Estimating Industry-Level Multifactor Productivity: methods and experimental results

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Presentation outline

- **Background**
- **Issues of methodological choice**
  - input-output based approach
  - the approach recommended by the OECD
- **Data issues**
- **Experimental estimates**
  - gross output & value-added based MFP indices
- **Other related issues**
  - industry-level vs aggregate MFP approaches
  - open vs closed economy MFP measures
  - quality adjustment for labour inputs
  - impact of using exogenous rate of return on capital services and MFP estimates
Background

- User demand
  - In the ABS publication (ASNA cat. 5204)
    - labour, capital & multi-factor productivity estimates for the aggregate market sector & at industry-level: only labour productivity estimates
    - no industry-level MFP estimates
  - rising interests in MFP estimates at the lower levels of aggregation

- Feasibility
  - improved ABS supply-use tables and full integration between the supply-use tables & national accounts in recent years
Methodological choice

**Considerations**
- use well-established methods in the literature
- transparent and easy to implement for statistical production
  (to estimate MFP in 12 market-sector industries)

**Methods explored:**
- input-output based approach (Durand 1993, 1996; Cas & Rymes 1990)
  - has been developed & used by Statistics Canada
  - relies on the current and constant prices s-u tables
  - provides a set of consistent MFP measures at different levels of aggregation (the bottom-up approach)
  - at the industry-level: gross output; value-added; intra-industry & inter-industry MFP measures, reflecting different levels of integration
Methodological choice (cont.)

- different interpretations & theoretical origin
  - capital can be treated as a reproduced input
    - the Harrod-Robinson-Read concept of TFP/MFP vs. the neoclassical TFP/MFP measure (Rymes 1972, 1983; Cas & Rymes 1990)
- but it requires good quality and fully-balanced supply-use tables in both current & constant prices
  - balancing issues at the commodity level in ABS' constant price s-u tables
    - resulted in some implausible industry-level and aggregate MFP estimates
Methodological choice (cont.)

- This led us to consider the method recommended by the OECD (OECD 2001)
  - OECD productivity manual recommends
    - both industry-level gross output MFP (also called KLEMS MFP) & value-added MFP
  - they are consistent with the same types of index based on the I/O based approach
  - both are non-parametric and under the growth accounting framework
    - closely related to the approach by Jorgenson et. al. 1987
  - but the commodity dimension is suppressed in the approach recommended by the OECD
  - interpretations - integration vs. production functions: the Hicks neutral technological change
Methodological choice (cont.)

- indices of MFP growth for industry $i$
  - value-added based MFP
  - gross output based MFP

- the indices can be derived from production functions or from the accounting identities (Balk 2003)

- two assumptions: CRS & competitive equilibrium
  - but the estimated MFP can reflect the combined effects of
    - technical change, scale economy, measurement errors & other non-technological factors (a residual!)
Methodological choice (cont.)

- Under discrete approx., the above indices can be directly estimated using the industry-level data.
  - We use them to derive the experimental estimates for the 12 market-sector industries in Australia.
## Data sources & issues

<table>
<thead>
<tr>
<th></th>
<th>VA MFP</th>
<th>GO MFP</th>
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<tbody>
<tr>
<td><strong>Output</strong></td>
<td>industry-level gross value added (GVA)-(current prices &amp; chain volume measure) since 1990 for this study</td>
<td>industry-level gross output (current &amp; constant prices) - s-u tables since 1995</td>
</tr>
<tr>
<td><strong>Intermediate input</strong></td>
<td>s-u tables (current &amp; constant prices), since 1995</td>
<td>s-u tables (current &amp; constant prices), since 1995</td>
</tr>
<tr>
<td><strong>Capital</strong></td>
<td>industry-level K services (agg. from 11 or 12 different types of asset)</td>
<td>industry-level K services (agg. from 11 or 12 different types of asset)</td>
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<tr>
<td><strong>Labour</strong></td>
<td>industry-level hours worked</td>
<td>industry-level hours worked</td>
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Data sources & issues (cont.)

