Connecticut Public Health Practice-Based Research Network DACS 71133

Product Type: Meeting and Conference Presentation

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Title of Presentation: Cost effectiveness, efficiency and equity of inspection services throughout Connecticut’s local public health system

Meeting: Research-in-progress Presentation at PH PBRN Monthly Virtual Meeting

Date: July 17, 2014

Location: Lexington, KY (virtual)
The project has two components.

- **Component 1** describes and analyzes the scope and cost of four environmental health services provided in Connecticut and the differences in associated costs incurred by local health jurisdictions that may arise from differences in the size and structure of local health departments.
  - These services include: *food protection, public water wells, subsurface sewage disposal and lead poisoning prevention and control*.
- **Component 2** evaluates the impact of size and organizational structure relative to a number of hypotheses about the efficiency, effectiveness and equity of food protection services.
# Full and Part-Time Health Departments in Connecticut

<table>
<thead>
<tr>
<th></th>
<th>#Towns</th>
<th>Population</th>
<th>Percent</th>
<th>Pop. Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-Time</td>
<td>145</td>
<td>3,374,354</td>
<td>94%</td>
<td></td>
</tr>
<tr>
<td>Municipal</td>
<td>29</td>
<td>1,657,005</td>
<td>46%</td>
<td>18,239 -145,638</td>
</tr>
<tr>
<td>Districts (21)</td>
<td>116</td>
<td>1,717,349</td>
<td>48%</td>
<td>28,194 -166,117</td>
</tr>
<tr>
<td>Part-Time</td>
<td>24</td>
<td>203,491</td>
<td>6%</td>
<td>1,917- 25,729</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>169</strong></td>
<td><strong>3,577,845</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Some Key Questions That Our Cost Functions Can Address

• Are providers “too small” or “too large”?  
• To answer: estimate scale economies

• Is it less costly to “produce” more or less of different types of inspections together?  
  (Some jurisdictions don’t do all inspections, or only small amounts of some inspections, due to small district size; others considering merging may do more of some – how does this affect the cost of doing others??)  
• To answer: estimate economies of scope
Economic Theory of Production and Costs

Production of Environmental Health Inspections

Inputs
- Capital
- Workers
- Other Inputs

Production Process

Outputs
- Inspections
- Permits
- Other Outputs
Health districts should choose their input mix to balance the benefits of spending more on workers vs. on physical capital.
Health Districts Should Strive to be at point $Y_e$

Average cost (AC) is the cost per unit of output ($Y$), while marginal cost (MC) is the change in total cost from a small change in output. Figure 3 shows that micro-economic theory implies the provider's AC curve is U-shaped, and the MC curve slopes up. AC is minimized at $Y_e$, so $Y_e$ is the "efficient" level of output. If $MC < AC$ (economies of scale), as in the provider output level $Y_a$, then the provider can lower its AC by increasing $Y$ until it reaches $Y_e$. 
Economies of Scope and Specialization

TYPE OF HEALTH JURISDICTION

- Muni 1 only
- Muni 2 only
- Muni 1 and Muni 2 merged

COSTS COMPARISON

? Which production approach costs less?
Outputs for Cost Functions

- Drinking Water:
  - Output:
    number of private well permits +
    number of public well permits
Outputs for Cost Functions (continued)

• Food Services:
  – Output: Number of inspections (in different “classes”, including temporary events)
Outputs for Cost Functions (continued)

- **Sewage:**
  - Outputs: total # of permits =
    - Number of new permits +
    - Number of repair permits +
    - Number tested +
    - Number of B100’s (makes sure have space for a workable septic system)
Outputs for Cost Functions (continued)

• Lead
  – Output:
    # of inspections
Cost Function Variables

- **Q**: Outputs in each category (lead, water, sewer, food)
- **P**: Price of inputs (average wage for all workers; price index for capital structures)
- **X**: any nurse staff (yes/no);
  urban or rural (yes/no);
  # of patients w/blood lead levels ≥ 10
- **D**: (D1=municipal health dept, D2=district, 3=part-time)
- **t**: time trend
- All dollar values are adjusted for inflation
Estimating Equation

Variation of a Translog Total Cost Function:

\[ \log(TC_{it}) = \log(TC_{it}(Q_{it}, P_{it}, X_{it}, t, D_{j})) = \alpha_0 + \alpha_p \log(P_{Lit})\log(P_{Kit}) + \alpha_L \log(P_{Lit})^2 \]

\[ + \sum_m \sum_n \delta_{mn} \log(Q_{nit})\log(Q_{mit}) + \sum_n \delta_n \log(Q_{nit})^2 + \sum_j \delta_j D_j + \sum_r \alpha_r X_{rit} + \gamma t + u_{it} \]

\[ t = 2005, 2006, \ldots, 2012; \quad i = 1, 2, \ldots, 75; \quad j = 1 \text{ (municipal)}, 2 \text{ (district)}; \]
\[ (m, n) = \text{water, septic, food, lead}; \quad r = \text{(any nurse; urban/rural; blood level} \geq 10) \]

