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One-directional adjacency matrices in spatial autoregressive model: A land price example and Monte Carlo results

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ABSTRACT

In the context of spatial econometrics, we discuss the specification of one-directional effects, not mutual dependencies. Using an empirical study (a spatial autoregressive model of land price data in Fukui Prefecture, Japan) and Monte Carlo simulation results (contiguity matrices built based on regular lattices using the rook criteria), we show that spatial dependencies might not be recognized if such dependencies are assumed to be reciprocal.

1. Introduction

Spatial autoregressive models, which at first were applications of time-series models, incorporate modeling of spatial (network) covariance structures, which are often neglected in econometrics. Mutual interdependency is generally assumed in these cases. However, in some cases, it is commonly assumed that there are only one-directional dependencies, not mutual dependencies. In research such as the land price spillover model proposed by Ando and Uchida (2004), concepts similar to one-directional dependencies have been adopted. In this paper, we discuss the specification of one-directional effects, not mutual dependencies.[1] Using an empirical study (a spatial autoregressive model of land price data in Japan) and Monte Carlo simulation results (contiguity matrices built based on regular lattices using the rook criteria), we show that spatial dependencies might not be recognized if such dependencies are assumed to be reciprocal.

The organization of this paper is as follows. In Section 2, we describe the research background and discuss one-directional spatial weight matrices in spatial autoregressive models. In Section 3, we apply a one-directional spatial weight matrix in an empirical analysis. In Section 4, we perform Monte Carlo simulations. We present our conclusions in Section 5.

2. One-directional adjacency matrix

There is an implicit assumption that interdependency is mutual in most spatial econometric literature. Anselin and Bera, (1998, p.245) pointed out the following.

> While not inherently invalidating estimation or testing procedures, the unconnected observations imply a loss of degrees of freedom, since, for all practical purposes, they are eliminated from consideration in any "spatial" model.

The model becomes simply an ordinal regression model since the isolated sample has no effect on the others.

It is sometimes assumed that some samples affect others but are not affected themselves. For example, land prices in the central business district (CBD) of a large metropolitan area are determined independently, and those in other areas of the metropolitan area depend on the land prices in the CBD (Ando and Uchida, 2004). Rincke, (2006) pointed out the possibility of such relationships in the context of local public finance. In the context of international economy linkages, there is a saying that 'when America/China sneezes, the rest of the world catches a cold.' The leader and follower relationship in the game theory is also an example of such one-directional relationship. [2]

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[1] For further discussion of this issue, see (Anselin and Kelejian, 1997, p. 158). Spatial autoregressive models with multiple spatial weight matrices, LeSage and Pace, (2008) for an example, might also be important in this context.

[2] In addition, a helpful referee pointed out that there is (latent) one-directionality in the literature. She or he wrote that 'One common way to specify a weight matrix is a sort of nearest-neighbor kernel. For example, the closest 10 or 25 neighbors might receive some weight. In this case, w_{ij} may be positive if i is a relatively isolated observation, but w_{ji} may equal zero if j has many close neighbors'.

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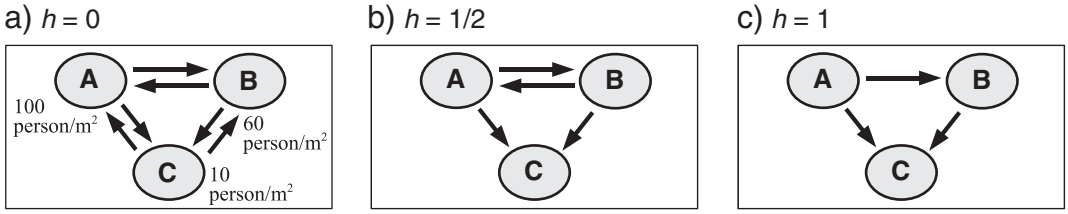

Fig. 1. Land price interaction and threshold h.

Here, we apply this concept of one-directional influence to a land price model. Land prices are determined mainly by location attributes. Another important factor is the price of land in surrounding areas. Speculation may determine some component of land prices. Forecasts of the price of land will be heavily influenced by the prices of land in the neighborhood. However, if the place is less accumulated, their price might be disregarded as a criterion in the forecast. Interdependency of land price may also caused by competitions in the land market.

We introduce a simple economic model of land prices. There are n locations. We assume interdependency in the land prices of the locations (y_i). We also assume there is a threshold h in the interdependency. Location j influences location i if the relative urban accumulation of j (x_j/x_i) is higher than h. For an example, we may treat population densities as a proxy of urban accumulation. Fig. 1 illustrate the concept. Table 1 shows the spatial weight matrix **W** for each value of paramter h.

