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Spatial econometrics, land values and sustainability: Trends in real estate valuation research

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ABSTRACT

In the aftermath of the recent boom and bust of US real estate, both a refinement and a deeper understanding of real estate valuation methods have become critical concerns across a number of broad urban-related academic fields. Out of this we see three major trends in the field of real estate valuation research: (1) the expansion of spatial econometrics; (2) the recognition of the differences between land values and improvement values; and (3) acknowledgment of value premiums stemming from more sustainable forms of development. This paper offers a brief summary of the latest work in these emerging areas of academic valuation research.

Introduction

The academic field of property valuation research crosses many disciplines, and includes not only economics, geography, urban planning and design, but also business, finance, statistics and even specialized real estate departments and schools. As a result, research in the field is often moving in many directions at a single time, as some innovations are following those of the associated disciplines mentioned above while others emanate from the large commercial sector that deals with real estate on a daily basis. Given the dynamic nature of this field, periodic reflections on current developments can offer great insight into the world of academic real estate valuation research.

We have identified three separate but related trends in valuation. The first, and perhaps most prevalent, is the increased use of advanced spatial methods in published studies. Second, we see the recent interest in various land value issues, including the focus on land values as a major shaper of both real estate values and of urban spaces in general, as another major trend. The third is the measurement of value premiums offered by energy efficient, sustainable, or green locations and buildings. We address each trend below, followed by a concluding synthesis.

Spatial methods in valuation

The importance of space or location in determining real estate values is, to even the novice, axiomatic. Properly incorporating space into valuation models, however, is not without its difficulties. Spatial dependence, spatial heterogeneity, anisotropic phenomena and boundary effects all combine to render obsolete the simple non-linear decline of values from the central business district (CBD), as assumed in the basic monocentric urban economic model. In place of this stylized circular city are polycentric urban regions complete with localized amenities (or disamenities), geographic heterogeneities, fragmented municipal governments, and complex systems of land use regulations.

To deal with these inherent complexities, a host of advanced spatial methods have been developed over the last few decades. These tools can roughly be divided into those dealing with spatial dependence and those dealing with spatial heterogeneity. The number of papers on these topics is vast. We cover a select few here to illustrate the breadth of uses and variations on them that are occurring in the academic research.

Spatial dependence

There is a long history of attempts to account for spatial effects in real estate valuation studies. Early work by Goodman (1978) and Li and Brown (1980) examined spatial effects at the scale of the neighborhood. Building on this, Dubin (1988), and Can and Megbolugbe (1997), among others, presented work that considered property-specific impacts of spatial dependence in the market. Throughout the late 1980s and early 1990s, more advanced spatial econometrics methods were being developed in other disciplines (see Anselin, 1988) which eventually made their way into the field of property valuation research. Real estate, an industry whose

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defining mantra is considered "location, location, location," is well suited to benefit from these advances in spatial econometrics (Cohen & Coughlin, 2008).

Two basic models underlie attempts to model spatial dependence, the spatial lag (or spatial autoregressive) model and the spatial error model. Spatial lag models allow for the observed value of nearby observations—in the case of real estate, nearby sales prices—to impact the dependent variable in the models. These lag models attempt to capture the spatial dependence in the real estate market, or in other words, account for the impact of nearby sales on current home prices. Given the fact that asking prices for homes on the market are often the direct product of nearby home prices (Brasington & Hite, 2005) and that appraisers determine values for financing purposes based on nearby comparable sales (Koschinsky, Lozano-Gracia, & Piras, in press) it seems natural that spatial dependence would play a role in home price estimation. Spatial error models (SEMs), on the other hand, deal specifically with spatial autocorrelation in the error terms, a violation of the basic assumptions of ordinary least squares (OLS) regression. By accounting for the spatial autocorrelation in the disturbances, SEM models can help to eliminate omitted variable bias generated by missing spatial variables.

Spatial econometrics is not limited to the two basic models. By combining spatial lag and spatial error models, a general spatial model (GSM) can be estimated. If spatial dependence is suspected to exist in both the dependent variable and the explanatory variable(s) a Spatial Durbin model is the most appropriate specification (LeSage & Pace, 2009).

Though spatial econometrics has developed into a complex, multi-faceted analytical technique, it does not need to remain unavailable to the general practitioner of valuation-related research. Recent work by Osland (2010) provides a useful overview of spatial econometric models with a focus on real estate valuation. Using house price data from Norway, Osland works through the specification of various spatial models as well as a discussion on application and interpretation of a set of diagnostic tests aimed at choosing the proper spatial specification. Her comparative analysis shows that these spatially explicit models vastly outperform a traditional OLS model.

