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Urban Housing Prices and Regional Integration: A Spatial Analysis in the City of Kaifeng, China

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Abstract
Regional integration is increasingly used as a policy strategy to accelerate urban development and regional cooperation. This research assesses the effects of regional integration on housing prices to evaluate policy effectiveness for small and medium-sized cities on the peripheries of core cities. Taking as a case study the Chinese city of Kaifeng—a contiguous city in the Zhengzhou megaregion—we utilized hedonic house price modelling and spatial econometrics to investigate the effect of Kaifeng's integration with the core city on the dynamics and determinants of housing prices between 2001 and 2016. The results show that housing prices in Kaifeng increased significantly after the city's integration with Zhengzhou in 2005. Further, the results confirm that the regional integration had a significantly positive effect on housing prices, especially in border areas. Moreover, the new time-saving cross-border light rail system had more influence on the prices of nearby housing than the new expressway, and new urban districts with high-quality amenities led to a sharp rise in housing prices in Kaifeng. Our findings offer policymakers some guidance concerning regional cooperation and urban development.

Keywords Regional integration · Urban housing prices · Urban development · Kaifeng, China

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Introduction

Government policies and planning have a substantial impact on the housing market (Hui and Wang 2014; Zhou 2018; Qin and Han 2013). Numerous studies have examined how housing prices are affected by government interventions, including mortgage policies (Gimeno and Martínez-Carrascal 2010; Iacoviello 2005), sale price restrictions, purchase restrictions (Li et al. 2017; Li and Xu 2016), land-use regulations, and land supply policies (Ihlanfeldt 2007). While these studies have broadened our knowledge of the effects of policies on both long- and short-term housing market dynamics at the inter-urban scale (Li and Xu 2016; Li et al. 2017; Roh and Wu 2016), research exploring the influence of government policies at the inner-city level is limited.

Urban development policies are increasingly debated in housing literature, as they are thought to influence the locational and neighborhood characteristics of properties, and thus also property prices (Boarnet and Chalermpong 2001). This is supported by studies on housing renewal (Liu 2010), urban amenities (Yuan et al. 2018), urban street configuration (Xiao et al. 2014), polycentric urban restructuring (Qin and Han 2013), urban regeneration (Faye and Fur 2012), and new town construction (Firman 2004). To date, such studies in the Chinese context have been limited to a few megacities, for example, Beijing, Shanghai, Hangzhou, and Nanjing (Feng and Lu 2013; Xu et al. 2015; Wen et al. 2015; Yuan et al. 2018). This research extends these analyses to small and medium-sized cities, which we hypothesised differ from metropolises regarding the determinants.

In recent years, regional integration has become the Chinese government's national strategy for achieving "new-type urbanization"[1] (Chen et al. 2018). Such integration facilitates the exchange of labor and capital, the sharing of public resources, and a reduction in transportation costs. It also promotes cooperation among contiguous cities (Fang and Yu 2017; Chen et al. 2018), which further enhances inter-urban socioeconomic interaction and accelerates inter-urban population migration (Feng 2003; Zheng and Wan 2014; Vickerman 2015), and improves the quality of life in underdeveloped areas (Zheng and Wan 2014). Evidence, albeit weak, suggests that regional integration policies are beneficial for cross-border urban developments and population agglomeration, which could lead to higher housing prices close to the border region (Fujimura 2004; Vickerman 2015). Unlike the spatial distribution of housing prices in monocentric or polycentric urban areas, the spatiotemporal dynamics of urban housing prices during regional integration are regarded as the central indicator of the efficiency of regional integration policies (Song and Liu 2018; Gong et al. 2016, 2015).

Taking the city of Kaifeng in the province of Henan, China, as our case study, we assessed the effect of regional integration on housing prices in a city on the periphery of a core city given the process of regional integration. Kaifeng was integrated with the capital city of Zhengzhou (Zheng & Kai Integration; ZKI) between 2005 and 2016. Hence, Kaifeng presented an ideal opportunity to assess the effects of regional integration on housing prices. The two research questions were:

[1] "New-type urbanization" stresses the development of urban culture and public services by means of people-oriented urbanization, and facilitates regional integration by eliminating administrative barriers across regions to promote coordinated regional development.

(1) How did housing prices change in Kaifeng in the context of the ZKI?

(2) How did the integration policies affect urban housing prices in Kaifeng at different stages of integration?

Literature Review

Urban Development and Housing Prices

It is well known that urban development is closely associated with housing prices (Baumont 2010, 2004), and that the implicit prices of housing attributes, especially neighborhood and locational characteristics, are affected by different urban development policies (Baumont 2007; Kauko 2009). First, the quality and distribution of urban amenities play a central role in explaining housing price variation. Along with economic growth and improvements in the standard of living in China, residents increasingly prefer urban amenities (Lu et al. 2013; Huang and Yin 2014). Access to public facilities such as schools, hospitals, and public transportation makes people's daily lives easier, which can be capitalized into housing prices (Hui et al. 2012). The quality and accessibility of these facilities to a great extent determine residents' locational choices and strongly affect housing prices (Wen et al. 2017; Yuan et al. 2018). Likewise, despite not having tangible market prices, urban green landscapes and historical amenities—such as parks, lakes, seascapes, and wetlands—provide leisure opportunities and aesthetic enjoyment to enrich urban life, the values of which thus are reflected in the prices of nearby housing (Hui et al. 2012; Zahirovic-Herbert and Chatterjee 2012).

Second, urban planning indirectly influences housing prices through the layout of urban infrastructure and public amenities. Urban planning is one measure taken in response to rapid urbanization and the urban cycle (Lu et al. 2013), where housing prices are sensitive to specific projects such as new zone construction or urban regeneration (Wen and Tao 2015; Baumont 2007). New town building is generally defined as the construction of a new urban center that creates new opportunities for employment and economic growth, and has higher quality buildings and public amenities compared with other areas (Cho and Kim 2017), which contributes to a housing price premium and attracts new residents. Housing prices also increase with the updated neighborhood environment created by urban regeneration projects, which are intended to improve the quality of life by refurbishing old buildings and creating amenities in deprived areas (Leather and Nevin 2014; Faye and Fur 2012; Lee et al. 2017).

Finally, housing price variation is also affected by the urban spatial structure (Wen and Tao 2015). Along with the process of urban sprawl, housing and employment have become more decentralized, and there has been a shift in urban spatial configuration from monocentric to polycentric (Fernandez Maldonado et al. 2013; Helbich 2015). In the monocentric model, both employment and amenity centers are clustered in the traditional central business district (CBD), to and from which residents need to commute. The monocentric distance–decay function demonstrates a trade-off between commuting cost and housing prices (Alonso 1964). As the polycentric model emerges, the specialization of subcenters and the decentralization of economic activities broaden the scope of housing location choice (McDonald and McMillen 1990), and the premium of CBD accessibility shifts to the accessibility of different subcenters. Some empirical research has found that multiple subcenters have a stronger influence than the urban CBD on the housing price distribution (Dubin and Sung 1987; Wen and Tao 2015) and that the transportation infrastructure has a stronger impact on the spatial change in housing prices (Qin and Han 2013).