Parameters to be estimated by least squares regression: \( \alpha, \delta, \gamma; \quad u_{it} \sim N (0, \sigma^2) \)
Elasticity of Scale

- Can easily compute scale economies for each \((i, t)\) observation:

  With only one output,

  \[
  \varepsilon = \left[\frac{\partial TC}{\partial Q}\right]\frac{Q}{TC} \\
  = \frac{\partial \log TC}{\partial \log Q} \\
  = \frac{MC}{AC}
  \]

  If \(\varepsilon > 1\), \(MC > AC\), so AC rising (decreasing returns to scale)
  If \(0 < \varepsilon < 1\), \(MC < AC\), so AC falling (increasing returns to scale)
  If \(\varepsilon = 1\), \(MC = AC\) (constant returns to scale, or minimum efficient scale)
Health Districts Should Strive to be at point $Y_e$

Average cost (AC) is the cost per unit of output ($Y$), while marginal cost (MC) is the change in total cost from a small change in output. Figure 3 shows that micro-economic theory implies the provider's AC curve is U-shaped, and the MC curve slopes up. AC is minimized at $Y_e$, so $Y_e$ is the "efficient" level of output. If $MC < AC$ (economies of scale), as in the provider output level $Y_a$, then the provider can lower its AC by increasing $Y$ until it reaches $Y_e$. 
Elasticity of Scale and Scope: Total Cost

Scale Economies with 4 Outputs (Baumol et al, 1982):

\[ \varepsilon = \frac{\partial TC}{\partial Q_1} \cdot \frac{Q_1}{TC} + \frac{\partial TC}{\partial Q_2} \cdot \frac{Q_2}{TC} \]

\[ + \frac{\partial TC}{\partial Q_3} \cdot \frac{Q_3}{TC} + \frac{\partial TC}{\partial Q_4} \cdot \frac{Q_4}{TC} \]

Scope Economies with 2 or more Outputs:

\[ \frac{\partial \left[ \frac{\partial \log TC}{\partial \log Q_1} \right]}{\partial Q_2} \cdot \frac{[TC/Q_1]}{[TC/Q_1]} = \frac{\partial^2 TC}{\partial Q_1 \partial Q_2} \cdot \frac{[TC/Q_1]}{[TC/Q_1]} \]

\[ = \left[ \frac{\partial MC_1}{\partial Q_2} \right] \cdot \frac{[TC/Q_1]}{[TC/Q_1]} < 0 \]

is a sufficient condition:

MC curve for one output drops when more of the other output is produced (weak complementarity, Vita, 1990)

(In reverse, could have economies of specialization if > 0)
Data and Organizational Issues

• Annual Report Data: issues include completion rates, completeness and validity of data, changes in data elements
• Missing values for key variables in some years for some districts reduces sample
• Determining appropriate outputs for lead, water and septic
## Descriptive Statistics

<table>
<thead>
<tr>
<th>TOT_COST_...</th>
<th>WAGE_AVG_...</th>
<th>PK</th>
<th>WATER_PRI...</th>
<th>WATER_PUB...</th>
<th>LEAD_INSPE...</th>
<th>FOOD_INSPE...</th>
<th>SEPTIC_TOT...</th>
<th>ANYNURSES...</th>
<th>RURAL_URB...</th>
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<tbody>
<tr>
<td>Mean</td>
<td>1541909.</td>
<td>36438.35</td>
<td>1.222980</td>
<td>40.15667</td>
<td>1.645000</td>
<td>21.93000</td>
<td>434.4133</td>
<td>256.8017</td>
<td>0.451667</td>
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<td>Median</td>
<td>565452.8</td>
<td>38659.47</td>
<td>1.265176</td>
<td>14.50000</td>
<td>1.000000</td>
<td>1.000000</td>
<td>268.5000</td>
<td>140.0000</td>
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<td>Maximum</td>
<td>31742872</td>
<td>282258.3</td>
<td>1.380691</td>
<td>2450.000</td>
<td>1216.000</td>
<td>2175.000</td>
<td>2326.000</td>
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<td>1.000000</td>
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<tr>
<td>Minimum</td>
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<td>1.000000</td>
<td>1.000000</td>
<td>1.000000</td>
<td>1.000000</td>
<td>1.000000</td>
<td>1.000000</td>
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<tr>
<td>Std. Dev.</td>
<td>3618671.</td>
<td>22383.82</td>
<td>0.120494</td>
<td>117.5077</td>
<td>4.213300</td>
<td>103.9473</td>
<td>474.8163</td>
<td>349.0570</td>
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<td>Skewness</td>
<td>5.323260</td>
<td>2.348341</td>
<td>-0.612508</td>
<td>14.96361</td>
<td>9.005902</td>
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<td>Jarque-Bera</td>
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<td>54.34251</td>
<td>2188979.</td>
<td>335622.0</td>
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<td>0.000000</td>
<td>0.000000</td>
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<tr>
<td>Sum</td>
<td>9.25E+08</td>
<td>20004653</td>
<td>733.7878</td>
<td>24094.00</td>
<td>987.0000</td>
<td>13158.00</td>
<td>260648.0</td>
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<td>Sum Sq. Dev.</td>
<td>3.84E+15</td>
<td>2.75E+11</td>
<td>8.696796</td>
<td>8271031.</td>
<td>10633.39</td>
<td>6472217.</td>
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<td>150.5983</td>
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<td>Observations</td>
<td>600</td>
<td>549</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
</tr>
</tbody>
</table>
Summary of Cost Function Results