Where Osland's work is primarily concerned with the predictive accuracy of house prices, other recent research uses spatial econometrics in a valuation framework to isolate the price impacts of various variables of interest. Brasington and Haurin (2006) find the impact of school spending on home prices is larger when using a spatial lag model that accounts for spatial dependence than with a basic OLS model including neighborhood descriptors. Cohen and Coughlin (2008) compare spatial lag, spatial error and general spatial models in a study on the impacts of airport noise on home prices in Atlanta, Georgia. They find that the coefficient estimates of impact from airport noise do not differ significantly in the spatial models from a baseline OLS model, but that when the spatial multiplier effect is considered the traditional models are shown to be likely underestimating the impact of airport noise on housing prices. Kuethe (2012) uses spatial lag and spatial error models to examine the impact of land use diversity and land use fragmentation on house prices in Milwaukee, Wisconsin. His baseline OLS model suggests that land use diversity has a positive impact on house prices whereas the impact of land use fragmentation shows no statistically significant relationship. After accounting for spatial autocorrelation in the error terms with a spatial error model, Kuethe's updated model shows that land use diversity has no effect and high levels of fragmentation are related to increases in housing prices. In a study on the magnitude of welfare effects as related to housing attributes (including location), Koschinsky et al. (in press) find that estimates from a basic OLS model, and OLS models with fixed spatial effects, are different enough from those found with spatial econometric models to be misleading to the researcher. Their work suggests that the spatial dependence between observations (in this case home prices) is not properly accounted for by fixed spatial effects such as discrete geographic boundaries.

These studies exhibit the dangers that can result from ignoring spatial effects and proceeding with basic OLS models when valuing real estate. In each case, adding in spatial effects through spatial lag or spatial error models significantly changed the magnitude of the effect or even the finding of an effect at all. This work–and many other similar projects—indicates that in research on real estate pricing the impacts of spatial dependence should not be ignored.

Over the past decade spatial econometrics has become firmly entrenched in the real estate valuation literature. However, a nagging question has plagued the field for years: How is the proper spatial weights matrix determined? In a recent paper, LeSage and Pace (2011) show that, in contrast to published work, in most situations the specification of the weight matrix does not substantially change the estimates of the model. They have deemed this pervasive idea—that finding the ideal weight matrix is critical—as the "Biggest Myth in Spatial Econometrics." Their work shows that two pitfalls often lead to this erroneous conclusion. First, because coefficient estimates should not differ between a correctly specified OLS and SEM model (differences should show up in the measures of error), large changes in coefficient estimates due to changes in weight matrices are a sign of model misspecification rather than a response to matrix specification. Second, the incorrect interpretation of β coefficients in spatial lag models will lead researchers to notice a large change in effects due to small variations in the spatial weight matrix. As LeSage and Pace show, a properly specified model containing spatial lags will use variations in the β and ρ estimates to keep the true effect estimates (partial derivatives) relatively constant over changing weight matrices. In sum, the authors do not suggest that the identification of weight matrices makes no difference at all, but rather that the two common errors discussed above are more likely to blame for large variations in effects estimates than the particular choice of the spatial weight matrix.

Spatial heterogeneity

The spatial econometric models discussed above have emerged to deal with the spatial dependence of nearby observations. Another set of modeling techniques seek to examine if the relationships between independent and dependent variables vary across space. Such models have a long history, dating back to spatial expansion methods developed by Casetti (1972) and later used by Can (1990), and a related variable interaction approach presented by Fik, Ling, and Mulligan (2003). Recently, the most common technique to deal with spatial heterogeneity in the coefficient estimates has been the use of local regression models (LOESS). Geographically weighted regression (GWR), as elaborated by Fotheringham, Brunsdon, and Charlton (2002), is the most prevalent of these methods. Since the early 1990s, local regression models have been used widely, examples being work by McMillen (1996), Pavlov (2000), and Bitter, Mulligan and Dall'erba (2007). Hannonen (2008) describes these local techniques as being "data-driven and flexible" and notes that their employment can allow the user to limit concerns over the choice of functional form.

Hannonen's (2008) recent work on forecasting land prices in Espoo, Finland finds that a robust form of local regression model outperforms a traditional OLS model, but not a structural time series model. Paez, Long, and Farber (2008), working with home sales data from Toronto, also find that localized models (GWR and a moving window regression, MWR) produce better out-of-sample home price predictions than a base OLS model and a moving window Kriging method. Conversely, Osland (2010) finds that while her GWR model does show evidence of heterogeneity in the coefficients over space, the predictive results do not differ significantly