Regional Integration and Housing Prices

Due to rapid urbanization and intensive urban competition, regional integration is now shaping regional spatial patterns in China and strengthening both the exchange of labor, capital, and knowledge, and the network connections between cities (Fang and Yu 2017; Chen et al. 2018). Regional integration is embodied in city integration, metropolitan region, and urban agglomeration at the inter-urban scale; examples are the Yangtze Delta urban agglomeration, the Central Plain urban agglomeration, and the Nanjing city-region (Gao et al. 2017; Luo and Shen 2009). Integrated regions are usually identified by means of population density, urban functions, and spatial continuity. Urban agglomeration and metropolitan regions require hierarchical structures with large, medium-sized, and small cities (Fang and Yu 2017), while city-regions cover different spatial organization patterns, including a core city and its neighboring cities, without limiting the structure and scales (Fang and Zhang 2014). Thus, regional integration not only affects the supply of and demand for housing, but also acts on spatial changes in housing prices as described through the hedonic model. Regional integration affects the housing market in several ways.

First, it accelerates regional economic growth, but its effect on housing market supply and demand raises concerns, especially for contiguous areas. Many integration initiatives, such as cross-border amenity construction, infrastructure, and shared resources, contribute to promoting cooperation. This further attracts more outside investment, improves the employment rate and income levels, and accelerates labor mobility (World Bank 2017; Buch et al. 2009; Kamau 2010). Changes in employment, population mobility, and income, in turn, affect urban housing demand (Hui et al. 2011). Moreover, because of the growth potential of contiguous areas, speculative demands for housing increase and more outside investment flows into real estate, leading to an increase in housing supply (Zhou and Guo 2015).

Second, targeted planning and policies for regional integration tend to trigger unintended spatial variation in housing prices. Public services and infrastructure are effectively improved in the whole area, depending on various regional initiatives, including the funding of infrastructure construction, and educational and medical development (Asher 2010). The value of these improvements is capitalized into housing prices, which change consistently and globally. However, there are differences between areas in the spatial distribution of housing prices. The cross-border area is where the core city meets the contiguous areas and forms a new growth alliance (Tan et al. 2018), one that benefits more from regional integration planning than other types of areas. Therefore, in border areas both the quality and the layout of buildings and neighborhood amenities are better than in other areas. In border areas, following hedonic theory, high-quality housing characteristics ensure higher housing prices (Ooi et al. 2014).

Third, regional infrastructure provides an impetus for regional cooperation and development (Fujimura 2004). The effect of these factors on housing prices has drawn considerable attention. Especially cross-border transportation, such as high-speed trains and highways, facilitate interregional interaction by reducing commuting costs. Compared with the core city, more cross-border transportation effects occur in contiguous areas, where transportation facilities make a greater contribution to improving regional accessibility (Vickerman 2015). Therefore, the proximity to a cross-border transit station becomes a critical neighborhood attribute, which may have a positive or negative impact on housing prices (Andersson et al. 2010). In effect, the regional housing market is interrelated based on inter-city connections, which are even more evident for integrated regions (Zhang and Fan 2018, Holly et al. 2011). To date, empirical work has mainly assessed associations between housing prices and regional integration in megacities such as the London metropolitan area and the Pan-Pearl River Delta. Results showed either a convergence or a diffusion of regional housing prices (Abbott and Vita 2012; Gong et al. 2015). The change in house prices in major cities—for example, Beijing, Shanghai, and Hangzhou—has been explored, and the findings indicate that housing prices are frequently affected by urban factors as well as the spatial urban structure (Qin and Han 2013; Huang et al. 2017; Wen and Tao 2015). For contiguous cities, the spillover effects of the core city decay with distance, and thus housing prices in the border area are more affected and become the hotspots of housing price increases (Gong et al. 2016). However, limited attention has been paid to contiguous cities compared to core cities.

Materials and Methods

Study Area

Kaifeng is a medium-sized city in the province of Henan, bordering the provincial capital of Zhengzhou to the west. Until 2016, Kaifeng comprised five districts covering a total area of 1,849 km^2 and accommodating a population of 1.67 million. Kaifeng's gross domestic product increased from 22,624 billion yuan in 2001 to 193,495 billion yuan in 2016 (+ 15.38%). This rapid economic growth was associated with the ZKI project, which was launched in 2005. The integrated regions are parts of the Central Plains Urban Agglomeration, where Henan provincial and two municipal governments positively engage with the policy agenda to pursue cooperation and joint development.

To identify the impact of the ZKI on housing prices, we examined the five administrative districts (Fig. 1) that were included in the first phrase of integration before 2014 (i.e., the districts of Longting, Shunhe, Gulou, Yuwangtai, and Jinming). Of these districts, Gulou and Longting are the most developed, whereas Shunhe and Yuwangtai are primarily comprised of urban villages and old houses. Jinming is positioned at the junction of Kaifeng and Zhengzhou and was a focus area of the ZKI project in 2005.

