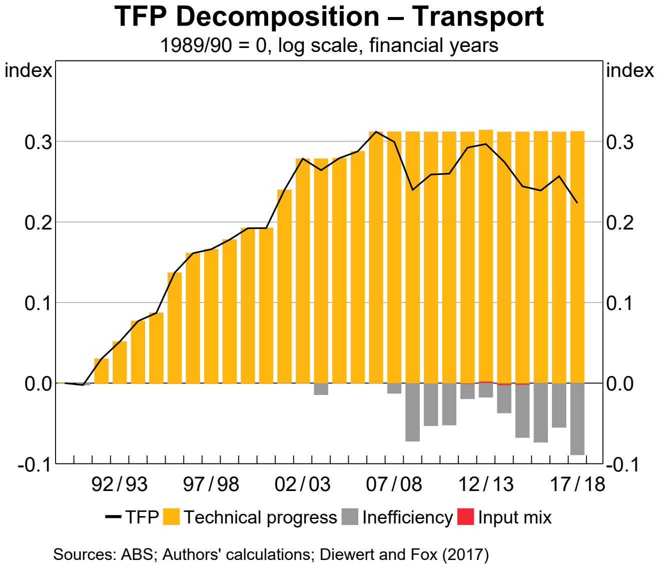

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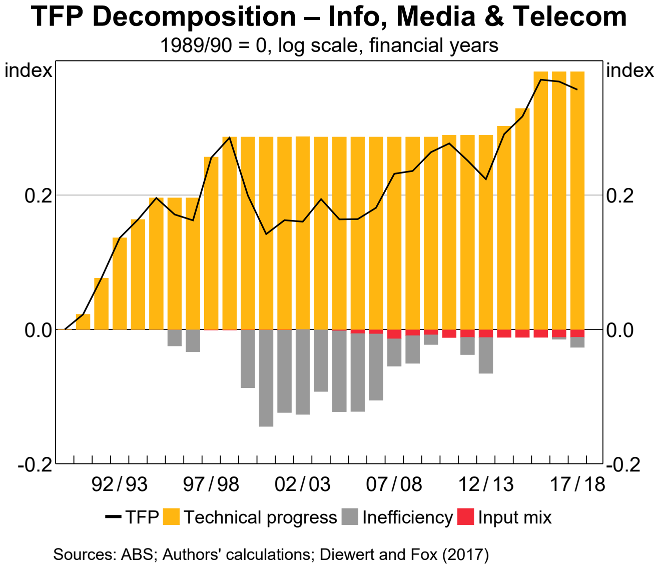
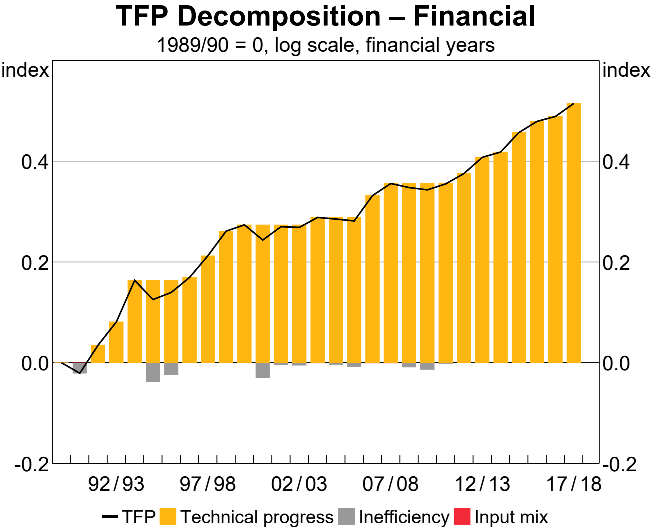
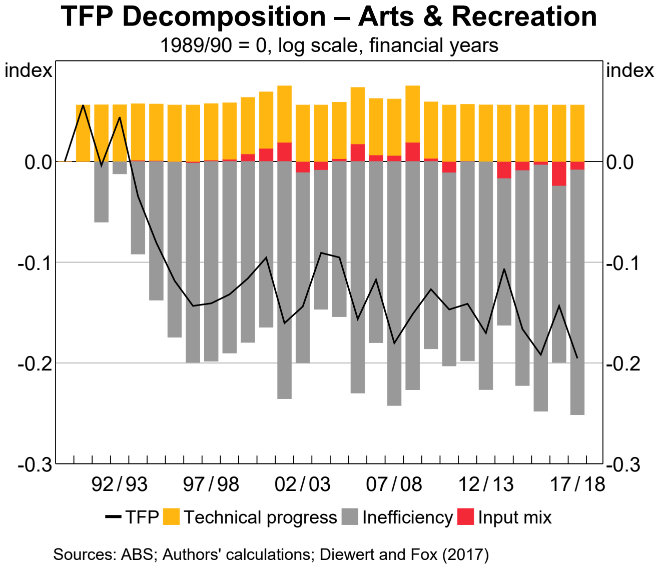


