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

Recall the main spatial econometric models we know

Starting point:

$$y_i = \boldsymbol{x}_i'\beta + u_i \tag{1}$$

To incorporate spatial dependence we know the

SAR model:

$$y_i = \rho \boldsymbol{w}_i'\mathbf{y} + \mathbf{x_i}\beta + \mathbf{u_i} \tag{2}$$

SLX model:

$$y_i = \boldsymbol{x}_i'\beta + \boldsymbol{w}_i'\boldsymbol{X}\gamma + u_i \tag{3}$$

SE model:

$$y_i = \boldsymbol{x}_i'\beta + u_i, \tag{4}$$

$$\text{where } u_i = \rho \boldsymbol{w}_i'\boldsymbol{u} + v_i \tag{5}$$

The Spatial Durbin Model nests all of them

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

$$\begin{aligned} y_i &= \rho \boldsymbol{w}_i' \boldsymbol{y} + \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{w}_i' \boldsymbol{X}\boldsymbol{\gamma} + \boldsymbol{u}_i \gamma, \\ \boldsymbol{u}_i &= \lambda \boldsymbol{w}_i' \boldsymbol{u} + v_i \end{aligned} \tag{6}$$

$$\begin{aligned} y_i &= \rho \boldsymbol{w}_i' (\rho \boldsymbol{W}\boldsymbol{y} + \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{W}\boldsymbol{X}\boldsymbol{\gamma} + \boldsymbol{u}) + \boldsymbol{w}_i' \boldsymbol{\beta} + \boldsymbol{w}_i' \boldsymbol{X}\boldsymbol{\gamma} + u_i \\ &= \rho^2 \boldsymbol{w}_i' \boldsymbol{W}\boldsymbol{y}_i + \rho \boldsymbol{w}_i' \boldsymbol{X}\boldsymbol{\beta} + \rho \boldsymbol{w}_i' \boldsymbol{X}\boldsymbol{\gamma} + \rho \boldsymbol{w}_i' \boldsymbol{u} + \boldsymbol{X}' \boldsymbol{\beta} + \boldsymbol{w}_i' \boldsymbol{X}\boldsymbol{\gamma} + u_i \\ &= \rho^2 \boldsymbol{w}_i' \boldsymbol{W}\boldsymbol{y}_i + \boldsymbol{X}' \boldsymbol{\beta} + \rho \boldsymbol{w}_i' (\boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{\gamma}) + \rho \boldsymbol{w}_i' \boldsymbol{W}\boldsymbol{X}\boldsymbol{\gamma} + v_i \\ &= \dots \\ &= \rho^n (\boldsymbol{W}')_i \boldsymbol{W}^{n-1} \boldsymbol{y} + \boldsymbol{X}' \boldsymbol{\beta} + \boldsymbol{W}' \boldsymbol{X} (\rho \boldsymbol{\beta} + \boldsymbol{\gamma}) \\ &\quad + \rho \boldsymbol{w}_i' \boldsymbol{X} (\boldsymbol{\beta} + \rho \boldsymbol{\gamma}) + \rho^2 \boldsymbol{w}_i' \boldsymbol{w}^2 \boldsymbol{X} (\boldsymbol{\beta} + \rho \boldsymbol{\gamma}) + \dots + v_i, \end{aligned} \tag{7}$$

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:

$$y_i = \mathbf{x}_i'\beta + \boldsymbol{w}_i'\boldsymbol{X}\pi_1 + \boldsymbol{w}_i'\boldsymbol{W}\boldsymbol{X}\boldsymbol{\pi_2} + \boldsymbol{w}_i'\boldsymbol{W}^2\boldsymbol{X}\pi_2 + ... + v_i \tag{8}$$

The only differences arise from the number of spatial lags of x_i, the constraints on the underlying parameters, and whether the error term is spatially correlated.

The Reflection Problem in the Context of Spatial Econometrics

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

$$y_i = \rho_1 \mathbf{E}[y_i|a] + \boldsymbol{x}_i'\beta + \mathbf{E}[\boldsymbol{x}_i'|a]\gamma + v_i, \tag{9}$$

Solving for the reduced form by taking the expectation of (9) and rearranging yields:

$$y_i = \boldsymbol{x}_i'\beta + \boldsymbol{E}[x_i'|a]\frac{(\beta\boldsymbol{\rho_1} + \gamma)}{(1 - \boldsymbol{\rho_1})} + \frac{\boldsymbol{\rho_1}}{1 - \boldsymbol{\rho_1}}E[v_i|a] + v_i \tag{10}$$

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:

$$y_i = \rho_1 \mathbf{w}_i' \mathbf{y} + \mathbf{x}_i' \beta + \mathbf{w}_i' \mathbf{X} \gamma + u_i \tag{11}$$

According to Gibbons and Overman (2012) the spatial econometrics literature is disregarding the identification issues as shown in Manski (1993). Why?

In spatial econometrics (11) is assumed to be the **true** data generating process. The spatial weighs matrix $\boldsymbol{W}$ is said to be known. Which allows identification of the parameters through IV estimation.

$$y_i = \boldsymbol{x_i'}\beta + \boldsymbol{w_i'X}(\beta\rho_1 + \gamma) + \rho_1 \boldsymbol{w_i'WX}(\beta\rho_1 + \gamma) + \rho_1^2 \boldsymbol{w_i'W^2X}(\beta\rho_1 + \gamma) + ... + \varepsilon_i \tag{12}$$

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!
- 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**:

$$y_i = \rho \boldsymbol{w}_i'\boldsymbol{y} + \boldsymbol{x}_i'\beta + \boldsymbol{w}_i'\boldsymbol{X}\gamma + u_i \qquad (13)$$

- 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: $\boldsymbol{y}$ 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)

References

References I

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