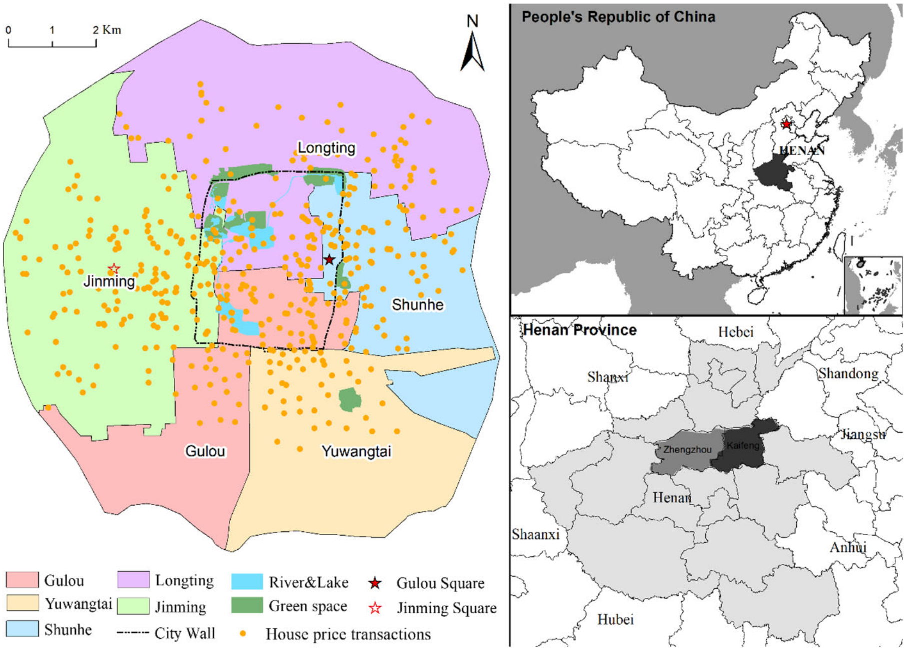

Fig. 1 Study area

Data

Housing Data

To establish the change in housing prices during the integration process and explore the dynamic effects of regional integration, we collected data from multiple sources. Data on annual average housing prices were obtained from the China Real East Statistical Yearbook and used to examine overall trends in housing prices in Zhengzhou and Kaifeng. Further, we obtained data on 1,556 new housing transactions from the Real Estate Transaction Management Center of Kaifeng. The data included housing price and physical properties (e.g., orientation and floor level). To represent the ZKI process, the housing transaction data covered four specific years—namely T_0 (2001), T_1 (2006), T_2 (2009), and T_3 (2016)—which represent the uninitiated, early, middle, and end of the ZKI project.

For each house, we derived structural, locational, neighborhood, and integration factors that are thought to be related to transaction prices (Rosen 1974; Helbich et al. 2014; Yuan et al. 2018). The variables are summarized in Table 1. Table 4 in the appendix presents the statistical description of all variables.

Zhengzhou and Kaifeng Integration Factors

Data representing integration factors were compiled by quantifying governmental measures gathered from government websites (e.g., https://www.henan.gov.cn/; https://www.kaifeng.gov.cn/). The data covered the Zhengzhou–Kaifeng Expressway, the Jinming new town district, the new Jinming Square CBD, and the Z&K Light Rail Station. The following four integration factors were considered.

First, from 2005 to 2016, the government issued several policies and measures to boost inter-urban cooperation and integration. The development of new towns has a crucial influence on housing prices (Yuan et al. 2018). The Jinming new town district was originally designed in 2005 as the key development area of the ZKI in Kaifeng, connecting Kaifeng with Zhengzhou. The building standards of housing and public facilities in Jinming are in line with those in Zhengzhou and higher than those in the old town in Kaifeng. We expected housing prices to be higher in Jinming than in other areas.

Second, with the improvement of the residential environment and the increase in employment opportunities in Jinming, a new urban center (Jinming Square) was gradually developed. Jinming Square's positive effect on the prices of nearby housing was expected to become increasingly significant. Moreover, cross-border transportation facilitates regional cooperation and adds a premium to housing prices along the transportation route (Andersson et al. 2010; Fujimura 2004).

Third, the Z&K Expressway, which links Zhengzhou with Kaifeng, was opened in 2006, formally marking the start of the ZKI era. The opening of the expressway reduced the commuting time from Zhengzhou to Kaifeng to approximately 1 h. Because the population density is low along the Z&K Expressway, and referencing expressways' effective scope of influence reported in a previous study (Levkovich et al. 2016), we used a dummy variable for houses located within 1 km of the Z&K Expressway, thus ensuring a sufficiently large number of houses.

Fourth, the opening at the end of 2014 of the Z&K Light Rail, which reduced the commuting time to a mere 17 min, marked the end of the next phase of the ZKI. Based on the earlier finding that rail stations influence urban housing prices within a radius of approximately 1.8 km (Shi and Guo 2009; Liu et al. 2015), and taking the local circumstances of Kaifeng into account, we employed a dummy variable to represent whether there was a light rail station within 2 km. This cross-border transportation infrastructure shortens the inter-urban spatiotemporal distance and supports population mobility, which we expected to influence housing prices.

Structural Housing Characteristics

Three of the physical properties of housing that play a vital role in housing prices—namely orientation, floor level, and floor area—served as structural variables. Besides the floor area of the apartment, residents generally favor a south-facing orientation, which provides better light conditions, and this may result in higher housing prices for units with this orientation (Jim and Chen 2006). Although apartments on higher floors have better natural lighting and airiness, their location might make coming and going inconvenient, so the effect of floor level on housing prices is somewhat difficult to predict (Sirmans et al. 2005).

Locational Characteristics

The accessibility of the CBD and the convenience of commuting contribute to increasing housing prices (McDonald and McMillen 1990), which is likely to be related to the actual distance to the CBD and a transit station. However, some residents are unwilling to live near transit stations because of traffic noise and emissions (Jim and Chen 2006). We included the straight-line distances from the apartment to Gulou Square and to the nearest bus station, as well as a dummy variable for the train station[2] (1 if the house is within 2 km, 0 otherwise), to represent locational advantage.

Neighborhood Characteristics

With improvements in the standard of living, people pay more attention to floor area ratio of buliding, educational quality, medical services, and nearby green landscapes, and these public amenities are capitalized into housing prices (Feng and Lu 2013; Wen et al. 2015). Farmers' markets and department stores fulfil people's basic daily needs. Neighborhood attributes were straight-line distances to the nearest park or scenic spot, first-class hospital, farmers' market, department store or supermarket, and first-tier kindergarten, primary school, and junior high school. The accessibility of these locations was expected to have a positive impact on housing prices.

Statistical Analyses

Baseline Hedonic Price Model

A baseline hedonic price model establishes a relationship between housing prices and a bundle of attributes by estimating the implicit prices of different attributes (Yu et al. 2007). To examine the effects of the ZKI on housing prices, we assessed hedonic price models in each of the four specific periods separately. To stabilize the variance while improving the goodness-of-fit, we applied the following logarithmic equation:

$$\begin{aligned} \ln p_{it} = \beta_{0t} + \beta_{1t} ZKEW_{it} + \beta_{2t} D\_JMS_{it} + \beta_{3t} NJM_{it} + \beta_{4t} ZKIR_{it} + \mathbf{k}_{it}\mathbf{X}_{it} + \varepsilon_{it} \\ (\mathrm{t} = \mathrm{T}_0, \mathrm{T}_1, \mathrm{T}_2, \mathrm{T}_3) \end{aligned} \tag{1}$$

where t is set as T_0, T_1, T_2, and T_3, respectively, and p_{it} refers to the housing prices of dwelling i in t year. ZKI factors include ZKEW, D_JMS, NJM, and ZKIR; X comprises the structural, neighborhood, and location control variables; β_0, β_1, β_2, β_3, and β_4 are the estimated coefficients, and K is the i *1 vector of the coefficients of control variables; ε is an error term.

