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The economic value of streets: mix-scale spatio-functional interaction and housing price patterns

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A R T I C L E I N F O

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A B S T R A C T

Location factors are vital elements for describing housing price variation. However, limited studies have explicitly illustrated the relationship between urban design and the heterogeneity of housing price patterns. This article specifically evaluates how the interactions between the spatial layouts and land-use system at various scales through street network affect the valuation of the residential properties and the segmentation of housing markets in a network-based Mixed-scale Hedonic Model (MHM) where the submarkets pattern are determined and annotated by the spatially varying estimates on streets. The application of the delivered method in the case of Shanghai City, China, confirms the necessity of using the non-Euclidean distance metric and represent the coexistence between the stationarity and the non-stationarity of the introduced street accessibility variables. The results provide evidence that the impacts of street accessibility measures on the local levels showcase significant spatial variation. It is common for all the places that the properties located on the streets with the higher levels of angular closeness, smaller values of angular betweenness and longer angular distance to the nearby land-uses at the larger scales will be bided higher. It is proven that our delineation of submarket performs better in prediction accuracy than the traditional submarket specifications. The detected submarkets pattern yields that reachable land-use diversity at the pedestrian level is not a preferred factor in the housing submarkets located in the developed city centres. The signs of the price effects of the angular distance to local land-uses distinguish the developing submarkets as two main groups with different degrees of geometrical walkability. It is suggestive that continuously developing pedestrian-oriented neighbours in the walkable areas could contribute to decelerating the growth of house price in Chinese cities. The productions of this study can enrich the understanding of the socioeconomic effects of urban design with greater spatial precision across submarkets.

1. Introduction

As the vital factors reflecting the economic externality, location variables capture the geographical characteristics of city properties. The connotations of location can span from environmental quality, landscape comfort, socioeconomic features, to travelling impedance, etc. In urban studies, accessibility is a critical concept that represents the *potential of opportunities for interaction* in different locations (Hansen, 1959). It has been widely adopted for assessing urban place's advantages and related policy distributions (e.g., Geurs, Montis, & Reggiani, 2015; Stewart, 1948; Geurs & van Wee, 2004). Its origins can be traced back to the monocentric Alonso–Muth–Mills model (Anas, Arnott, & Small, 1998). The effectiveness of accessibility measures has been proven in the housing price analysis for describing the process that how location advantages are capitalised into residential property values (e.g., Adair, McGreal, Smyth, Cooper, & Ryley, 2000; Boyle & Kiel, 2001; Smersh & Smith, 2000; Song & Knaap, 2003). Related research focusing on the regional determinants or the distance factors in the analysis of housing price patterns were typically conducted based on the assumption that built environment is homogeneous across the landscape (Batty, 2009). Consequently, the influence of the fine-grained design of built environment upon the housing price variation is over-simplified or overlooked. The absence of the proper consideration of spatial disparity of urban space thereby constraining the possibility of explicitly understanding the socioeconomic impacts of urban design.

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Accessibility is formed in urban spatial configurations which can be divided into two subsystems: the spatial configuration and the functional system. Efforts have been made on measuring accessibility symmetrically based on these two structures respectively without proper interlinks between one another (Karlström & Mattsson, 2009). In the field of transport geography, the land-use system is one of the main focuses; the accumulated chances and the travelling energy/cost expenditure to them are conceptualised as the metrical gravity to urban opportunities (Wegener, 2004). Related measures have been widely discussed in housing studies to investigate the impacts of the transport transits (Bowes & Ihlanfeldt, 2001), school quality (Haurin & Brasington, 1996), transport investments (Banister & Berechman, 2003; Henneberry, 1998) and the attractiveness of landscape (Luttik, 2000) on housing appreciation. By contrast, configurational studies use public space as the opportunity landscape and emphasise on the cognitive efforts beyond the metric distance cost that are required to interconnect segmented spaces, which provides an opportunity of scrutinising how the topo-geometrical properties of urban grids differentiate urban places and implying the informational efforts for human movement (Hillier & Hanson, 1984; Hillier, 2003; Kim & Penn, 2004; Kwan, 2000). The topo-geometrical nature of urban movement is reflected in the process how people recognise the value of location externality because location conditions are sensed by individuals though other people's observable movement rather than though the 'unreadable' built environment directly (Hillier, 1996). As the fundamental of public goods, the geometrical properties of urban grids will be priced to maximise the efficiency of accessibility allocation (Webster, 2010). Recent concern has been given to investigate the relationship between street network centralities and the property value patterns and the impacts of urban form on submarket delineation (e.g., Chiaradia, Hillier, Barnes, & Schwander, 2009; Enström & Netzell, 2008; Law, 2017; Law, Karimi, Penn, & Chiaradia, 2013, 2015; Matthews & Turnbull, 2007; Shen & Karimi, 2015; Xiao, Webster, & Orford, 2016). Understanding the linked nature between these spatial and functional structures is critical for the cities in the process of rapid urban growth and generation (Tallon, 2013), where the change of spatial and functional elements are increasingly significant, such as the cities in current urbanised China.

