

# Mostly Pointless Spatial Econometrics

(Gibbons & Overman, 2012)

*Spatial Economics Seminar Presentation*

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April 19, 2024

# **Spatial Econometric Models And Their Issues**

**The Experimentalist Paradigm And Spatial Econometrics**

# The Spatial Durbin Model Nests all Our Models

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

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

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

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

## 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:

$$y_i = \mathbf{x}_i' \beta + \mathbf{w}_i' \mathbf{X} \pi_1 + \mathbf{w}_i' \mathbf{W} \mathbf{X} \pi_2 + \mathbf{w}_i' \mathbf{W}^2 \mathbf{X} \pi_2 + \dots + v_i \quad (3)$$

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

# The Reflection Problem in the Context of Spatial Econometrics

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

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

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

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

No chance that we can distinguish the endogenous ( $\rho_1$ ) from the exogenous peer effects ( $\gamma$ )!

# The Difference Between the Peer Effects Literature and Spatial Econometrics

Spatial Durbin Model again:

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

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  $\mathbf{W}$  is said to be known
- Exogeneity of  $\mathbf{X}$  and  $\mathbf{w}_i' \mathbf{W} \mathbf{X}$ , ...

$$y_i = \mathbf{x}_i' \beta + \mathbf{w}_i' \mathbf{X} (\beta \rho_1 + \gamma) + \rho_1 \mathbf{w}_i' \mathbf{W} \mathbf{X} (\beta \rho_1 + \gamma) + \rho_1^2 \mathbf{w}_i' \mathbf{W}^2 \mathbf{X} (\beta \rho_1 + \gamma) + \dots + \varepsilon_i \quad (7)$$

# 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  $\mathbf{X}$  to identify the parameters.

Identification breaks down in most spatial econometric models because:

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

**Spatial Econometric Models And Their Issues**

# **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”<sup>1</sup>

“[...] we argue that spatial research would be best served by turning away from the application of generic spatial models”<sup>1</sup>

“[Any] alternative approach also has to solve the identification problems that plague spatial economic analysis”<sup>1</sup>

Consider a **standard SD specification**:

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

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

<sup>1</sup>Gibbons and Overman (2012, p. 181)

<sup>2</sup>Assuming we do not know the true functional form and spatial weights.

# Two Alternatives Considered

## Instrumental Variables Estimation

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

## Reduced Form SLX Models

- **Composite reduced form parameter** describes the influence of neighbors'  $X$  or  $y$
- It doesn't distinguish, but the information is useful anyway
- The SAR model's identification problem is absent,
- **But:** Exogeneity of  $x_i$  and  $w_i'X$  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!”<sup>3</sup>

<sup>3</sup>Gibbons and Overman (2012, p. 187)

**Thank you!**

# Appendix: Spatial Econometric Models

Starting point:

$$y_i = \mathbf{x}_i' \boldsymbol{\beta} + u_i \quad (9)$$

To incorporate spatial dependence we know the

**SAR** model:

$$y_i = \rho \mathbf{w}_i' \mathbf{y} + \mathbf{x}_i' \boldsymbol{\beta} + u_i \quad (10)$$

**SLX** model:

$$y_i = \mathbf{x}_i' \boldsymbol{\beta} + \mathbf{w}_i' \mathbf{X} \boldsymbol{\gamma} + u_i \quad (11)$$

**SE** model:

$$y_i = \mathbf{x}_i' \boldsymbol{\beta} + u_i, \quad (12)$$

$$\text{where } u_i = \rho \mathbf{w}_i' \mathbf{u} + v_i \quad (13)$$

# 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>