Model with Interaction Terms

To overcome an endogenous bias and further distinguish the changes in the influence of integration factors on housing prices in different periods, we took T_1[3] (2006) as the baseline year and fitted a model with interactions between the quantitative variables of the ZKI and a time dummy variable (i.e., ZKEW * T_2 (ZK2), D_JMS * T_2 (ZM2), NJM*T_2 (ZY2), ZKEW * T_3 (ZK3), D_JMS * T_3 (ZM3), and NJM * T_3 (ZY3)). Three

[2] Note, the train stations refer to the old Kaifeng railway station and not to Kaifengbei railway station. The latter was put into operation at the end of 2016.

[3] The integration of Zhengzhou and Kaifeng began in 2005. Integration factors were observed from 2006.

models were constructed using the pooled cross-sectional data in the periods $T_1 + T_2$ (2), $T_2 + T_3$ (3), and $T1 + T_2 + T_3$ (4).

$$\ln p_i = \beta_0 + \beta_1 ZKEW + \beta_2 D\_JMSz + \beta_3 NJM + \delta_1 T_2 + z_1 ZKEW{*}T_2 + z_2 D\_JMS{*}T_2 + z_3 NJM * T_2 + \mathbf{k}_i \mathbf{X}_i + \varepsilon \tag{2}$$

$$\ln p_i = \beta_0 + \beta_1 ZKEW + \beta_2 D\_JMS + \beta_3 NJM + \beta_4 ZKIR + \delta_1 T_3 + z_1 ZKEW{*}T_3 + z_2 D\_JMS{*}T_3 + z_3 NJM * T_3 + \mathbf{k}_i \mathbf{X}_i + \varepsilon \tag{3}$$

$$\ln p_i = \beta_0 + \beta_1 ZKEW + \beta_2 D\_JMS + \beta_3 NJM + \beta_4 ZKIR + \delta_1 T_2 + \delta_2 T_3 + z_1 ZKEW * T_2 + z_2 D\_JMS * T_2 + z_3 NJM * T_2 + z_5 D\_JMS * T_3 + z_6 NJM * T_3 + z_7 ZKEW * T_3 + \mathbf{k}_i \mathbf{X}_i + \varepsilon \tag{4}$$

where p_i indexes the housing price, and T_2 and T_3 are the time dummy variables for 2009 and 2016, respectively.

Spatial Econometric Models

Spatial autocorrelation may be observed in the prices of nearby housing, but the traditional ordinary least squares (OLS) method neglects this fact, leading to biased results (Anselin 1988). To assess whether the OLS residuals are spatially correlated, the Moran's I statistics and the lagrange multiplier (LM) diagnostics for residual spatial dependence were assessed (see Table 2). In the case of significant residual spatial autocorrelation, two alternative model specifications were fitted, namely the spatial lag model (SLM) and the spatial error model (SEM) (Yu et al. 2007).

First, the SLM assumes that housing prices depend on nearby housing prices and hedonic features:

$$\ln p = \rho Mp + X\beta + \varepsilon \tag{5}$$

Second, the SEM is primarily applied when spatial autocorrelation exists among the residuals and is given as:

$$\ln p = X\beta + \mu;\ \mu = \rho M\mu + \varepsilon \tag{6}$$

For the above formulae, $p(n \times 1)$ is the dependent variable; $X(n \times k)$ represents the independent variables; $\beta(n \times 1)$ is the coefficient to be estimated; ε is an error-disturbance term; ρ and λ are the spatial autoregressive and residual spatial autoregressive coefficients, respectively; and M is the spatial weight matrix. To specify the weight matrix, we followed

Chi (2013) and used k-nearest neighbor weight matrix. As sensitivity analysis, we estimated the models with different values for k ranging from 3 to 8.

Results and Discussion

Changing housing prices in the context of Zheng & Kai Integration

Figure 2 provides an overview of housing sales in Kaifeng from 2001 to 2016. The total sales area increased by 15.5 times between 2001 and 2016, namely from 0.3 million to 4.65 million square meters. The total sales price increased by 66.12 times in the same period, that is, from 3.31 billion to 218.87 billion yuan. After 2005, both total sales prices and total sales area continued to rise in Kaifeng, demonstrating that real estate investment and consumption were stimulated after the ZKI was implemented.

Figure 3 shows the annual change in the housing market from 2001 to 2016 in Kaifeng and Zhengzhou. In Kaifeng, the average price increased by 5.47 times between 2001 and 2016, namely from 889 yuan/square meter to 4,864 yuan/square meter. The annual growth rate showed significant short-term fluctuations, and the floating range decreased after 2009, with an average growth rate of 13.12% from 2001 to 2016. Compared with Zhengzhou, the housing market in Kaifeng indeed lost momentum. The price gap between the two cities widened slightly over time. This is consistent with findings based on the Yangtze River Delta, where the gap in housing prices across cities also widened during the integration process (Song and Liu 2018) and the gap in annual growth rates narrowed. Surprisingly, after 2009, the development focus in Zhengzhou shifted to the new Zhengdong District, inter-urban cooperation strengthened, and the trends in growth rate continued consistently.

Before the ZKI was proposed, the two cities developed independently. The average housing price and the average growth rate were significantly higher in Zhengzhou than in Kaifeng. After the ZKI, there was rapid growth in housing prices in Kaifeng, with the average housing price increasing more rapidly in Kaifeng than in Zhengzhou, especially in 2005. Government measures, including the Z&K Expressway and the approval of the Z&K Industrial Belt, gave rise to population mobility and industrial development across the two cities. After 2007, the growth rate declined because of a lack of substantive progress. Regional infrastructure—including finance and telecoms—realized the planned integration, the construction of the industrial belt began, and the ZKI was upgraded to a national strategy. Housing prices saw further growth from 2009 to 2013. Although tight government housing policies, such as purchase restrictions and property taxes, prevented housing prices from soaring in 2014, the development of new amenities, such as the Z&K Light Rail and an inter-urban dedicated logistics channel, provided another boost in housing prices.

