Mostly Pointless Spatial Econometrics

(Gibbons & Overman, 2012)

Spatial Economics Seminar Presentation

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Spatial Econometric Models And Their Issues

The Experimentalist Paradigm And Spatial Econometrics

The Spatial Durbin Model

The Spatial Durbin Model nests all other models. We can express the reduced form by recursive substitution:

$$\begin{aligned} y_i &= \rho \boldsymbol{w}_i' \boldsymbol{y} + \boldsymbol{x}_i' \beta + \boldsymbol{w}_i' \boldsymbol{X} \gamma + u_i, \\ u_i &= \lambda \boldsymbol{w}_i' \boldsymbol{u} + v_i \end{aligned} \tag{1}$$

$$\begin{aligned} y_i &= \rho \boldsymbol{w}_i' (\rho \boldsymbol{W} \boldsymbol{y} + \boldsymbol{X} \beta + \boldsymbol{W} \boldsymbol{X} \gamma + \boldsymbol{u}) + \boldsymbol{x}_i' \beta + \boldsymbol{w}_i' \boldsymbol{X} \gamma + u_i \\ &= \rho^2 \boldsymbol{w}_i' \boldsymbol{W} \boldsymbol{y} + \rho \boldsymbol{w}_i' \boldsymbol{X} \beta + \rho \boldsymbol{w}_i' \boldsymbol{X} \gamma + \rho \boldsymbol{w}_i' u + \boldsymbol{x}_i' \beta + \boldsymbol{w}_i' \boldsymbol{X} \gamma + u_i \\ &= \rho^2 \boldsymbol{w}_i' \boldsymbol{W} \boldsymbol{y} + \boldsymbol{x}_i' \beta + \rho \boldsymbol{w}_i' (\boldsymbol{X} \beta + \gamma) + \rho \boldsymbol{w}_i' \boldsymbol{W} \boldsymbol{X} \gamma + v_i \\ &= \dots \\ &= \rho^n (\boldsymbol{w})_i' \boldsymbol{W}^{n-1} y + \boldsymbol{x}_i' \beta + \boldsymbol{w}_i' \boldsymbol{X} (\rho \beta + \gamma) \\ &\quad + \rho \boldsymbol{w}_i' \boldsymbol{W} \boldsymbol{X} (\rho \beta + \gamma) + \rho^2 \boldsymbol{w}_i' \boldsymbol{W}^2 \boldsymbol{X} (\rho \beta + \gamma) + \dots + v_i, \end{aligned} \tag{2}$$

Under standard regularity conditions: $\lim_{n \to \infty} \rho^n (\boldsymbol{W}')^{n-1} \boldsymbol{W}^{n-1} = 0$

So what does this tell us?

Spatial interaction in y_i, spatial externalities through x_i, or spatial dependence in the error term leads to different econometric specifications

However, all of these models have the same reduced form, namely:

$$y_i = \mathbf{x}_i'\beta + \boldsymbol{w}_i'\boldsymbol{X}\pi_1 + \boldsymbol{w}_i'\boldsymbol{W}\boldsymbol{X}\pi_2 + \boldsymbol{w}_i'\boldsymbol{W}^2\boldsymbol{X}\pi_3 + ... + v_i \tag{3}$$

Spatial Economics uses neighbors characteristics ($\boldsymbol{w}_i'\boldsymbol{X}$, $\boldsymbol{w}_i'\boldsymbol{W}\boldsymbol{X}$, ...) under the assumption that these are exogenous to instrument for $\boldsymbol{w}_i'\boldsymbol{y}$

The Reflection Problem in the Context of Spatial Econometrics

Remember the **Linear-in-Means** model of neighborhood effects? (Manski, 1993)
No?

$$y_i = \rho_1 \mathbf{E}[y_i|a] + \boldsymbol{x}_i'\beta + \mathbf{E}[\boldsymbol{x}_i'|a]\gamma + v_i, \tag{4}$$

Solving for the reduced form by taking the expectation of (4) and rearranging yields:

$$y_i = \boldsymbol{x}_i'\beta + \boldsymbol{E}[x_i'|a]\frac{(\beta\boldsymbol{\rho_1} + \gamma)}{(1 - \boldsymbol{\rho_1})} + \frac{\boldsymbol{\rho_1}}{1 - \boldsymbol{\rho_1}}E[v_i|a] + v_i \tag{5}$$

No chance that we can distinguish the endogenous (ρ_1) from the exogenous peer effects (γ)!

The Difference Between the Peer Effects Literature and Spatial Econometrics

Spatial Durbin Model again:

$$y_i = \rho_1 \mathbf{w}_i' \mathbf{y} + \mathbf{x}_i' \beta + \mathbf{w}_i' \mathbf{X} \gamma + u_i \tag{6}$$

According to Gibbons and Overman (2012) the spatial econometrics literature is disregarding the identification issues as shown in Manski (1993). Why?
In spatial econometrics (6) is assumed to be the **true** data generating process.

