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Schools, land markets and spatial effects

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ABSTRACT

This paper uses a spatial modeling approach to explore the capitalisation effect of proximity to schools on land markets. The results suggest that adjacency to primary schools leads to considerable price premiums but there are no significant effects on middle schools and universities. The results also provide some reassurance that spatial simulations offer a useful representation of localised variations in values attached to proximity to schools in Beijing, China.

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1. Introduction

China has experienced substantial land and housing marketisation in the past decade (Liang et al., 2007; Cheshire, 2007; Zheng and Kahn, 2008). This transformation has come alongside massive local public infrastructure investments, booming real estate investments (Zheng and Kahn, 2013). Such rapid but differential spatial expansion in infrastructure and real estate markets will transform the determinants of property prices within cities. In Chinese cities, especially large cities such as Beijing and Shanghai, educational resources are scarce and distributed non-uniformly across space, and thus how school facilities are capitalised into land values have drawn increasing attention of households, policy makers and planners.

As an important source of urban externalities, recent studies have shown that proximity to schools can influence property price premiums and parents' housing location choice (e.g. Cheshire and Sheppard, 2004; Gibbons and Machin, 2008; Cellini et al., 2010; Gibbons et al., 2013). For example, whilst living near a primary school or middle school may result in commuting time savings for parents and their children, there might also be traffic congestions and noise associated with schools. While mayors in China want to balance the optimal distribution of educational facilities for their cities to achieving an equalisation of educational resources, an important but untested question to optimal education resource allocations is a solid understanding of how the capitalisation effect of proximity to schools varies with the persistence of spatial dependence effects in a land market. This is an important issue because ignoring or mis-specifying spatial dependence in a hedonic land price model is likely to result in biased and inconsistent estimates of the amenity value of proximity to schools (e.g. Brasington and Haurin, 2006).

This paper aims to shed lights on these questions by looking at the distributional effects of proximity to schools on Beijing's residential land market, by capturing the hierarchical structure underlying the land price data. We improve on the traditional spatial econometric evaluation of proximity to schools by simultaneously modelling two types of unobservables via a Bayesian hierarchical spatial autoregressive model developed in Dong and Harris (2015). More specifically, the property level unobservable effect is modelled by the inclusion of a spatially lagged land price variable as in Brasington and Haurin (2006). The neighbourhood level unobservable impact is modelled as a spatial autoregressive process (see detailed discussions in Section 4). The former corresponds to a horizontal spatial dependence effect—an effect arising from the geographical proximity amongst properties while the latter corresponds to a vertical dependence effect—a top-down effect induced by neighbourhoods (unobservable characteristics such as neighbourhood prestige) upon properties (Dong and Harris, 2015; Dong et al., 2015).

The rest of this paper is organized as follows. Section 2 highlights the limitations of previous studies on the economic valuation of schools. Section 3 describes our econometric models, followed by a summary of the institutional context and data in Section 4. Section 5 presents the results. In the final section, we draw conclusions.

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2. Limitations of previous research

Most existing research evaluating the captialisation effects of schools assesses their effects on property values and residential sorting patterns. Typically, these studies compare house prices across school catchment zones and boundaries. The empirical results vary across studies. In this section, we highlight some limitations of the existing methodologies on which we try to improve in the present study.

Suppose that we build a statistical model of land price determinants using data where land parcels are nested into neighbourhoods (e.g. census units such as lower layer super output areas in England). A complete model specification would be the one that relates land prices to all land parcel and neighbourhood characteristics. However, not all of the variables are observable or quantitatively measureable and the unobservable part will be embedded into the hedonic equation as a compound model error term. It is reasonable to decompose the unobservable factors to the land parcel level effect denoted as ν (e.g. the presence of a hazardous landfill near a land parcel) and the neighbourhood level effect denoted as θ (e.g. neighbourhood physical and cultural characteristics or prestige). Under this context, if these unobservable factors (either ν or θ or both) are varying systematically across space and correlate with the school variables of interest, the hedonic model residuals will be spatial dependent and the estimates of the school captalisation effect will be biased by using a traditional ordinal least square estimation strategy.

An innovative identification strategy to control for the unobservable factors is the application of boundary fixed effect (or spatial discontinuity) approach (e.g. Black, 1999; Gibbons et al., 2013). In essence, this approach compares house values on the opposite sides of school attendance zone (or catchment area) boundaries in a school district and estimates the value of school quality as differences of the adjusted house prices—controlling for other house characteristics and boundary dummy variables. The key assumption of this approach is that all neighbourhood variables other than school quality remain the same when crossing borders, thus a boundary fixed effect approach can capture both the observed and unobservable neighbourhood characteristics, leaving the property price differentials solely attributable to differences in school quality. While the approach is intuitively straightforward and logically sound, it is not without its problems. For example, neighbourhood characteristics do vary near school attendance zone borders due to a household sorting process (e.g. Brasington and Haurin, 2006; Bayer et al., 2007). If people with high educational status had a stronger preference for schools with high quality than those with low educational status, differences in the neighbourhood-level educational status would exist. This however cannot be effectively controlled by the boundary fixed effect approach.