Dynamic Impact of Zheng & Kai Integration on Housing Prices

Tables 2 and 3 summarize the results obtained from the hedonic models. The variance inflation factors for all variables were below the critical value of 3, indicating that multicollinearity was not an issue. The adjusted R^2 indicated moderate model fits. However, given that spatial dependence existed in 2006, 2009, and 2016 (Models 2–4),

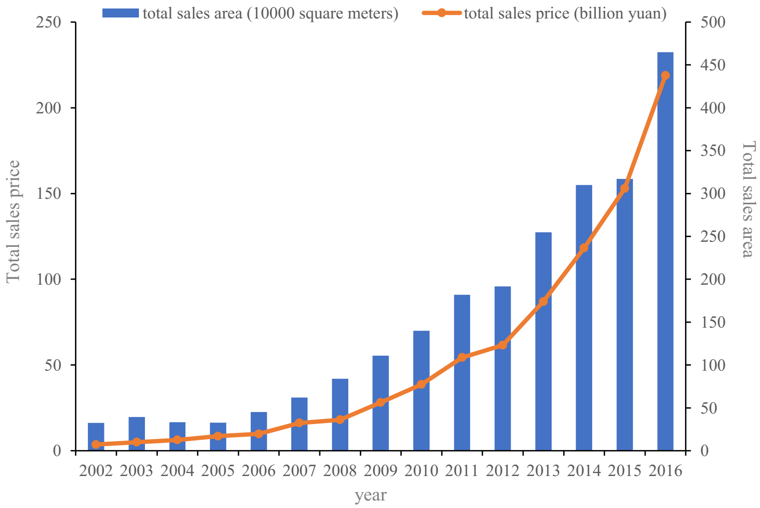

Fig. 2 Total sales areas and housing prices in Kaifeng, 2001–16

as confirmed by significant Moran's I statistics (all $p < 0.01$), we fitted SEMs and SLMs to account for spatial autocorrelation. The significance levels of the lag coefficients ρ and λ for Models 2–7 were below 0.01, indicating the existence of spatial dependence. The log likelihood values for SLM and SEM were larger than those for the basic OLS, whereas the Akaike information criterion (AIC) and the Schwarz criterion (SC) values for the spatial models were considerably lower, indicating a better model fit than the OLS models. The three fit measures (LIK, AIC, and SC) consistently showed that the SEM performed better than the SLM. Hence, the results of the SEM are further discussed.

According to hedonic price theory, housing attributes play an important role in determining housing prices (Table 2). First, regarding structural attributes, floor level and floor area were, as expected, significantly and positively associated with housing prices, and a southern orientation enhanced the comparative advantage of the housing

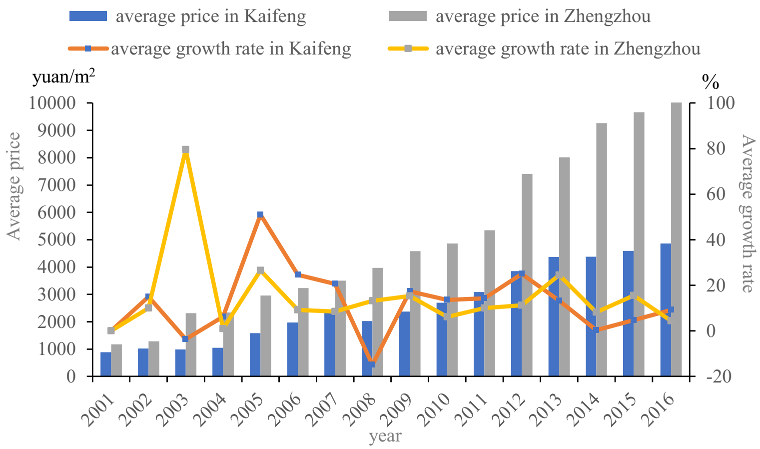

Fig. 3 Average housing prices and average growth rates in Zhengzhou and Kaifeng,2001–16

Table 1 Summary of residential characteristics and expected signs of the associations

Variables type	Abbreviation	Variable definition	Expected sign
Dependent variable	HP	The average apartment price (yuan/m^2)	
Zhengzhou and Kaifeng integration factors	NJM	1 if the apartment is located in new town Jinming district, 0 otherwise	+
	D_JMS	Distance from the apartment to the new CBD (Jinming Square) (in m, log-transformed)	-
	ZKEW	1 if the apartment is located within 1 km of Zhengzhou–Kaifeng Expressway, 0 otherwise	+
	ZKIR	1 if the apartment is located within 2 km of Zhengzhou and Kaifeng Light Rail station, 0 otherwise	+
Structural characteristic	OR	1 if the apartment has a south-facing orientation, 0 otherwise	+
	FL	Floor on which the apartment is located	±
	FL_AR	The total floor area of the apartment (in m^2, log-transformed)	+
Location characteristic	D_GLS	Distance from the apartment to the old CBD (Gulou Square) (in m, log-transformed)	+
	D_BS	Distance from the apartment to the nearest bus station (in m, log-transformed)	+
	TS	1 if the apartment is located within 2 km of the train station, 0 otherwise	±
Neighborhood characteristic	D_PSS	Distance from the apartment to the nearest park or scenic spot (in m, log-transformed)	-
	FAR	The ratio of the building's floor area to the gross lot area (log-transformed)	-
	D_HOSP	Distance from the apartment to the nearest hospital (in m, log-transformed)	-
	D_FM	Distance from the apartment to the nearest farmer's market (in m, log-transformed)	-
	D_DS	Distance from the apartment to the nearest department store and supermarket (in m, log-transformed)	-
	D_KG	Distance from the apartment to the nearest kindergarten (in m, log-transformed)	-
	D_PS	Distance from the apartment to the nearest primary school (in m, log-transformed)	-
	D_JHS	Distance from the apartment to the nearest junior high school (in m, log-transformed)	-

unit. A significant decrease in the coefficient for floor area ratio indicates the importance of the communal environment for residents (Yuan et al. 2018). Moreover, with respect to locational attributes, the coefficient of Distance to the old Gulou CBD changed from negative to positive between 2009 and 2016, reflecting a decline in the importance of Gulou Square. This result is possibly related to planning practices in Kaifeng; that is, most of the streets surrounding Gulou Square are under preservation orders—which means that both building renovation and population density are limited—and the area has been designated by the local government as a critical tourist