Yet, successful marriage between the geometrical and the configurational models with consistent theoretical and methodological foundations is still sparse, thereby restricting our knowledge with regard to the socioeconomic consequences of urban design. In recent time, it was argued that accessibility of urban form and its related attractions can be reconceptualised as 'spatial capital' to assess the performativity of urban space (Marcus, 2010; Berghauser Pont & Marcus, 2014). It is shown that adding geographical accessibility into the space syntax model can enhance the predictability of the statistical regression model for predicting human pedestrian patterns (Ozbil, Peponis, & Stone, 2011) and describing the distribution of commercial frontages (Porta et al., 2012; Scoppa & Peponis, 2015; Sevtsuk, 2014). As a reflation on the criticism of configurational measures as a one-dimensional approach for simplifying the impacts of urban attractions (Ratti, 2004), recent methodological developments of network accessibility have addressed the role of the buildings' attractiveness in the configurational analysis (Ståhle, Marcus, & Karlström, 2005; Sevtsuk & Mekonnen, 2012). Lately, through incorporating the place attractiveness and the cognitive cost, Shen and Karimi (2016) introduced a more comprehensive framework of characterising and segmenting streets based on the delivered urban function connectivity measures, including the accessible density, diversity and the delivery efficiency with social media check-ins data and validated its methodological novelty of predicting socioeconomic performance. In this study, we unravel the price effects of location advantages that are measured by space syntax centralities and urban function connectivity indices, respectively, on the property values.

In hedonic price theory, the urban property is priced for its inherent utility-bearing characteristics (Lancaster, 1966; Rosen, 1974) including its structural features, location situations and the neighbourhood effects (Bourassa, Cantoni, & Hoesli, 2007; Dubin, 1988). The existence of spatial heterogeneity of housing price pattern indicates that property value is not self-existent but closely related to its surrounding property values. In this sense, the spatial autocorrelation between property values can hardly be captured by the structural or locational variables; therefore, the neighbourhood effects should be taken into account in the hedonic regression models (e.g., Goodman, 1978; Hwang & Thill, 2009; Hui, Zhong & Yu., 2014). Due to the recent development of the local regression methods, for instance, notably the locally weighted regression (LWR) method (Cleveland & Devlin, 1988), geographically weighted regression (GWR) (Brunsdon, Fotheringham, & Charlton, 1996; Fotheringham, Brunsdon, & Charlton, 2003), spatial autoregressive models (Kelejian & Prucha, 1998), etc., addressing the neighbourhood impacts is suggested to be an effective way of controlling the spatial variation of hedonic price functions, improving the prediction accuracy (e.g., Goodman & Thibodeau, 1998) and generating the reasonable submarkets (Bourassa, Hamelink, Hoesli, & MacGregor, 1999, 2007; Helbich, Brunauer, Hagenauer, & Leitner, 2013). Nevertheless, it was found that not all variables vary geographically, and sometimes only certain parameters influence housing prices based on spatial locations (Wei & Qi, 2012). Thus, spatially homogeneous factors and heterogeneous elements should be considered simultaneously so that spatial knowledge of property valuation can be advanced. Moreover, the priority of adopting the landscapes of local estimates in housing submarket segmentation process has been distinguished from conventional ways to define submarkets, for instance, demarcating the submarkets according to the constant marginal prices (Goodman & Thibodeau, 2007) or with distinct patterns of observed characteristics (Palm, 1978), as its independence of the exogenously predefined units and effectiveness for improving the accuracy of the hedonic models for the defined submarkets (Helbich, Brunauer, Vaz & Nijkamp, 2013). Against this background, the mixed-hedonic model (MHM) is recognised as an efficient regression approach to address the neighbourhood effects by combining the standard GWR model and the conventional hedonic model to capture the complex interactions between variables and to define the emergent submarket patterns in a data-driven procedure.

Housing hedonic studies can be conducted with different variables settings on different scales, which might lead to the different conclusions with the modifiable areal unit problems (MAUPs). Conventionally, the MHM was employed with the regional indicators and the Euclidean distance metrics beyond the sampling landscape (Fotheringham et al., 2003), which are not particularly suitable for studying the impacts of built environments within non-Euclidean metrics on an intra-city scale (Lu, Charlton, & Fotheringhama, 2011, 2014). Urban streets, the places where the real urban economy occurs (Hillier & Hanson, 1984, 1997; Hillier & Vaughan, 2007; Jacobs, 1961), have been paid very few attention in hedonic regression models. In fact, they are not only the urban elements that deliver spatial and functional convenience but also the proper spatial units for the high-resolution analysis of housing price pattern. Additionally, the network distance along the streets explicitly portrays the actual spatial interactions between properties, and its contribution to optimising the statistical performance