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Research Paper

Cumulative impacts of polluted urban streams on property values: A 3-D spatial hedonic model at the micro-neighborhood level

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HIGHLIGHTS

- Cumulative impacts combine amenities and disamenities of two bifurcated streams.
- Cumulative impacts of polluted urban streams on property values were investigated.
- A novel 3-D spatial contiguity matrix, cube contiguity, was constructed.
- Streams' chemical, physical and ecological features were evaluated holistically.
- An extra premium was paid to live farther away from two bifurcated streams simultaneously.

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ABSTRACT

Urban streams could concurrently bring about both positive amenities accruing to the view of waterscape and negative disamenities associated with water pollution. In this paper, we focus on a specific question that has not yet been explicitly answered in the extant literature: how to estimate the cumulative impacts of urban streams (which refer to the combined impacts of amenities and disamenities of multiple sources) in high density and high-rise urban contexts. A typical residential apartment complex (comprised of a number of apartment units located in dozens of mid- to high-rise commercial apartment buildings on a contiguous land parcel) in Guangzhou, south China, is used as a case study. A detailed palette of natural amenities and environmental disamenities of two bifurcated streams are quantified via the generalized spatial two-stage least squares (GS2SLS) model. In this model, an originally constructed 3-D spatial connectivity matrix, cube contiguity, is applied to address, in a sophisticated manner, an array of endogenous, exogenous, and error interactions along both horizontal and vertical dimensions that inherently exist in the spatial context of high-rise housing markets. Our results from spatial hedonic models at the micro-neighborhood level demonstrate that homebuyers tend to evaluate urban streams' chemical, physical, and ecological features holistically. A cumulative impact is also found, as homebuyers would like to pay an extra premium for an apartment located farther away from both polluted streams. This study advances the extant literature by contributing to a novel and effective extension of the conventional two-dimensional spatial matrix which can capture the long-ignored spatial correlation existing amongst apartment units located on contiguous floors, as well as a robust estimation of the demand of urban natural and environmental amenities in the gradually rising mid- and high-rise housing market in both developing and developed countries.

1. Introduction

Over the past several decades, a large body of literature has formed on hedonic housing price modelling of non-marketed amenities and disamenities bestowed by natural and environmental elements in urban settings (e.g., Chen & Jim, 2010; Gibbons, Mourato, & Resende, 2014; Li, Wei, Yu, & Tian, 2016; Nilsson, 2014; Powe, Garrod, & Willis, 1995; Redfearn, 2009), a fraction of which concerns the impacts of urban waterbodies, such as rivers, streams, lakes, and wetlands (e.g., Chen, 2017; Jim & Chen, 2007; Leggett & Bockstael, 2000; Luttik, 2000; Mahan, Polasky, & Adams, 2000; Polyakov, Fogarty, Zhang, Pandit, & Pannell, in press; Sander & Zhao, 2015; Tapsuwan, Ingram, Burton, & Brennan, 2009). Bundled positive amenity and negative disamenity impacts would be generated by polluted urban streams. The amenity is mainly attributed to accessibility to, and views of, watercourses.

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Riverside areas with moving water and plants have been found to constitute the most preferred urban natural landscapes (Ryan, 2005) and recreational venues (Völker & Kistemann, 2011; Haase, 2015; Sander & Zhao, 2015). Moreover, a view of urban streams, their calm or flowing water, reflection of surroundings and variable color, would induce pleasurable feelings and induce beneficial psychophysiological effects, so as to significantly reduce mental fatigue, stress, and anxiety commonly experienced by urban residents as a result of ordinary visually blighted urban scenes (Burmil, Daniel, & Hetherington, 1998; Sakıcı, 2014, 2015; Ulrich, 1979; Völker & Kistemann, 2011, 2013; White et al., 2010). A combination of recreational and visual contact makes urban rivers a key and appealing natural amenity element in urban contexts (Sakıcı, 2015; Völker, Matros, & Claßen, 2016). Aside from these positive amenities, urban streams can sometimes produce negative disamenity impacts on adjacent residential properties, which are mainly associated with water pollution, riverbank erosion, irritating odor, repugnant color, and insect annoyances (Cho, Roberts, & Kim, 2011; Chen, 2017; Mahan et al., 2000; Netusil, Kincaid, & Chang, 2014; Poor, Pessagno, & Paul, 2007).

To capture the implicit value of urban waterbodies capitalized into the selling prices of residential properties, the most common approach is to measure proximity to the property (mostly in Euclidean distance) (Anderson & West, 2006; Cho, Clark, Park, & Kim, 2009; Paterson & Boyle, 2002; Walsh, Milon, & Scrogin, 2011). In addition, views of urban waterbodies have increasingly attracted scholarly attention (e.g., Bishop, Lange, & Mahbubul, 2004; Baranzini & Schaerer, 2011; Hui & Liang, 2016; Kulshreshtha & Gillies, 1993; Sirmans, Macpherson, & Zietz, 2005; Schläpfer, Waltert, Segura, & Kienast, 2015), as the beauty and scenery afforded by views of waterbodies and associated riparian vegetation, as contrasting elements within normally monotonous urban fabrics, become a scarce natural good for urban dwellers of surrounding buildings (Gobster & Westphal, 2004; Junker & Buchecker, 2008).