- R-squared = 0.63
- All inspections variables are jointly significant (P-value=0.000)
Elasticity of Scale – all jurisdictions, 2005-2012

Frequency

ELAS_OF_SCALE
Elasticity of Scale – Districts, 2005-2012

ELAS_OF_SCALE

Frequency
Elasticity of Scale – Municipal Health Departments

![Histogram of Elasticity of Scale](image)
Elasticity of Scale – Part-Timers

The chart illustrates the distribution of Elasticity of Scale (ELAS_OF_SCALE) values for part-time employees. The x-axis represents the frequency of observed values, ranging from 0.0 to 0.8, while the y-axis indicates the frequency of occurrence, with a range from 0 to 35. The data shows a significant peak around the 0.2-0.3 range, indicating a higher concentration of part-time employees within this elasticity range.
Elasticity vs. Total Output - Overall

The diagram illustrates the relationship between elasticity (ELAS_OF_SCALE) and total output (TOTAL_STUFF). The scatter plot shows a positive correlation, with points clustering around the trend line, indicating that as total output increases, elasticity also tends to increase.
Elasticity vs. Total Output - Municipalities
Elasticity vs. Total Output - Districts
Elasticity vs. Total Output – Part-Timers
Elasticity vs. Total Costs – Overall

![Graph showing the relationship between Elasticity (ELAS_OF_SCALE) and Total Costs (TOT_COST_REAL). The graph includes a scatter plot with data points and a trend line indicating a positive correlation.](image-url)
Elasticity vs. Total Costs – Municipalities
Elasticity vs. Total Costs – Districts

![Graph showing scatter plot with ELAS_OF_SCALE on the y-axis and TOT_COST_REAL on the x-axis. The graph includes a linear trend line showing a slight positive correlation.](image-url)
Elasticity vs. Total Costs – Part-Timers

![Graph showing elasticity vs. total costs](image)
Elasticity vs. FTE – all municipalities
Elasticity vs. FTE – Municipal Health Departments
Elasticity vs. FTE - Districts
Elasticity vs. FTE – Part-Timers
Economies of Scope or Specialization

• By doing more inspections of one type, how does that affect the incremental costs of other types of inspections?
• Can be important to understand when considering merging or sharing services
• If > 0, more of an output increases MC of another output (economies of specialization)
• If < 0, more of an output decreases MC of another output (economies of scope)
Economies of Scope or Specialization

- Water and Septic: <0
- Water and Lead: >0
- Water and Food: >0
- Food and Lead: <0
- Food and Septic: <0
- Lead and Septic: <0
Economies of Scope - Interpretations

• <0 – cost savings for mergers when two jurisdictions focus on different outputs (economies of scope)

• >0 – cost savings for not merging when two jurisdictions focus on different outputs (economies of specialization)

• e.g., district A does many food inspections, few others; district B does many lead inspections, few others.
  • If <0, cost savings from merging or sharing resources
  • If >0, cost savings from not merging/sharing
Limitations

- Data !!!
- Economies of scale: depend on small changes in output;
- Economies of scope: assumes hold all other types inspections constant (difficult to compare 3 types of inspections, but pair-wise comparisons more relevant)
- Many municipal health departments and districts offer other services; we only control for environmental health outputs, so output may be understated – perhaps they are further down on AC curve than we have found
Summary of policy implications

- Drawbacks from merging or sharing resources:
  - Elasticity of scale assumes small changes
  - Some jurisdictions may be experiencing economies of specialization for some outputs

- Benefits to merging or sharing resources:
  - Economies of scale to be gained for merging small jurisdictions (such as part-timers)
  - Some jurisdictions may benefit from economies of scope for some outputs
Conclusions and Future Research

• Supplemental survey to annual reports
• Hope to obtain information for calculating unit costs
• Focus groups – for component 2
• Key informant interviews – for component 2