- **Issues of valuation**
  - Based on the s-u tables
    - Industry gross value added (GVA) - at basic prices
    - Industry gross output - at basic prices
    - Intermediate inputs - at purchaser's prices

- As GVA includes other net taxes on production & imports, need to allocate them to K & L to preserve the accounting identity
  - GVA = compensation of employees + GOS + gross mixed income + other net taxes on prodn. & imports
  - We use proportional allocation due to lack of detailed information on these net taxes at industry level
Experimental estimates

- Two types of industry-level MFP estimates for the 12 market-sector industries
  - gross output based MFP (since 1995) & value added based MFP since (1990)
Experimental estimates (cont.)
Experimental estimates (cont.)

- Note the relationship between the two indices

- Are the experimental estimates plausible?
  - use aggregation to indirectly assess the estimates
    - industry-level results are aggregated to derive the agg. market-sector estimates
    - the results are then compared with the ABS published agg. MFP estimates
    - also address the issues of consistency in aggregation
Industry-level vs aggregate MFP (cont.)

A comparison of the aggregate market-sector MFP growth estimates

![Chart showing comparison of MFP growth estimates](chart.png)
Industry-level vs aggregate MFP (cont.)

- Why are the estimates different?
  - the difference due to the diff. in measurement
    - use different measures for output and factor income shares (see appendix A of the paper)
  - methodological difference
    - new estimates: based on industry-level approach
    - 5204 results: from direct aggregate approach
      • both are valid approaches
Industry-level & aggregate MFP (cont.)

- Relationship between industry-level & aggregate approaches to the estimation of agg. MFP

An augmented Domar aggregation formula (Jorgenson et. al. 1987)

\[ \text{agg MFP} = \text{agg MFP based on industry-level approach} + \text{contributions of changes in industry distribution of outputs & inputs} \]
Open vs closed economy MFP

- Note that the previous MFP indices do not distinguish between the effects under the open and closed economy
  - According to Gollop (1987): imported intermediate inputs should be treated as additional primary inputs
    - Should use Deliveries to Final Demand as a measure of output to derive the open economy MFP (see the results in the paper based this approach)
  - Other methods (e.g. Diewert & Morrison 1986, Kohli 1990, Fox & Kohli 1998, Cas & Rymes 1990, Durand 1996) have also been suggested - focusing on the terms of trade effect in the open economy
  - But there is no generally accepted solution; many MFP work do not address this issue
Quality adjustment for labour inputs in MFP estimation

- Hours worked should be adjusted for quality difference
- ABS has produced experimental QALI for the aggregate market sector
  - follows US BLS' approach
    - taking into account the differences in educational attainment & the length of workforce experience in hours worked
  - has incorporated QALI into the market sector MFP estimates in ASNA (5204.0)
Using quality adjusted labour inputs in MFP estimation (cont.)

- Adjusting labour quality difference at the industry level may not be possible at this stage due to the data constraint.
Impact of using exogenous rate of return on capital services & MFP estimates

- **ABS uses a mixed approach to deriving rental prices (user cost) used for aggregating productive capital stock**
  - the internal rate of return (irr), a component in the user cost formula (Hall and Jorgenson 1967), is derived by equating capital income to cost (endo. irr), or set to be equal to 4% + CPI (exo. irr) if it is below 4%+CPI from the former

- **Erwin & Lawrence (2004) reveal some problems associated with the ABS approach & the industry-level data**
  - suggesting to use 4% real irr across industries and time
Impact of using exogenous rate of return on capital services & MFP estimates (cont.)
Impact of using exogenous rate of return on capital services & MFP estimates (cont.)

- Highlighted one of the many difficulties in measuring capital & MFP accurately, particularly at the industry-level (see e.g. Diewert 2000)
  - Caution has to be exercised in using these estimates
  - Further improvements in data sources and measurement are necessary, and are continuously being attempted