Whither hospital productivity in NZ?

Jaikishan Desai, Nick Bowden, Jackie Cumming
Health Services Research Centre
Victoria University of Wellington

Acknowledgement: This research was funded by a grant from the Health Research Council of New Zealand
Overview of presentation

• What **is** productivity and efficiency
• What are we (HSRC) **doing**
• What is the **data** we are working with
• What have we **done** so far
• What is the **basic story** we can tell from this
• What **more** can we do
What is productivity and efficiency

Change from $t$ to $t+1$:

Technical progress:
\[ f(x,t+1;\beta) > f(x,t;\beta) \]

Productivity has increased:
\[ \frac{y_{t+1}}{x_{t+1}} > \frac{y_t}{x_t} \]

Efficiency has increased:
\[ \frac{y_{t+1}}{f(x,t+1;\beta)} > \frac{y_t}{f(x,t;\beta)} \]
What are we (HSRC) **doing**

- Using available data (to us) to ......
  - Measure hospital productivity
  - Analyse variation in it
    - Across DHBs (because of data limitations)
    - Over time
  - Decompose change in productivity into
    - Technical change
    - Technical efficiency
    - Allocative efficiency (??)
What is the **data** we are working with

- **Hospital outputs**
  - NMDS (2001-09) complete *event-level* information on inpatient stays and day stay treatments
  - NNPAC (2007-09) complete *event-level* information on outpatient and emergency department treatments

- **Hospital inputs**
  - Monthly provider expenditures by DHBs (2001-09) – by type of expenditure

- **Data issues – coverage, detail, accuracy:**
  - NMDS is for 2001-09, NNPAC is for 2007-09 (2006 data not reliable)
  - Solution: (a) Restrict analysis to 2007-2009 ; (b) **Impute 2001-06 information using a model based on data from 2007-09 – using information on all outputs – NOT RELIABLE**
  - Output data – *event-level* data aggregated to monthly/annual level with case-mix weighting
  - Input data – only at DHB level (not at facility level)
  - Event-level output data has many coding and recording errors. Aggregation of events to monthly and annual level reduces seriousness of this issue IF number of errors are relatively small. Still there is bound to be measurement error
  - Input data – seems reasonable but could have reporting errors
What have we done so far

• Descriptive analysis of data on hospital outputs and inputs – at DHB level

• An index number measure of productivity change (Hicks-Moorsteen)

• Data Envelopment Analysis (2007-09)
  – Several models with varying details on outputs and inputs

• Stochastic Frontier Analysis (2007-09)
  – Cobb-Douglas & Translog functions with time-invariant and time-varying inefficiency
Total Discharges per month (NMDS)

Mean discharges per month

Mean case mix-weighted discharges per month

Time (2001 – 2009)
All Hospital outputs (NMDS & NNPAC)

Mean monthly inpatient treatments

Mean monthly day stay treatments

Mean monthly outpatient treatments

Mean monthly ED visits

Time (Jan 2007-Dec 2009)
Case mix variation over the years

MDC

Percent of total admissions

2001 2002 2003 2004 2005 2006 2007 2008 2009
Change in Types of hospital admissions

Index: 2001=100

<table>
<thead>
<tr>
<th></th>
<th>In 2001</th>
<th>In 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arranged</td>
<td>27%</td>
<td>24%</td>
</tr>
<tr>
<td>Acute</td>
<td>47%</td>
<td>53%</td>
</tr>
<tr>
<td>Waiting List</td>
<td>18%</td>
<td>18%</td>
</tr>
</tbody>
</table>

Proportion of Arranged Admissions (in total)

Proportion of Acute Admissions (in total)

Proportion of Waiting list Admissions (in total)
Variation in hospital outputs
(inpatient nights + daystays + outpatient treatments + ED treatments)
Main output patterns (so far)

• Month-to-month variation
  – Substantial but also somewhat predictable (drop in summer months and increase in winter months)

• Increasing number of day stays and outpatient treatments

• No obvious (overall) change in case mix – as measured by shares of Major Diagnostic Categories in total admissions (inpatient & day stays)

• Small decline in proportion of arranged admissions and increase in proportion of acute admissions
DHB provider expenditure over the years

Total DHB (real) expenditure

$ billions

2001 2002 2003 2004 2005 2006 2007 2008 2009

43% increase
Main input patterns (so far)

- 42% increase in real terms (i.e. after accounting for overall increase in health sector prices) between 2001 & 2009