Table 2 Regression results for housing prices in each period

Model	M1 (2001)	M2 (2006)			M3 (2009)			M4 (2016)		
Method	OLS	OLS	SLM	SEM	OLS	SLM	SEM	OLS	SLM	SEM
Constant	7.345***	4.376***	7.40***	4.84***	6.893***	5.628***	6.877***	7.355***	5.641***	7.357***
ZKEW	#	0.092**	0.089***	0.091**	0.141**	0.147***	0.152**	0.04***	0.036**	0.038*
D_JMS	#	0.073	0.025*	0.017*	-0.138***	-0.138***	-0.138***	-0.030**	-0.027**	-0.030**
NJM	#	0.159***	0.155***	0.149***	0.079*	0.080*	0.078*	0.044**	0.043**	0.044***
ZKIR	#	#	#	#	#	#	#	0.028*	0.031*	0.030*
OR	0.293***	0.306**	0.309**	0.309**	0.402***	0.421***	0.420***	0.293***	0.286***	0.291***
FL	-0.074***	-0.051***	-0.051***	-0.051***	0.141***	0.141***	0.139***	0.012***	0.012***	0.011***
FL_AR	0.100***	0.336***	0.334***	0.348***	0.259***	0.256***	0.259***	0.111***	0.110***	0.111***
PR	-0.056*	-0.188***	-0.188***	-0.185***	-0.044***	-0.043***	-0.042**	-0.118***	-0.116***	-.117***
D_GLS	-0.166**	-0.0701**	-0.074***	-0.057***	-0.002	-0.008	-0.004	0.152***	0.124***	0.149**
D_BS	-0.018*	-0.018	-0.016	-0.030	0.037	0.038	0.039	-0.020**	-0.020***	-.021***
TS	-0.033	0.032	-0.042	-0.029	-0.052	-0.048	-0.051	-0.038	-0.035	-0.035
D_PSS	0.109**	-0.051**	-0.054***	-0.072***	-0.094***	-0.091***	-0.091**	-0.028***	-0.026*	-0.026*
D_HOSP	0.035	-0.053**	-0.054**	-0.048**	-0.047	-0.046*	-0.047*	-0.061***	-0.063***	-.062***
D_FM	-0.155***	0.079***	0.083***	0.102***	0.034**	0.033	0.034	0.047	0.046**	0.046**
D_DS	-0.016	-0.036*	-0.035*	-0.047***	0.044***	0.047	0.045	-0.037**	-0.054*	-.036**
D_KG	0.099*	0.000	0.005	0.007	-0.097*	-0.095***	-0.094***	-0.011*	-0.011*	-0.011*
D_PS	-0.116*	0.0356	0.036	0.005	0.122**	0.118**	0.124***	0.019	0.018	0.020
D_JHS	0.03	0.025	0.035	0.067**	-0.016	-0.014	-0.014	0.004	0.003	0.005
ρ	-	-	0.137***	-	-	0.382***	-	-	0.224**	-
λ	-	-	-	0.116***	-	-	0.218***	-	-	0.124**
Adjusted R^2	0.276	0.570	-	-	0.441	-	-	0.545	-	-

Table 2 (continued)

Model	M1 (2001)	M2 (2006)			M3 (2009)			M4 (2016)		
Method	OLS	OLS	SLM	SEM	OLS	SLM	SEM	OLS	SLM	SEM
Log likelihood	-128.93	36.213	36.294	37.74	-185.112	-183.962	-184.230	161.368	163.385	161.55
AIC-score	287.87	-36.426	-34.588	-41.705	406.224	405.924	404.462	-284.736	-286.771	-285.107
SC-score	340.08	35.996	31.857	30.716	478.338	472.045	476.576	-204.811	-202.639	-205.182
Moran's I	0.094	0.037**	-	-	0.018***	-	-	0.118***	-	-
N	240	413	413	413	406	406	406	497	497	497

Signif. codes: '***' 0.001; '**' 0.01; '*' 0.05

Table 3 Dynamic influence of regional integration on housing prices

Model	M5 (2006 + 2009)			M6 (2009 + 2016)			M7 (2006 + 2009 + 2016)		
Method	OLS	SLM	SEM	OLS	SLM	SEM	OLS	SLM	SEM
Constant	6.969***	5.133***	6.969***	7.566**	7.962***	7.635***	5.336**	5.420***	5.494***
T_2 (2009)	0.257**	0.298**	0.202**	#	#	#	0.232***	0.230***	0.214***
T_3 (2016)	#	#	#	0.088***	0.095***	0.096***	0.064***	0.064***	0.066***
ZK2	0.117***	0.072***	0.041**	#	#	#	0.116**	0.116**	0.106**
ZM2	-0.051***	-0.071***	-0.069***	#	#	#	-0.026***	-0.026***	-0.029***
ZY2	0.009***	0.005***	0.016***	#	#	#	0.008***	0.007***	0.012***
ZK3	#	#	#	-0.136	-0.136**	-0.138**	-0.061*	-0.061**	-0.066**
ZM3	#	#	#	-0.101***	-0.101***	-0.107***	-0.092*	-0.091***	-0.092***
ZY3	#	#	#	0.086*	0.080*	0.081*	-0.069**	-0.069**	-0.075**
ZKEW	0.134**	0.132**	0.131***	0.211***	0.212***	0.019***	0.122***	0.122**	0.112**
D_JMS	-0.168***	-0.148***	-0.180***	-0.174***	-0.174***	-0.178***	-0.029**	-0.029**	-0.030**
NJM	0.185***	0.179***	0.011***	0.016	0.017	0.023	0.134***	0.134***	0.136***
ZKIR	#	#	#	0.015***	0.018*	0.014*	0.019*	0.019*	0.021***
OR	0.329***	0.323***	0.323***	0.410**	0.412***	0.405**	0.332***	0.332***	0.335***
FL	0.040***	0.039***	0.039***	0.039***	0.039***	0.038***	0.014***	0.014***	0.014***
FL_AR	0.341***	0.329***	0.327***	0.195***	0.196***	0.190***	0.257***	0.257***	0.255***
PR	-0.134***	-0.133***	-0.140***	-0.103***	-0.104***	-0.101***	-0.136***	-0.136***	-0.136***
D_GLS	-0.013	-0.016	-0.019	0.021	0.037	0.021	0.030	0.021	0.013
D_BS	-0.016*	-0.004	-0.003*	0.002***	-0.003	0.002	-0.013*	-0.014*	-0.009**
TS	-0.055	-0.058*	-0.066*	-0.053*	-0.056*	-0.052*	-0.054**	-0.055**	-0.054**
D_PSS	-0.072***	-0.074***	-0.095**	-0.050***	-0.050***	-0.059***	-0.048***	-0.048***	-0.060***
D_HOSP	-0.092***	-0.078***	-0.033*	-0.039**	-0.037*	-0.039*	-0.050***	-0.086***	-0.044**
D_FM	0.047**	0.043*	0.060*	0.020	0.021	0.024	0.041**	-0.05***	0.044**
D_DS	-0.047***	0.038*	0.017	0.008	0.007	-0.000	0.005	0.005	-0.003
D_KG	-0.042***	-0.029***	-0.030***	-0.052***	-0.051***	-0.051***	-0.030**	-0.031***	-0.028**
D_PS	0.120***	0.101***	0.108	0.088***	0.093*	0.089***	0.077***	0.079**	0.082***
D_JHS	-0.042	-0.047*	-0.033*	0.015	0.018	0.026	0.002	0.002	0.007
ρ	-	0.240***	-	-	0.071***	-	-	0.014***	-
λ	-	-	0.453***	-	-	0.273***	-	-	0.361***
Adjusted R^2	0.366	-	-	0.724	-	-	0.785	-	-
LL	-323.523	-319.217	-318.764	-262.142	-261.77	-260.469	-324.394	-324.363	-322.55
AIC	691.047	684.433	681.528	570.285	569.539	566.939	702.789	701.726	699.111
SC	794.625	792.719	785.106	680.791	678.85	677.445	842.692	841.811	839.014
N	819	819	819	903	903	903	1316	1316	1316