Spares – Industry TFP Decompositions

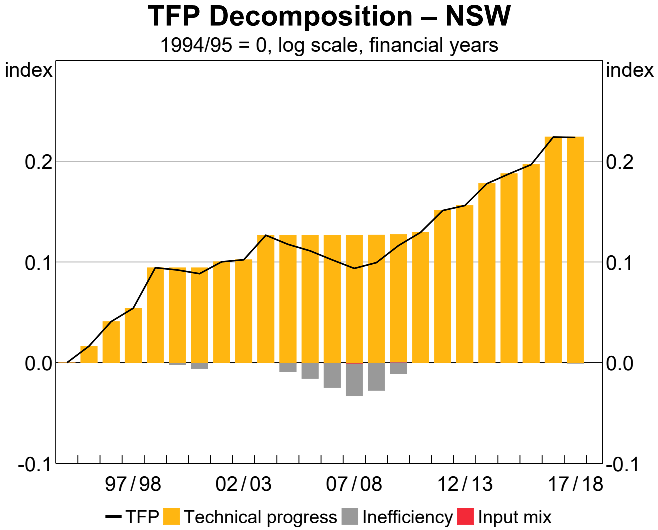


Sources: ABS; Authors' calculations; Diewert and Fox (2017)

Spares – Industry TFP Decompositions



Spares – State TFP Decompositions



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

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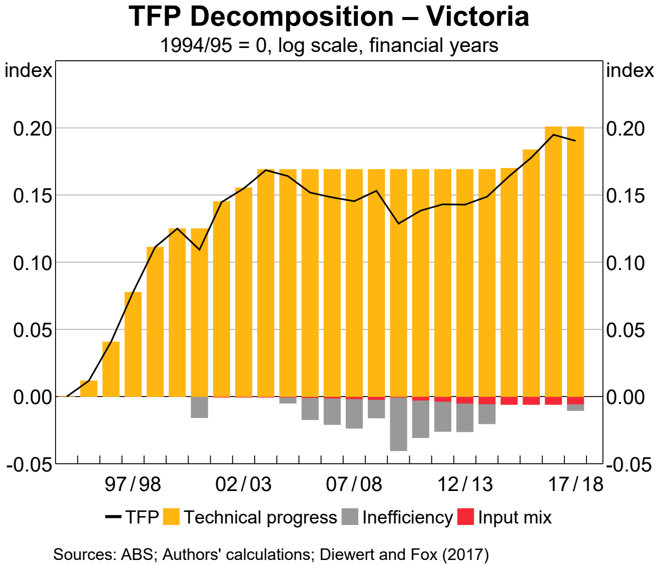

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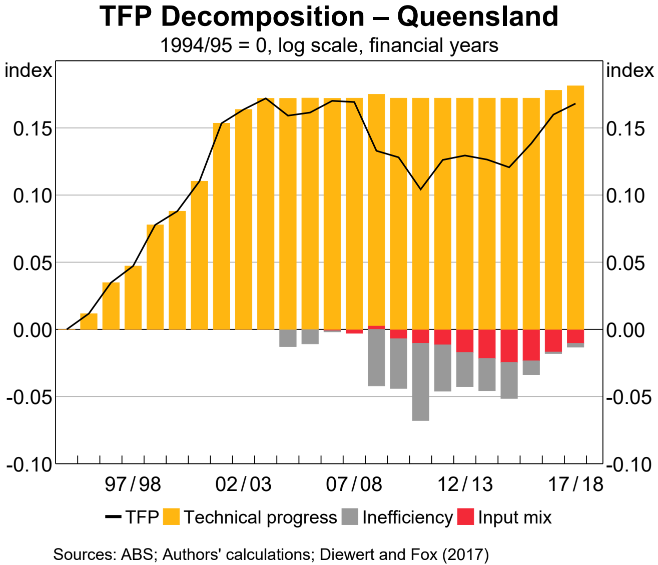

