Pricing the priceless; applying spatial hedonic techniques to value open space in South Africa.

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Presentation layout

The Hedonic Property Value model

- The hedonic model assumes that a residential property is a heterogeneous good that is made up of a bundle of characteristics or attributes composed of structural (**S**), neighbourhood (**N**), accessibility to location (**L**), and environmental attributes (**Q**) (with $\varphi, \gamma, \omega, and \psi$ as the corresponding parameter vectors), and can be modeled as:

$$p(\mathbf{z}) = f(\mathbf{S}, \mathbf{N}, \mathbf{L}, \mathbf{Q}; \varphi, \gamma, \omega, \psi) + \varepsilon$$

This can be presented in a linear vector form as $\mathbf{P} = \mathbf{Z}\boldsymbol{\beta} + \boldsymbol{\varepsilon}$ (1)

P is a $n \times 1$ vector of observations on the dependent variable

Z is a $(n \times k)$ matrix of observations on the characteristics of the house,

$\boldsymbol{\beta}$ is the associated $(k \times 1)$ vector of regression coefficients

$\boldsymbol{\varepsilon}$ is a vector of normally distributed error terms (the assumption of normality necessary for Maximum Likelihood (ML) estimation.

The Spatial Hedonic property value model

- The spatial lag model includes a spatially lagged dependent variable on the right hand side of (1), such that

$$P = \rho WP + Z\beta + \varepsilon \text{ or } P = (I - W\rho)^{-1}\beta Z + (I - W\rho)^{-1}\varepsilon$$
$$\varepsilon \sim N(0, \sigma^2 I_n) \quad (2)$$

- The spatial error model is the basic hedonic regression specification (1) with a spatial autoregressive error term such that:

$$\varepsilon = \lambda W\varepsilon + \xi \text{ or } \varepsilon = (1 - \lambda W)^{-1}\xi \quad (3)$$
$$\xi \sim N(0, \sigma^2 I_n)$$

ρ is the spatial lag parameter and λ is a spatial error parameter $\rho \text{ and } \lambda \neq 0$

W is a $n \times n$ spatial weight matrix

Motivation for spatial analysis

- Spatial econometric analysis motivated by **Tobler's first law of Geography (everything is related to everything else but near things are more related than distant things)**. Moreover, residential values at one location is likely to be correlated with that of residential properties located at nearby locations.
- Spatial correlation motivated by
  - (a) "herd effect"
  - (b) Nearby residential property values tend to converge over time
  - (c) Benefit from residing close to nicer (more expensive properties)
  - (d) Any omitted variable that varies spatially and affects property values will cause property values located close to each other to have similar values for that omitted variable thus leading to correlated values.
- (a) to (c) gives rise to a spatial lag dependence and OLS estimation provides biased regression estimates.
- (d) gives rise to spatial error dependence and OLS estimation provides unbiased but inefficient estimates.

Creation of spatial weights matrix, and Model selection

- A spatial weight matrix is the main operational tool for dealing with spatial dependencies in regression analysis.
- It describes the neighbourhood relationship between spatially dependent functional relationships.
- If *i* and *j* are neighbours, then $w_{ij} = 1$ and $w_{ij} = 0$ otherwise
- No agreement in the literature regarding how a weight matrix ought to be constructed (could be based on contiguity or some variant of distance).
- Distance based matrices used in this study.
- Diagnostic tests confirm spatial dependencies up to 2500m and that a spatial lag model is the appropriate spatial specification.
- Box-Cox test indicate the semi-log specification (i.e. log p =f(z)) is the appropriate functional specification.

Data and results

Variable	Model(1)D_2000	Model(2)OLS
ρ	0.51***	
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PARK_Dist	-0.00051***	-0.00079***
SPECPARK_Dist	-0.00020***	-0.00023***

Determining the value of open space

$$\frac{\partial P_1}{\partial z_{1k}} = \frac{\partial P_1}{\partial z_{1k}} + \sum_{i=2}^{n} \frac{\partial P_1}{\partial z_{ik}}, \forall i = 2,3,....,\ n$$

- $MWTP = \beta_i \times \frac{1}{1-\rho} \times \overline{P}$ and $AMB = \beta_i \sum_{i=1}^{n} \left(\frac{1}{1-\rho} \right) \overline{P}$ or $AMB = \left\{ \beta_i \times [\mathbf{I} - \rho \mathbf{W}]^{-1} \times \mathbf{P} \right\}$
- Willingness to pay for regular parks

$$\frac{\partial P}{\partial Park\_Dist} = \beta_{park\_dist} \times \frac{1}{1-\rho} \times \bar{\mathbf{P}} = 0.00051 \times \frac{1}{1-0.47} \times 315{,}042.82 = R315.04$$

- Aggregate Marginal Benefits of regular Parks = R 2.5m
- Willingness to pay for special parks = R123.55
- Aggregate Marginal Benefits of Special parks = R 988 000

Conclusion

- Important to explicitly account for spatial dependence
- Open space positively valued
- Residents are willing to pay more for proximity to different types of open space
- Tangentially, model provides economic justification for public policies aimed at incentivising property owners to maintain their properties

Thank you