While the majority of the literature has consistently agreed that urban waterbodies and associated views could produce amenities and contribute positively to property values (e.g., Jim & Chen, 2007; Poudyal, Hodges, & Merrett, 2009; Schläpfer et al., 2015; Tapsuwan et al., 2009), the water quality of urban waterbodies has been treated separately and independently in hedonic studies (Walsh et al., 2011). Although it is argued that most water pollution is hardly observable for homebuyers (Leggett & Bockstael, 2000), some empirical evidence suggests that pollution of waterbodies could significantly depress property values and generate disamenities (e.g., Cho et al., 2011; Chen, 2017; Gibbs, Halstead, & Boyle, 2002; Netusil et al., 2014; Poor et al., 2007; Walsh et al., 2011). Despite the fact that most urban waterbodies worldwide have been polluted and degraded due to intensive and pervasive anthropogenic disturbances along with the ongoing process of urbanization (Halstead, Kliman, Berheide, Chaucer, & Cock-Esteb, 2014; Walsh, Roy, Feminella, Cottingham, & Groffman, 2005), some to the extent that their recreation and aesthetic functions have been severely impaired (Haase, 2015), little empirical evidence exists concerning the combined impacts (the bundled amenities associated with view of, and proximity to, waterbodies and disamenities caused by water pollution and relevant health concerns, as noted in Netusil et al., 2014; Scholes, Faulkner, Tapsell, & Downward, 2008), which might accrue or decay in different ways within varying spatial contexts (Isard, 1962). For example, positive amenities accrue with shortening the distance between apartment units and urban streams equipped with well-designed green landscapes. Negative disamenities accrue and decay with increasing the distance when residents could sufficiently detect water pollution and resultant detrimental impacts (Chen, 2017). A thorough understanding of the combined impacts of amenities and disamenities would provide useful information to real estate developers, greening planners, environmental managers, and policy-makers concerned with urban river management and restoration.

Two factors, however, add further complexity to the combined impacts of urban waterbodies on housing prices. One is the existence of multiple polluted waterbodies at neighborhood levels, which might exert cumulative impacts (referring to the combined impacts of both amenities and disamenities of multiple sources), an issue that has received little attention so far. Empirical hedonic studies primarily focus on single sources of a specific urban amenity/disamenity of interest. When multiple sources of amenity/disamenity exist within a study area, however, their impacts have been assessed either individually or by introducing the numbers of amenity/disamenity sources in certain areas (e.g., Boxall, Chan, & McMillan, 2005; Farber, 1998; Kong, Yin, & Nakagoshi, 2007; Michaels & Smith, 1990), which suggests that all sources with varying features are likely treated identically in hedonic pricing models. Thus, the potential overlap and cumulative impacts arising from multiple sources have been overlooked. This is problematic for real estate developers, urban planners, and policy-makers who are considering investing in enhancing urban amenities or ameliorating disamenities to stratify public demand.

The other is spatial effects, in the form of spatial dependence, spatial heterogeneity or both, which have constituted a common issue in hedonic housing price modelling (Anselin, 2003; Anselin & Lozano-Gracia, 2009; Hui & Liang, 2016; LeSage & Pace, 2009; Mueller & Loomis, 2008; Osland, 2010), but have been accounted overwhelmingly in the horizontal axis (defined by the x, y coordinates on a plane). Spatial effects in the vertical dimension (potential endogenous, exogenous, and error interactions between apartment units located on different floors along the vertical z axis) are seldom discussed vigorously and rarely taken into account in the extant literature (Liu & Jakus, 2015; Wong, Chau, Yau, & Cheung, 2011). This is despite the fact that many megacities in both developed and developing countries have exhibited a trend towards high-rise urban living (Al-Kodmany, 2011; Ayan & Erkin, 2014; Chen, 2017; Oh, Jeong, Lee, Lee, & Choi, 2005; Yuen et al., 2006), and thus natural and environmental urban waterbody amenities (via recreational contact and visual contact) assume additional importance as the continuing and necessary linkage between place of residence and natural environment (Bishop et al., 2004).

This study aims to fill the knowledge gap by elucidating the cumulative impacts of two bifurcated streams of the Pearl River at the micro-neighborhood level in Guangzhou (south China) through the innovative application of a spatial hedonic model in which 3-D spatial effects (spatial interactions defined by the x, y, z coordinates, such as spatial correlation in apartment prices, spatial heterogeneity in explanatory parameters, and error terms associated with both horizontal and vertical dimensions) are incorporated and accounted for via an originally constructed 3-D spatial connectivity matrix, cube contiguity. The remainder of this paper is organized as follows. The next section describes the research methodology, including the theoretical model for cumulative impacts of polluted urban streams, the description of the study area and data, the development of the 3-D spatial weighting matrix, and the selection of spatial econometric model. The results and discussion are then presented. The final section draws conclusions with policy implications.

2. Methodology

2.1. Study setting

This study focuses on a residential apartment complex, the Regal Rivera Court (RRC), located in the Haizhu District of Guangzhou