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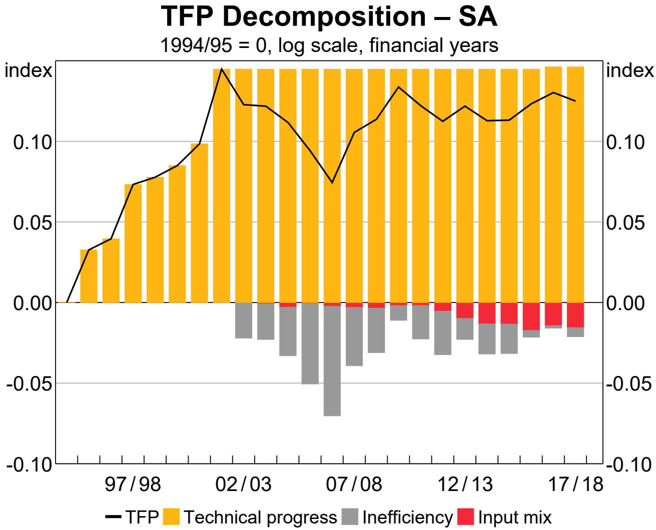
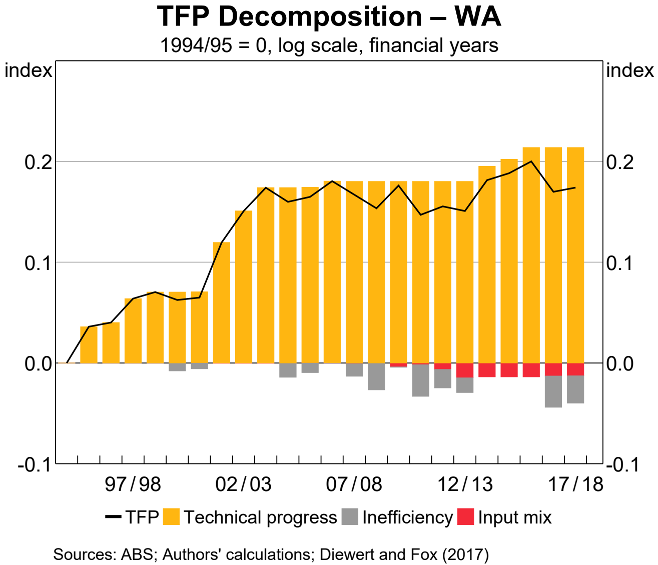


Sources: ABS; Authors' calculations; Diewert and Fox (2017)

Spares – State TFP Decompositions



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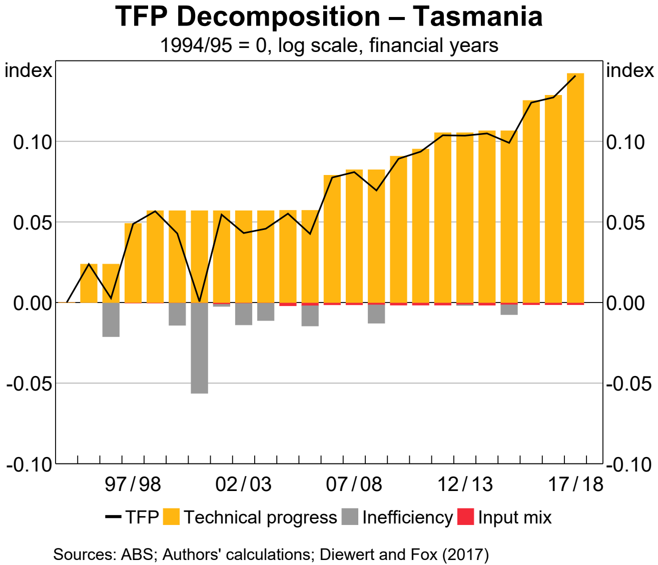

