“An Application of Spatial Poisson Models to Manufacturing Investment Location Analysis”

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Background

• Loss of manufacturing jobs in Indiana ≈ 100,000 (2000-2004)
• Equivalent to 16% of employment
• Job-less recovery
• Business restructuring out of 2001 recession

Figure 4 – Annual Manufacturing Employment Growth from 1994 to 2004 in the US and Indiana
Research Question

• Location of Manufacturing Investment
• Growth of rural communities
• Policy question – Sustainability of rural manufacturing in Indiana
• Which local factors increase likelihood of investment?
• Posed as an empirical question
Conceptual Model

- Following Woodward, Bartik 1989; Henderson and McNamara 1996
- Plant location – proxy for investment
- Two-stage process
  - Region
  - Cost minimizing location
- Site location $L$ expressed as a function

$$l = Q(A, S, L, I, F) \rightarrow Q \text{ is assumed cost min. location}$$

*Where* $l$ is site choice, $A, S, L, I, F$ are agglomeration factors, industry structure, labor, infrastructure and fiscal characteristics.
Agglomeration Economies (A)+*

- **Urbanization Economies**
  - Associated with size or economic diversity
- **Localization Economies**
  - Geographic specialization and economies of scale
- Represent cost savings – labor search, infrastructure, specialized skills, etc.
- Measure urbanization with county population and localization with percent employed by manufacturing sector

* Denotes hypothesized relationship to plant location choice
Industry Structure (S)+

- Plant investment decisions influenced by access to product markets
- Market potential captures effective demand relative to supply
- Firms choose to locate near product markets to lower transportation costs
- Measured by median household income and county population
- Job losses (2000 – 2004) used to control for restructuring
Labor Determinants (L)+

- Productivity is dependent upon labor availability
- Plants located near a small labor pool face turnover and recruitment problems
- Plants are likely to locate near skilled labor
- Four variables
  - Manufacturing wage
  - Unemployment rate
  - Percent of people 25+ with H.D.
  - Percent employed in technology or professional services
Infrastructure Determinants (I)+

- Create access to regional, national, and international markets, i.e. transportation systems, land availability, etc.
- Increase the attractiveness of a region
- Measured by presence of an interstate highway in the county
Fiscal Determinants (F)-

• Tax policies and expenditure patterns
• Influence public services
• High vs. low corporate taxes – hierarchy of tax
• Fiscal expenses on educational facilities, worker training, and public infrastructure
• Fiscal effects are measured by using the county-level net tax rate
## Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td>NEW0004</td>
<td>New plant announcements (2000-2004)</td>
<td>2.16</td>
</tr>
<tr>
<td>Market Structure (S)</td>
<td>Jobloss</td>
<td>Lost jobs</td>
<td>642</td>
</tr>
<tr>
<td></td>
<td>Medinc</td>
<td>Median household income</td>
<td>41.99</td>
</tr>
<tr>
<td>Agglomeration (A)</td>
<td>POP (000s)</td>
<td>Population, 2000</td>
<td>66.09</td>
</tr>
<tr>
<td></td>
<td>MEMPL</td>
<td>% of WF in Manuf.</td>
<td>21.0%</td>
</tr>
<tr>
<td>Infrastructure (S)</td>
<td>INTER</td>
<td>Presence of Interstate 1 = yes, 0 = no</td>
<td>59.0%</td>
</tr>
<tr>
<td>Labor (L)</td>
<td>UNEMP</td>
<td>Unempl. Rate, 2000</td>
<td>5.4%</td>
</tr>
<tr>
<td></td>
<td>EDUC</td>
<td>% Pop 25+ w/ H.D.</td>
<td>81.0%</td>
</tr>
<tr>
<td></td>
<td>MWAGE (000s)</td>
<td>Manuf. Wage, 2000</td>
<td>34.62</td>
</tr>
<tr>
<td></td>
<td>EMP54</td>
<td>% of LF in skilled tech.</td>
<td>3.0%</td>
</tr>
<tr>
<td>Fiscal (F)</td>
<td>TAXRATE</td>
<td>Net county tax rate</td>
<td>8.0%</td>
</tr>
</tbody>
</table>
Empirical Model

- Linear model specified to estimate establishment of new manufacturing plant location announcements

\[
\text{NEW004}_i = \beta_0 + \beta_1 \text{JOBLOSS}_i + \beta_2 \text{POP}_i + \beta_3 \text{MEMPL}_i + \beta_4 \text{MEDINC}_i + \beta_5 \text{INTER}_i + \beta_6 \text{UNEMP}_i + \beta_7 \text{EDUC}_i + \beta_8 \text{MWAGE}_i + \beta_9 \text{EMP54}_i + \beta_{10} \text{TAXRATE} + \varepsilon_i
\]