- Month-to-month variation – consistent with output variation

- Personnel largest component of input expenditures & has increased 19% per FTE in real terms

- Considerable variation in wage expenditure (per FTE) increase – 7% to 36%
An Index measure of hospital productivity (output index/input index: Base=2007)

NOTE: Data on outpatient and ED visits for 2001-2006 are imputed, thus productivity estimates for these years are less reliable.
Data Envelopment Analysis (DEA)

• Linear programming to construct a non parametric piece-wise frontier (isoquant) of the data.

\[
\begin{align*}
\max_{u,v} \left( \frac{u'q_i}{v^ix_i} \right) \text{ subject to } & \left( \frac{u'q_i}{v^ix_i} \right) \leq 1, \quad u, v > 0 \\
\end{align*}
\]

• Model 1:
  - 3 outputs - WIES weighted inpatient stays, ED, Outpatient
  - 2 inputs - Medical and Nursing FTEs
  - Input Orientation
  - Annual data 2007 to 2009
DEA – Model 1 Results

TFP (Year to Year) Change

Components of TFP Change

Technology

ITE

ISE

2007 2008 2009

1.023 1.058

1.026 0.822

1.659

0.776

1.039 1.026

0.96 0.822

1.07
Stochastic Frontier Analysis

- Parametric estimation
  \[ q_{it} = \alpha_0 + \alpha_1 l_{it} + \alpha_k k_{it} + \omega_{it} + \varepsilon_{it} \]
  \[ \omega_{it} \text{ represents productivity difference} \]

- Productivity comparison is then
  \[ \ln A_{it}^P - \ln A_t^P = (q_{it} - \bar{q}_t) - \hat{\alpha}_l^P (l_{it} - \bar{l}_t) - \hat{\alpha}_k^P (k_{it} - \bar{k}_t) \]

- Stochastic Frontier Analysis
  \[ \ln q_{it} = x_{it}'\beta + v_{it} - u_{it} \]
  \[ u_{it} \geq 0 \text{ is technical efficiency}; \ u_{it} \sim \text{iidN}^+(\mu, \sigma_u^2) \]
  \[ v_{it} \text{ is random error}; \ v_{it} \sim \text{iidN}(0, \sigma_v^2) \]
Specifying inefficiency structure

\[ u_{it} = f(t) * u_i \]

- **Time-invariant inefficiency**

  \[ u_{it} = u_i, \ u_i \sim iidN^+(\mu, \sigma_u^2), \ v_{it} \sim iidN(0, \sigma_v^2) \]

- **Time-varying (decay)**

  \[ u_{it} = \exp\{-\eta(t - T_i)\}u_i, \ u_i \sim iidN^+(\mu, \sigma_u^2), \ v_{it} \sim iidN(0, \sigma_v^2) \]
Results of SFA (very basic)

• Log(price-weighted sum of hospital outputs) \( i_t = -\alpha + \beta_1 \log(\text{labour } X)_{i_t} + \beta_2 \log(\text{other inputs } X)_{i_t} + u_{i_t} + v_{i_t} \)

• Quarterly data: 2007-09
• Efficiency increased from 2007-2009: 0.780 -> 0.826
• ~ Constant Returns to scale technology

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff</th>
<th>s.e.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>6.5820</td>
<td>0.3079</td>
<td>0.000</td>
</tr>
<tr>
<td>Log(labour X)</td>
<td>0.7209</td>
<td>0.0833</td>
<td>0.000</td>
</tr>
<tr>
<td>Log(other input X)</td>
<td>0.3598</td>
<td>0.0852</td>
<td>0.000</td>
</tr>
<tr>
<td>( \mu )</td>
<td>-0.1219</td>
<td>0.5666</td>
<td>0.830</td>
</tr>
<tr>
<td>( \eta )</td>
<td>0.0319</td>
<td>0.0079</td>
<td>0.000</td>
</tr>
<tr>
<td>N=252</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Change in Technical efficiency

Nelson Marlborough
Hawke's Bay
Waitemata
Southland
Lakes
Hutt
Mid Central
Whanganui
Auckland
Counties Manukau
Bay of Plenty
South Canterbury
Canterbury
Wairarapa
Tairawhiti
Northland
Otago
Taranaki
Waikato
Capital and Coast
West Coast
Going forward

• Understanding the data better

• Further refinement of Indices, DEA, and SFA, calculation of productivity measures & discussion of results

• Instrumental Variables (BB) – dynamic effects with MoH monitoring changes

• Semi-parametric models (OP, LP) - those best-suited to the data and issue