Signif. codes: '***' 0.001; '**' 0.01; '*' 0.05

center. In addition, as a result of the urban center being transposed from Gulou to Jinming in Kaifeng and the increasing employment opportunities and convenient services, housing prices increased in Jinming (Wen and Tao 2015). No significant effect was found for Distance to train station. The significant negative coefficient of Distance to bus station in 2001 was in line with expectations; the insignificant positive coefficients of Distance to bus station in 2006 and 2009 may be linked to the increase in the number of private cars. In 2016, urban environment renovation and restrictions on private cars promoted a reconsideration of the demand for public transportation (Xu et al. 2015). In line with earlier studies (Li et al. 2016; Yuan et al. 2018), we found that neighborhood attributes, such as parks and scenic areas, hospitals, department stores, and supermarkets, were significantly positively associated with housing prices. Reflecting parents' increasing concern about their children's education, the capitalization effect of kindergartens in Kaifeng was more significant and positive compared to the effects of primary and junior high schools. The effect of farmers' markets on nearby housing prices became negative, possibly because the construction of community vegetable markets replaced the demand for farmers' markets.

Table 2 shows that the integration measures had different impacts on housing prices in each period of the integration project (2006, 2009, and 2016). The SEM results show significantly positive coefficients of Near Z&K Expressway, indicating that the Z&K Expressway was positively associated with housing prices across the integration periods. Similar to Fujimura's (2004) findings, cross-border transportation played an increasingly important role in residents' lives and in regional cooperation. The Z&K Expressway facilitated convenient transportation between Zhengzhou and Kaifeng. The decreasing positive coefficient of Distance to the new Jinming Square CBD from 2006 to 2016 indicates that the effect of Jinming faded with urban development. Jinming was the future growth pole of Kaifeng in the early period of the ZKI, and Jinming's development potential attracted large numbers of investment-oriented purchasers from Zhengzhou, in addition to local homebuyers. However, as the integration advanced, Jinming became the main activity area in Kaifeng, with high population density, and its sufficient housing supply may have reduced the attraction of the new town. The decreasing coefficient of Distance to the new Jinming Square CBD implies that homebuyers increasingly preferred to live near Jinming Square and enjoy more convenient services. This conclusion is supported by the spatial distribution of high prices in 2009 and 2016. Until 2016, the significant positive coefficient of Near Z&K Light Rail indicates that the Z&K Light Rail contributed to increases in housing prices, which supports the conclusion that there is a positive relationship between light rail and housing prices (Lin et al. 2018). Overall, the ZKI had a significant and positive effect on housing prices in Kaifeng.

Further, we estimated the changes in the effects of the integration factors on housing prices using one specific model. Table 3 shows the regression results of Models 5–7, with time variables (T_2 and T_3) included to control for the time effect on housing prices. We used the interaction terms between the quantitative planning variables and the time dummy variables to examine whether each phased effect of the ZKI was significantly different. Given that the Z&K Light Rail was opened at the end of 2014, its impact on housing prices could only be examined in the later period (T_3), so we excluded interactions with ZKIR. The OLS, SLM, and SEM models were applied in the specific regression analysis. The SEM was found to have the best model fit.

In Model 5, the coefficient of T_2 was 0.257, meaning that the overall housing price was 22.38% higher (exp (0.257) – 1) (Halvorsen and Palmquist 1980) in T_2 than in T_1. In Model 6, the coefficient of T_3 was 0.096, meaning that the overall housing price increased by 5.02% between T_2 and T_3. Similar results are shown in Model 7, indicating that housing prices in Kaifeng had an increasing trend during the integration process, despite the decline in growth rate.

Model 7 is a nested extension of Models 5 and 6 with three complete periods of the ZKI using the full sample of housing prices. We selected this model to examine the changes in the effect of the ZKI on housing prices. At T_1 (2006), the coefficients of the integration factors Near Z&K Expressway, Distance to the new Jinming Square CBD, and Located in Jinming new town district were 0.112, -0.030, and 0.136, respectively, and all were significant below the 0.1 level. At T_2 (2009), the corresponding coefficients changed to 0.218 (0.112 + 0.106), -0.059 (-0.03 − 0.029), and 0.148 (0.136 + 0.012). These results show that the implemented integration measures—especially the increased efficiency of the Z&K Expressway—had a growing positive influence on housing prices in Kaifeng. At T_3 (2016), the coefficients of Near Z&K Expressway and Distance to the new Jinming Square CBD were 0.046 and 0.061, respectively, representing increases from T_2 but decreases from T_1. The coefficient of Distance to the new Jinming Square CBD decreased to -0.122 at T_3, indicating that the impact of Distance to the new Jinming Square CBD on housing prices increased. The coefficient of Near Z&K Light Rail was 0.021, which was significant at $p < 0.01$, showing a positive and significant effect of the Z&K Light Rail on housing prices.

Throughout the process, the Z&K Expressway, Jinming Square, and Jinming new town positively influenced housing prices, and the premium effect of Jinming Square increased with the expansion of Jinming. However, the effects of the Z&K Expressway and Jinming new town declined somewhat from 2009 to 2016. A significant positive effect was also found for the Z&K Light Rail, probably because people prefer to purchase housing near the Z&K Light Rail, which reduces intercity commuting time to 17 min, rather than near the Z&K Expressway. The interactions between the three quantitative planning variables and T_2 (ZK2: 0.106, ZM2: -0.029, ZY2: 0.012) were all larger than the corresponding interactions with T_3 (ZK3: -0.066, ZM3: -0.092, ZY3: -0.075), indicating that the capitalization effects of the Z&K Expressway and Jinming new town declined, whereas the positive effect of Jinming Square grew as the integration advanced. These results show that the ZKI accelerated the construction of Jinming new town, and that Jinming Square replaced Gulou Square as the new urban center. Homebuyers thus prefer to live near the new CBD rather than elsewhere in Jinming. Cross-border transportation including the Z&K Expressway and the Z&K Light Rail also played a critical role in the changing housing prices and urban development during the ZKI process. Overall, the ZKI facilitated urban development, improved urban amenities, and influenced urban housing prices.