3. An empirical application

In this section, we apply one-directional adjacency matrices to an example of empirical analysis, namely, a land price model for Fukui Prefecture, which located in the Chubu region on Honshu island of Japan. We conjecture that land prices are determined by two factors. The first factor includes socioeconomic attributes, for example, floor area ratio. The second factor takes into account psychological or speculative attributes, for example, the land prices in neighboring areas. It is more likely that land prices are affected not by every price in nearby areas, but only by prices in tracts of the regional center. We assume that the relative population density determines whether there is an influence on the price in one location due to the prices in another location.

3.1. Data and model

We use statistics provided by the Japanese national government. [3] The explained variables are the notified residential land prices in Fukui Prefecture in 2006. The notified prices are estimated land prices of representative tracts provided by Japanese government. The sample size is 139. We use the following variables for each location i.

y_i	Land price in 2006 (Yen/m^2)
$x_{i0}=1$	Constant term
x_{i1}	Parcel size of the tract (m^2)
x_{i2}	Distance from the nearest railroad station (m)
x_{i3}	Dummy variable for gas supply
x_{i4}	Dummy variable for drainage
x_{i5}	Upper limit restriction on floor area ratio [4] (%)
x_{i6}	Wooden house dummy
x_{i7}	Population density (Person/km^2)
x_{i8}	Distance from the prefectural center (km)

[3] Statistics on land prices are obtained from http://nlftp.mlit.go.jp/ksj/. Population density statistics are from http://www.e-stat.go.jp.

[4] Local governments utilize this restriction to control urban developments.

Table 1
h and **W**.

h	0	1/2	1
$\mathbf{W}_h$	$\begin{pmatrix} 0 & 1/2 & 1/2 \\ 1/2 & 0 & 1/2 \\ 1/2 & 1/2 & 0 \end{pmatrix}$	$\begin{pmatrix} 0 & 1/2 & 0 \\ 1/2 & 0 & 0 \\ 1/2 & 1/2 & 0 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 0 \\ 1/2 & 0 & 0 \\ 1/2 & 1/2 & 0 \end{pmatrix}$

Table 2
Descriptive statistics.

Variable		Mean	SD	Min	Max	Unit
y_i	Land price in 2006	42619.8	24103.4	2250	109,000	Yen/m^2
x_{i1}	Parcel size	287.827	162.985	85	1037	m^2
x_{i2}	Distance from the nearest station	4552.68	6475.46	1	29500	m
x_{i3}	Gas supply	0.194245	0.397049	0	1	
x_{i4}	Drainage dummy	0.705036	0.457676	0	1	
x_{i5}	Maximum floor area ratio	161.295	55.3884	80	200	%
x_{i6}	Wooden house dummy	0.94964	0.219477	0	1	
x_{i7}	Population density	1963.2	1722.2	33	6226	Person/km^2
x_{i8}	Distance from the prefectural center	25.387	24.4593	0	93.0494	km

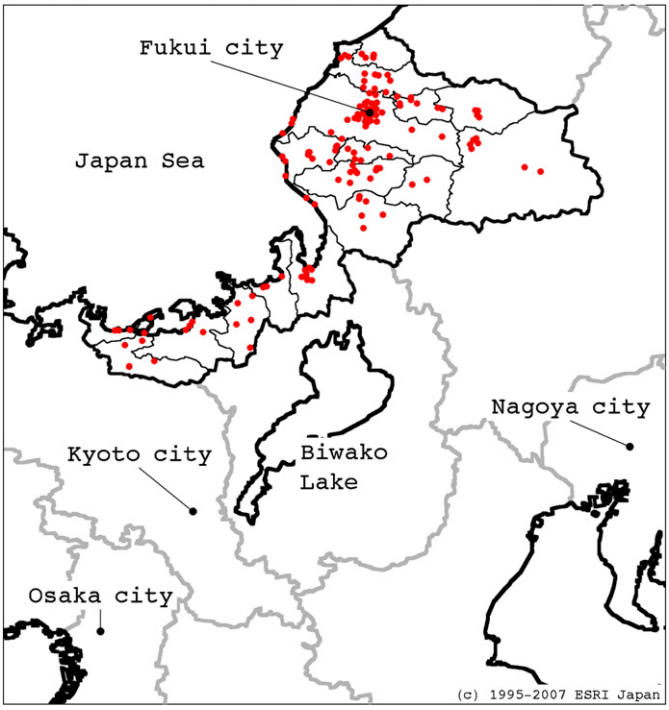

Fig. 2. Location of the Fukui Prefecture and sample spatial distribution.