Dynamic Efficiency and Productivity Analysis

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Dynamic Efficiency and Productivity Analysis

Sevilla 2-4 June

Alfons Oude Lansink

(ongoing work with Spiro Stefanou, Elvira Silva)
Overview

- Motivation
- Dynamic Directional Distance Function and Technical inefficiency
- Dynamic Cost function and Cost Inefficiency
- Applications
Motivation: Dynamic Technical Efficiency and productivity analysis

- Technical efficiency and total factor productivity are key determinants of the cross country competitiveness.
- Technical efficiency reflects the extent to which the production potential is used.
- Total factor productivity is usually reflected as a ratio of all outputs and all inputs (e.g. Tornquist, Malmquist) or as a difference between output and inputs (Luenberger).
- Investments in quasi-fixed factors (capital assets) can improve the productivity (better technology, more optimal scale of production).
Motivation: Static Technical Efficiency and productivity Analysis

Inputs

Capital (quasi-fixed factor)

Technical Efficiency

\[ \text{O'}A'/O'A \]
Motivation: Dynamic Technical Efficiency

- Dynamic dimension of technical efficiency and productivity?
- Costs of adjustment in quasi-fixed factors of production
  - Low prices for second hand machinery due to asymmetric information in markets of second hand machinery
  - Environmental costs of disposal of buildings (e.g. asbestos)
  - Costs of capital increase with the size of the amount borrowed.
  - Human capital related costs: Learning costs and search costs
Motivation: Dynamic Technical Efficiency

- $A =$ Investment needed to achieve the long-run optimal capital stock
- Cheaper to split investment in two steps of $\frac{1}{2}A$ rather than in one step of size $A$
Dynamic Technical Efficiency

In the dynamic context the decision maker seeks to:

Minimize
- variable inputs

Maximize
- Investment in quasi-fixed factors
- Variable outputs
Dynamic Directional Input Distance Function and technical inefficiency

\[ z(x, l) \]

\[ Z' = (x - \beta g_x, l + \beta g_l) \]
Dynamic Directional Input distance function

\[ \overrightarrow{D_i}(y, x, I, k; g_x, g_I) = \]
\[ \sup \{ \beta : (x - \beta g_x, I + \beta g_I) \in V(y : k) \} \]

\( V(y : k) \) Technology: \( x, I \) can produce \( y \), given \( k \)
\( y \) Output vector
\( x \) Variable input vector
\( k \) Quasi – fixed input vector
\( I \) Net investment quasi – fixed input
\( g_x, g_I \) Directional dist. vectors
Dynamic Cost Inefficiency

Technical inefficiency
Allocative inefficiency

Endogenously determined shadow price of capital

\[ x^*, l^* \]

\[ W_k^* \]

\[ \frac{W_k^*}{w} \]
Dynamic Cost function: Cost minimization

\[
 rW(w, c, k, L, y) = \min \left\{ wx + ck + W_k \left( I - \delta'k \right) \right\}
 s.t. \quad \tilde{D}(y, x, I, k, L; g_x, g_I) \geq 0
\]

\[
 W(\cdot) = \text{Intertemporal Shadow Cost Function}
 w, x = \text{price, quantity variable inputs}
 c, k = \text{price, quantity quasi fixed inputs}
 W_k = \text{Shadow value capital}
 I = \text{Investments}
 \delta = \text{Depreciation rate}
 y = \text{Output}
 g_x, g_I = \text{Directional distance vectors of } x \text{ and } I
\]
Dynamic Luenberger TFP growth Indicator

Technical inefficiency in $t = C$ and in $t+1$ it is $B$

Technical Inefficiency Change = $B - C$

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Dynamic Luenberger TFP growth Indicator

Technical Change = ½(A+B)
Application (DEA): Data Dutch Horticulture

- Specialized vegetables (greenhouse) firms in the Netherlands
- Main outputs: Peppers, Cucumbers, Tomatoes
- Farm Accountancy Data: 265 observations from 103 farms
- Data Envelopment Analysis was used to estimate dynamic technical, allocative and cost inefficiency
Results: Dynamic Technical, Allocative and Overall Cost Inefficiency

<table>
<thead>
<tr>
<th>Period</th>
<th>Technical inefficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>0.39</td>
</tr>
<tr>
<td>1998</td>
<td>0.34</td>
</tr>
<tr>
<td>1999</td>
<td>0.26</td>
</tr>
<tr>
<td>1997-1999</td>
<td>0.33</td>
</tr>
</tbody>
</table>
Application (parametric): Data Dutch Dairy

- Specialized dairy farms from Farm Accountancy Data Network
- Main outputs: milk, beef plus some crops
- 80% of revenues are from milk
- 2614 observations from 669 farms
Empirical Specification

- Quadratic dynamic directional distance function
- Normalized Quadratic dynamic cost frontier
- Results: Serra, Oude Lansink and Stefanou, 2011 (*American Journal of Agricultural Economics*)
Results: Dynamic Technical, Allocative and Overall Cost Inefficiency

<table>
<thead>
<tr>
<th>Period</th>
<th>Technical inefficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995-2000</td>
<td>0.100</td>
</tr>
<tr>
<td>2001-2005</td>
<td>0.107</td>
</tr>
<tr>
<td>Mean</td>
<td>0.104</td>
</tr>
</tbody>
</table>
Application: Dynamic versus Static productivity growth in the Spanish Meat processing Industry

- More EU regulation regarding food safety, consumer information and sustainable practices. Leads to productivity decline?
- Data from Spanish meat processing firms (SABI data base)
- 928-1527 firms per year in the period 2000-2010
- Static Malmquist compared with dynamic Luenberger
Productivity growth in Spanish Meat Processing firms

- Total Factor Productivity growth (static and dynamic)
  - Technical change
  - Technical efficiency change
  - Scale efficiency change
## Results: Static versus Dynamic measures (2000-2010)

<table>
<thead>
<tr>
<th>Static Malmquist productivity change</th>
<th>Technical change</th>
<th>Technical efficiency change</th>
<th>Scale efficiency change</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.010</td>
<td>-0.093</td>
<td>0.052</td>
<td>0.025</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dynamic Luenberger productivity change</th>
<th>Technical change</th>
<th>Technical inefficiency change</th>
<th>Scale inefficiency change</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.003</td>
<td>-0.031</td>
<td>0.022</td>
<td>0.005</td>
</tr>
</tbody>
</table>
Results: Evolution of Malmquist index and its components
Results: Evolution of the Luenberger indicator and its components
Conclusions

- Adjustment costs of investments in quasi fixed factors may have a (temporary) downward impact on the production potential.
- Hence cross country competitiveness of countries with substantial investments may be temporarily negatively affected.
- Static models do not properly reflect the dynamic nature of capital and may misrepresent the sources of productivity growth.
Thank you!