Identification of parameters works because:

- The structure of the spatial weights matrix $\boldsymbol{W}$ is said to be known
- Exogeneity of $\boldsymbol{X}$ and $\boldsymbol{w}_i' \boldsymbol{WX}$, ...

$$y_i = \boldsymbol{x}_i' \beta + \boldsymbol{w}_i' \boldsymbol{X}(\beta \rho_1 + \gamma) + \rho_1 \boldsymbol{w}_i' \boldsymbol{WX}(\beta \rho_1 + \gamma) + \rho_1^2 \boldsymbol{w}_i' \boldsymbol{W^2 X}(\beta \rho_1 + \gamma) + ... + \varepsilon_i \tag{7}$$

The Difference Between the Peer Effects Literature and Spatial Econometrics

Gibbons and Overman (2012) note that there are serious problems in relying on the spatial lags of $\boldsymbol{X}$ to identify the parameters.

Identification breaks down in most spatial econometric models because:

- the exact structure of $\boldsymbol{W}$ is not known! (exclusion restriction is not fulfilled)
- Weak Instruments because of high correlation between spatial lags $\boldsymbol{w_i'X}$, $\boldsymbol{w_i'WX}$, $\boldsymbol{w_i'W^2X}$, ...

The Experimentalist Paradigm And Spatial Econometrics

Standard Spatial Models Are Plagued! (By Identification Problems)

"[Identification] problems are so fundamental that they must sit at centre stage of applied work"[1]

"[...] we argue that spatial research would be best served by turning away from the application of generic spatial models"[1]

"[Any] alternative approach also has to solve the identification problems that plague spatial economic analysis"[1]

Consider a **standard SD specification**:

$$y_i = \rho \boldsymbol{w}_i'\boldsymbol{y} + \boldsymbol{x}_i'\beta + \boldsymbol{w}_i'\boldsymbol{X}\gamma + u_i \qquad (8)$$

- No way to induce **exogenous change** in $\boldsymbol{w}_i'\boldsymbol{y}$ without changing $\boldsymbol{w}_i'\boldsymbol{X}$ (or $\boldsymbol{w}_i'\boldsymbol{u}$)
- But can this even be the true DGP? Our decisions probably rely on expectations of $\boldsymbol{y}$ and not $\boldsymbol{y}$ itself
- These **reflection issues** transfer to differenced specifications and are not solved by randomization[2]

[1] Gibbons and Overman (2012, p. 181)

[2] Assuming we do not know the true functional form and spatial weights.

Two Alternatives Considered

Instrumental Variables Estimation

- $\boldsymbol{w}_i'\boldsymbol{X}$ provides instruments for $\boldsymbol{w}_i'\boldsymbol{y}$ *in a correctly specified* SAR model
- **Exclusion restriction**: Has to be met, is often neglected
- How sensible is it to assume that $\boldsymbol{w}_i'\boldsymbol{X}$ affects y_i only through $\boldsymbol{w}_i'\boldsymbol{y}$?
- Sometimes **institutional arrangements** provide plausibly exogenous variation
- Another opportunity: $\boldsymbol{w}_i'\boldsymbol{y}$ represents **expectations**

Reduced Form SLX Models

- **Composite reduced form parameter** describes the influence of neighbors' $\boldsymbol{X}$ or $\boldsymbol{y}$
- It doesn't distinguish, but the information is useful anyway
- The SAR model's identification problem is absent,
- **But**: Exogeneity of $\boldsymbol{x}_i$ and $\boldsymbol{w}_i'\boldsymbol{X}$ is still not credible
- **How to proceed?**

How to Proceed With the SLX Model—And What Problems Remain

"Natural Experiments"

- **Intuition**: A change in w_i over time allows identification
- **Example**: The German Reunification

Standard IV / Differencing

- Use IV for parameters of interest (this time of the **SLX model**)

Spatial Differencing

- Removing unobserved spatial components by **differencing** observations with their **neighbors**

Problems of These Approaches

- Doesn't all of this lack **generalizability** outside the experiment sub-group?
  It might, but at least estimates are plausibly causal
- Are places simply too **spatially unique** to be treated with experimentalist techniques?
  No, a counterfactual only should be comparable along the explanatory dimensions

"[Any] empirical research that aims to find out if x causes y needs to find a source of exogenous variation in x!"[3]

[3] Gibbons and Overman (2012, p. 187)

Thank you!

Appendix: Spatial Econometric Models

Starting point:

$$y_i = \boldsymbol{x}_i'\beta + u_i \tag{9}$$

To incorporate spatial dependence we know the

SAR model:

$$y_i = \rho \boldsymbol{w}_i'\mathbf{y} + \mathbf{x_i}\beta + \mathbf{u_i} \tag{10}$$

SLX model:

$$y_i = \boldsymbol{x}_i'\beta + \boldsymbol{w}_i'\boldsymbol{X}\gamma + u_i \tag{11}$$

SE model:

$$y_i = \boldsymbol{x}_i'\beta + u_i, \tag{12}$$

$$\text{where } u_i = \rho \boldsymbol{w}_i'\boldsymbol{u} + v_i \tag{13}$$

References I

Gibbons, S., & Overman, H. G. (2012). Mostly Pointless Spatial Econometrics? *Journal of Regional Science*, *52*(2), 172–191. https://doi.org/10.1111/j.1467-9787.2012.00760.x

Manski, C. F. (1993). Identification of Endogenous Social Effects: The Reflection Problem. *The Review of Economic Studies*, *60*(3), 531. https://doi.org/10.2307/2298123