Brasington and Haurin (2006) proposed to use the spatial econometric approach to tackle the issue of omitted variable bias facing studies of school evaluation. The basic idea is to directly model the unobservable influences (the sum of ν and θ) by adding a spatially lagged dependent variable (house price in this context) into the traditional hedonic price model. The lagged house price variable (constructed through a spatial weights matrix that specifies the connection structure among properties) captures the unobservable influences on house prices and the spatial dependence of them. Technical details of the spatial econometric approach are provided in Anselin (1988) and LeSage and Pace (2009), among others. The spatial dependence in the unobservables is intuitively plausible as the unobservable influences might be similar for properties that are in close geographical proximities (e.g. Brasington and Hite, 2005; Brasington and Haurin, 2006; Wen et al., 2014; Anselin et al., 2010; Lazrak et al., 2014; Leonard et al., 2015).

But a potential problem associated with this econometric approach is the conflation of unobservable influences at the neighbourhood and property levels. It is important to distinguish between the two types of unobservables u and θ as they might represent different spatial processes—one operating at a property scale and another at a neighbourhood scale. In the methodological term, failing to separate the two sets of unobserved effects could lead to biased estimates of the spatial dependence effect (i.e. the coefficient of the lagged price variable). To explicitly address this concern, we recognise two types of spatial dependence effects in the estimation process. By constructing precisely geo-coded location information and combining this information with GIS maps, we can measure land parcel locations, proximity to school facilities, and other characteristics of local public goods in the spatial context.

3. Econometric models

Following the hedonic price modelling literature, land price is related to a series of locational and neighbourhood characteristic variables, as shown in Eq. (1):

$$LnPrice_{ij} = a + \boldsymbol{\beta} School'_{ij} + \boldsymbol{\varphi} L'_{ij} + \boldsymbol{\delta} Z'_{j} + \theta_j + \varepsilon_{ij} \quad (1)$$

where the dependent variable ($LnPrice_{ij}$) is the natural logarithm of the price for a residential land parcel i in neighborhood j. The school variables under investigation are in vectors $School_{ij}$, which include proximity to primary and middle schools, and to prestige universities. The quality of nearest primary and middle schools of each land parcel are also included. L_{ij} represents locational and structural variables of each land parcel while Z_{ij} includes neighbourhood level variables. $\boldsymbol{\beta}$, $\boldsymbol{\delta}$ and $\boldsymbol{\varphi}$ are vectors of regression coefficients to estimate. The vector θ_j are unobserved neighbourhood effects and ε_{ij} are random innovations, following as an independent normal distribution with mean of zero and variance of ${\sigma_e}^2$.

An important issue with the standard hedonic model specification is that the horizontal spatial dependence effect of land prices is not captured. A common practice would be incorporating fixed spatial effects in the hedonic price model (θ_j treated as fixed in Eq. (1)). It implicitly assumes that dependence in land prices is raised by the neighbourhood level unobservables. This is a fairly strict assumption for real-world land price data as dependence in land prices could also arise from the land parcel level unobservables and spillover effects from one land parcel upon surrounding land parcels and vice versa. By adopting a fixed effect estimation strategy, effects of neighbourhood level variables can no longer be estimated. To address this concern, a typical spatial hedonic price model is usually adopted (Brasington and Haurin, 2006; Anselin et al., 2010),

$$LnPrice_{ij} = a + \rho w_i \boldsymbol{LnPrice} + \boldsymbol{\beta} School'_{ij} + \boldsymbol{\varphi} L'_{ij} + \boldsymbol{\delta} Z'_{j} + \varepsilon_{ij} \quad (2)$$

where w_i is a vector of spatial weights, measuring the how closely other observations are related to the ith observation. Spatial weights are calculated either by using an inverse distance scheme with a pre-defined threshold distance or based on geographical contiguity (Cliff and Ord, 1981; Anselin, 1988). Multiplying w_i by the price vector gives a weighted average price of the neighbours of i if, as is usually the case, w_i is normalised so that the sum of its elements equal to 1. Eq. (2) allows for an explicit test of whether land price at location i is related to land prices at locations to which i is connected to (significance of the spatial autoregressive parameter ρ), which is a standard simultaneous autoregressive model (SAR) in the spatial econometrics literature.

One potential problem that has not been dealt with by using SAR is the vertical spatial dependence effect in land prices arising from the neighbourhood unobservables. Land parcels in the

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