- Estimated using OLS, a Poisson GWR, and Spatial Generalized Linear Model
Econometric Methods

• Poisson with GWR
  • Distributional assumptions of OLS no longer valid with discrete data, i.e. count data
  • Guimaraes, Figueiredo, and Woodward (2004) in *JRS*, linked industrial site selection to firm profit maximization and optimal strategies for site selection
  • GWR allows for marginal effects to vary by county
  • Purpose is to identify non-stationarity across space
Econometric Methods

• Spatial Generalized Linear Model
  • Success or failure of attracting a plant may spillover county to county
  • Model these global effects via a Poisson SGLM
  • Determines the intensity and rate of spatial decay between counties via parameters $\theta = [\sigma_{\text{spatial}}^2, \alpha]$
    $\sigma_{\text{spatial}}^2$ spatial covariance parameter
    $\alpha$ = influence range parameter
  Joint test for spatial dependence between counties
## Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>OLS</th>
<th>Poisson ML</th>
<th>Spatial GLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT</td>
<td>-8.43 (-1.66)***</td>
<td>-6.173 (-2.09)**</td>
<td>-6.825 (-2.40)*</td>
</tr>
<tr>
<td>JOBLOSS</td>
<td>0.0003 (1.30)</td>
<td>0.0001 (1.66)***</td>
<td>0.0001 (1.23)</td>
</tr>
<tr>
<td>POP</td>
<td>0.012 (93.03)*</td>
<td>0.003 (3.13)*</td>
<td>0.003 (3.34)*</td>
</tr>
<tr>
<td>MEMPL</td>
<td>2.687 (1.04)</td>
<td>1.688 (1.32)</td>
<td>2.030 (1.64)</td>
</tr>
<tr>
<td>INTER</td>
<td>1.618 (2.55)*</td>
<td>0.865 (3.27)*</td>
<td>0.841 (3.40)*</td>
</tr>
<tr>
<td>UNEM</td>
<td>39.040 (2.31)*</td>
<td>17.30 (2.02)**</td>
<td>18.791 (2.21)**</td>
</tr>
<tr>
<td>EDUC</td>
<td>10.955 (1.80)***</td>
<td>7.416 (2.12)**</td>
<td>8.124 (2.44)**</td>
</tr>
<tr>
<td>MWAGE</td>
<td>-0.039 (-1.74)***</td>
<td>-0.015 (-1.13)</td>
<td>-0.015 (-1.23)</td>
</tr>
<tr>
<td>EMP54</td>
<td>-28.782 (-1.37)</td>
<td>-11.005 (-0.77)</td>
<td>-12.525 (-0.95)</td>
</tr>
<tr>
<td>TAXRATE</td>
<td>-11.177 (-0.77)</td>
<td>-5.256 (-0.57)</td>
<td>-4.627 (-0.55)</td>
</tr>
<tr>
<td>MEDINC</td>
<td>0.006 (0.10)</td>
<td>-0.001 (-0.06)</td>
<td>-0.004 (-0.18)</td>
</tr>
<tr>
<td>$\sigma^2_{\text{spatial}}$</td>
<td></td>
<td></td>
<td>0.33 (44.00)*</td>
</tr>
<tr>
<td>$\alpha$</td>
<td></td>
<td></td>
<td>0.23 (0.79)</td>
</tr>
<tr>
<td>Pearson's $\chi^2$ residuals</td>
<td></td>
<td>158.03</td>
<td>110.28</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td></td>
<td></td>
<td>429</td>
</tr>
</tbody>
</table>
Pearson’s Correlations

- See Table 3 in the paper
- Simply show the correlation between the variables and corresponding significance level
- Negative values indicate inverse relationships
- Lead to ad hoc comparisons
- Usefulness of these is questionable as output of GWR
- Localized effects & business restructuring (-0.54)
  - Counties where localized marginal effects increased competitiveness, marginal effect of job loss was less
County Competitiveness

- Cook’s Distance (Cook’s D) – Figure 4
- Measures the change to estimates that results from deleting each observation
- Help explain inter-county competitiveness
- Northwest region found to be competitive, others like Marion and Allen County
Conclusions

• Re-adjustment of Indiana manufacturing
• Manufacturers tend to select plant locations around urban areas
• Key determinants of location – population, labor quality and availability, and transportation infrastructure
• Community leaders, policymakers should consider investing in workforce improvement and public infrastructure investment
Considerations

• Robust results across three econometric specifications

• Inference from GWR is problematic, subsamples are not independent, e.g. LeSage (2004)

• What do we really know about quasi-maximum likelihood estimation?