Are there agglomeration effects in dairy production?: An empirical examination of Ontario’s dairy farms

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Agglomeration Defined

- The increase in total factor productivity attributable to one or more of the following:
  - Knowledge spillovers;
  - A local pool of skilled labor;
  - Enhanced supplier linkages
- All of the above are generally expected to be enhanced by the number of firms and their spatial concentration.


# of Farms by County (2004-2005)

Source: DFO
Production function

\[ y = A \cdot f(x_1, x_2) \]

\( y \) = output  
\( x_i \) = inputs  
\( A \) = productivity

\( u \) depends on farm and local characteristics

\[ A = g(z, e) \]

\( Z \) = farm characteristics  
(e.g., farm size)

\( e \) = local characteristics  
(e.g., farm density/cluster)
Ontario: Quota Fixes Output For Farm

TIE = BA/OA
TE = OB/OA
AE = OC/OB
EE = OC/OA
Empirical Model

- **Input Distance function (Shephard)- SFA**

\[ d^I_i (y, x) = \sup_{\lambda} \{ \lambda : (x / \lambda) \in L(y) \} \]

- \( \lambda \): is the scalar “distance” by which the input vector can be deflated

- proportional input-saving with output held fixed.
Empirical Model

- Input Distance function (Shephard)- SFA

\[
\ln d_i^I = \beta_0 + \sum_{k=1}^{K} \beta_k \ln x_{ki} + \sum_{m=1}^{M} \alpha_m \ln q_{mi} + \nu_i \quad \sum_{k=1}^{K} \beta_k = 1
\]

\[
-\ln x_K = \beta_0 + \sum_{k=1}^{K-1} \beta_k \ln (x_{ki} / x_{Ki}) + \sum_{m=1}^{M} \alpha_m \ln q_{mi} + \nu_i - u_i
\]

\[
u_i \equiv \ln d_i^I \equiv \lambda
\]

\[u_{it} \sim N^+(\mu_{it}, \sigma_{it}^2)\]

\[\mu_{it} = z_{it} \delta\]

\[\sigma_{it}^2 = \exp(z_{it} \gamma)\]
Key Variables defined

- Agglomeration measure (county)
  - The numbers of licensed dairy farms in a county (DFO)
  - Area of class 1 agricultural land (GIS - 1983) in ha.
  - Density = #farms / 100 ha of class 1
Proximity and Endowment

- Proximity to urban areas (GIS - township):
  - Calculated from the centroid of each municipality to the boundary of the nearest urban area
  - Calculated based on 2006 GIS maps.

- Natural endowment (county)
  - % of class 1 soil
Data and Variables

- **Production (ODFAP): 2000-2008**
  - Milk in hectoliters (3.6% butter content)
  - Labor (hours), capital ($), feed ($), energy ($), other inputs ($)
  - Technology: milking system (1/0), feeding system (1/0), breed (1/0)

- **Farm and farmer characteristics**
  - Farm size (number of cows)
  - Education (1/0)
  - Age the operator (year)
  - Location (1/0): six regions
Distribution of Technical Efficiency of Ontario Dairy Farms

Kernel density estimate
Normal density

Kernel = epanechnikov, bandwidth = 0.0321

~70%
Results

\[ \text{TIE} = \frac{BA}{OA} \]

Approximately 30%
Proximity to urban centre vs. \( E(u|e) \)
The inefficiency $E(u_i|e)$ and $V(u_i)$ Model

| Variables                        | $E(u_i|e)$     | $V(u_i)$     |
|---------------------------------|----------------|--------------|
| $\ln[\text{Density (#/100ha)}]$ | -0.031**       | 0.205***     |
| Distance (in km)                | -0.020***      | -0.045**     |
| $\ln[\# \text{ of farms /county}]$ | -0.020         | -0.542***    |
| $\ln[\text{Farm Size (#)}]$    | 0.039          | -0.760***    |
| Education (1/0)                 | 0.012          | -0.272       |
| Operator’s Age                  | 0.002*         | -0.039***    |
| Farm Age                        | 0.005***       | -0.022***    |
| Corporation                     | 0.029          | 0.142        |
| Record keeping                  | 0.120***       | -0.578*      |
| Debt-to-asset ratio             | -0.123**       | 0.151        |

*** $p < 0.01$ ; ** $p < 0.05$ ; * $p < 0.10$
### Average Marginal Effects (elasticities)

<table>
<thead>
<tr>
<th>Variables</th>
<th>$\partial E(u_i) / \partial z_i$</th>
<th>$\partial V(u_i) / \partial z_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (#/100ha)</td>
<td>-0.019</td>
<td>0.003</td>
</tr>
<tr>
<td>Distance (in km)</td>
<td>-0.017</td>
<td>-0.002</td>
</tr>
</tbody>
</table>
Marginal Effect ($\partial E(u_i) / \partial z_i$) of ln(Density)
<table>
<thead>
<tr>
<th>Variables</th>
<th>Tech. effects</th>
<th>Eff. Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (#/100ha)</td>
<td>-0.030</td>
<td>-0.019</td>
</tr>
<tr>
<td>Distance (in km)</td>
<td>-0.009</td>
<td>-0.017</td>
</tr>
<tr>
<td>% of Class 1 Soil</td>
<td>-0.002</td>
<td>--</td>
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</tbody>
</table>
- Measurement of agglomeration variable
- Negative externalities
  - Environmental
  - Animal diseases
- Economic (cost) efficiency estimation
- Total factor productivity (TFP)