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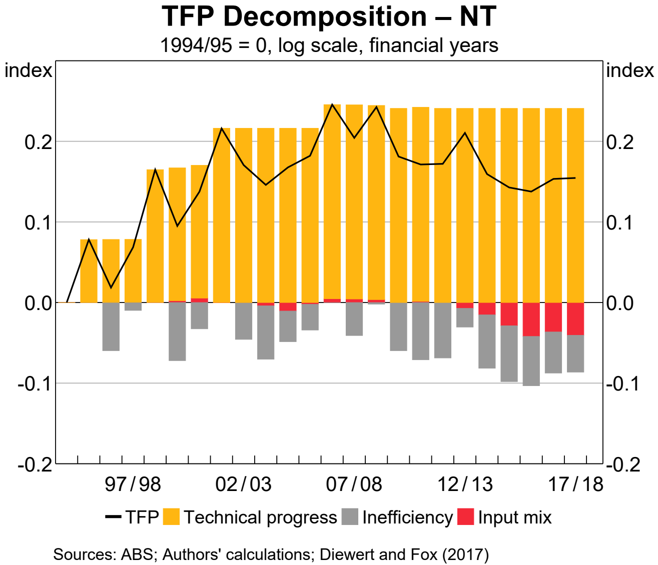

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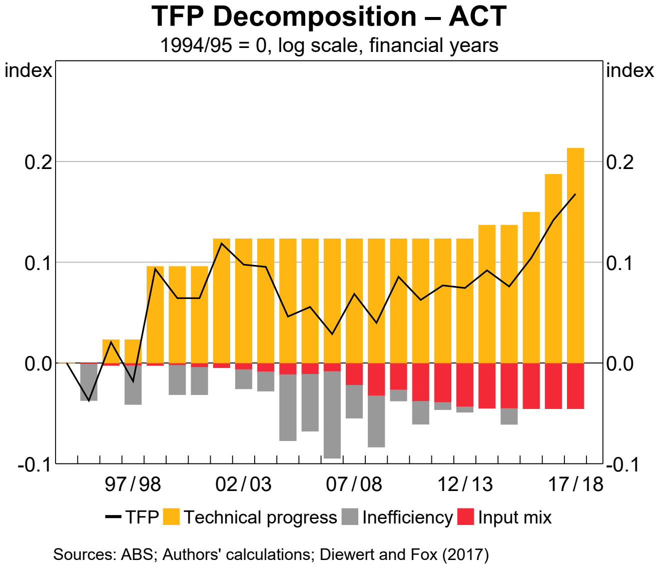
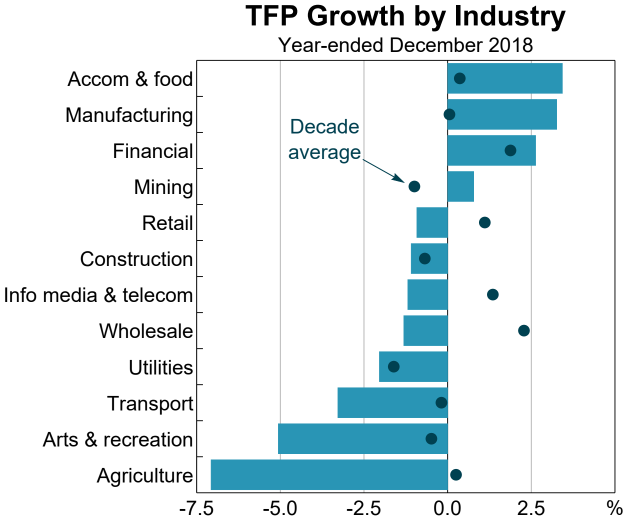
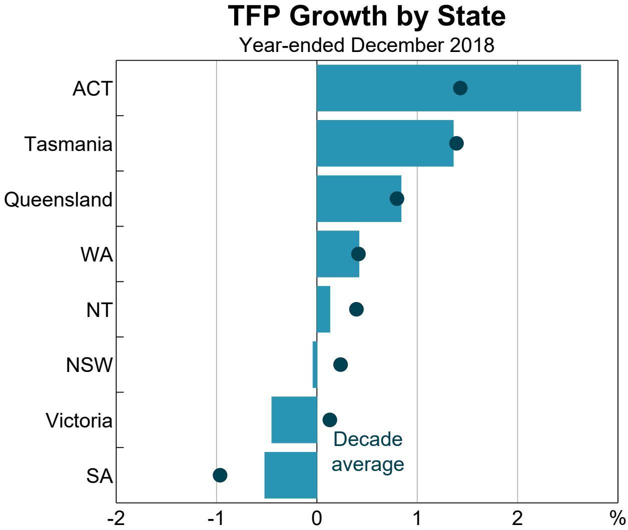


Spares – TFP by Industry



Source: ABS

Spares – TFP by State



Source: ABS