Conclusions

The present study investigated the effect of regional integration on the dynamics and determinants of housing prices in Kaifeng city (China) between 2001 and 2016. The housing market in Kaifeng has undergone restructuring in the context of the Zheng & Kai Integration (ZKI) project. Since the integration was implemented, the real estate market has boomed in Kaifeng, and the difference between Zhengzhou and Kaifeng in annual growth rate has declined. Our results suggest that residents of the core city increasingly prefer to purchase properties in contiguous cities, due to the unaffordable price of housing in Zhengzhou and reduced cross-border commuting costs (Lin et al. 2018). In addition, contrary to the belief that within metropolitan areas, core cities have a negative effect on their neighboring small and medium-sized cities (Wang 2015), Kaifeng benefited from the integration with the core city Zhengzhou. As expected, housing prices in Kaifeng showed newly emerging hotspots in border areas, deviating from the conventional core–periphery model of a single city. The regional integration resulted in new growth poles within the border area of Kaifeng.

Moreover, the regression results confirm earlier findings regarding the Guangzhou metropolitan area (He 2017), namely that housing prices were influenced by regional integration factors, and especially cross-border transportation. We found that the total capitalization impact of cross-border transportation is gradually decomposed into various modes of outbound traffic with the improvement of the transportation system. The positive influence of the Z&K Expressway on housing prices declined slightly, while that of the Z&K Light Rail increased dramatically. Thus, in line with the study by Lin et al. (2018) on the Shenzhen–Dongguan–Huizhou metropolitan area, the time-saving capacity of cross-border traffic is particularly attractive for residents in integrated regions.

Meanwhile, urban development driven by the integration (e.g., the building of a new district) was another critical determinant of housing prices. The construction of residential districts, industrial districts, and commercial areas in Jinming promoted the formation of the new urban center of Jinming Square, which echoes the notion of "zone fever" and "project fever" in urban China (Wei 2015). The local government formulates urban planning strategies concerning the ZKI; for instance, it focuses on westward development, pushing the development of the new Jinming district, and connecting new urban centers with Zhengzhou. Thus, the coordination of multilevel governments plays an important role in driving regional cooperation and local urban development (Luo and Shen 2009).

As evidenced by our findings, cross-border traffic is an important channel of interregional interaction. Improving the intercity transportation system for integrated regions, reduces commuting time, supports the flow of capital, labor, and information, and strengthens regional cooperation. In addition, building a new urban district in a small to medium-sized city relieves pressure on inner-urban housing prices. In the long run, due to the important role of small to medium-sized cities, infrastructure upgrades will be necessary to counteract spatially uneven housing prices.

Our study contributes to a better understanding of the evolution of housing prices in the context of regional integration, exemplifies the quantification of integration and the selection of methods, and provides a research perspective for evaluating the effectiveness of regional integration policies. However, our study had some limitations. First, the regression analysis considered only a limited number of housing characteristics and integration factors. Future studies should include additional socioeconomic and more policy-related factors as control variables. Second, the study covered four periods of the ZKI cross-sectionally. A longitudinal study design covering the entire integration period from 2001 to 2016 would enable a more precise analysis of house price dynamics.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Appendix

Table 4 Descriptive statistics

	Minimum	Maximum	Mean	S.D
T_0 ($N=240$)				
Housing price	101.69	1760	776.094	343.917
ZKEW	#	#	#	#
D_JMS	#	#	#	#
NJM	#	#	#	#
ZKIR	#	#	#	#
OR	0	1	0.2	0.401
FL	1	7	3.53	1.80
FL_AR	3.109	6.684	4.541	0.447
FAR	-2.303	2.826	0.597	1.012
D_GLS	5.428	8.677	7.721	0.647
D_BS	3.683	8.261	7.035	0.975
TS	0	1	0.225	0.418
D_PSS	4.073	8.359	6.793	0.986
D_HOSP	3.775	8.204	6.601	0.705
D_FM	4.874	9.943	7.034	0.680
D_DS	3.294	7.521	6.300	0.777
D_KG	3.516	7.060	5.748	0.667
D_PS	3.543	7.132	6.240	0.548
D_JHS	3.588	7.467	6.282	0.673
T_1 ($N=413$)				
Housing price	289.15	2669.29	1422.081	375.788
ZKEW	0	1	0.082	0.275
D_JMS	6.282	8.979	8.104	0.547
NJM	0	1	0.354	0.479
ZKIR	#	#	#	#
OR	0	1	0.007	0.085
FL	1	7	3.259	1.590
FL_AR	3.651	5.428	4.642	0.241
FAR	-0.967	2.333	1.893	0.896
D_GLS	5.509	8.985	7.764	0.679
D_BS	3.574	7.841	6.678	0.864

Table 4 (continued)

	Minimum	Maximum	Mean	S.D
TS	0	1	0.138	0.345
D_PSS	3.095	8.506	6.855	1.095
D_HOSP	4.771	8.317	6.844	0.684
D_FM	2.255	8.067	7.101	0.633
D_DS	2.939	7.704	6.460	0.832
D_KG	2.877	7.140	5.810	0.708
D_PS	4.698	7.901	6.464	0.480
D_JHS	4.014	7.831	6.492	0.604
T_2 ($N = 406$)				
Housing price	300	3773.9	1981.625	794.743
ZKEW	0	1	0.098	0.298
D_JMS	5.230	9.8	7.993	0.700
NJM	0	1	0.350	0.477
ZKIR	#	#	#	#
OR	0	1	0.020	0.139
FL	1	7	3.241	1.589
FL_AR	3.457	6.221	4.704	0.278
FAR	-0.968	3.268	1.287	0.819
D_GLS	5.255	8.788	7.837	0.638
D_BS	2.949	7.860	6.539	0.898
TS	0	1	0.241	0.428
D_PSS	3.094	8.771	7.005	1.031
D_HOSP	3.972	8.370	6.718	0.848
D_FM	2.255	8.061	7.126	0.628
D_DS	3.272	7.685	6.523	0.818
D_KG	2.121	7.140	5.747	0.648
D_PS	3.768	7.820	6.383	0.566
D_JHS	3.774	7.801	6.395	0.770
T_3 ($N = 497$)				
Housing price	2187.5	12,000	4854.879	1256.693
ZKEW	0	1	0.237	0.426
D_JMS	5.252	8.960	7.510	0.748
NJM	0	1	0.368	0.482
ZKIR	0	1	0.368	0.482
OR	0	1	0.074	0.263
FL	1	26	3.229	2.118
FL_AR	3.651	5.953	4.634	0.266
FAR	-0.968	2.333	1.710	0.934
D_GLS	6.404	10.506	8.339	0.488
D_BS	3.004	8.152	6.189	1.065
TS	0	1	0.070	0.256
D_PSS	-2.198	8.985	7.605	1.023

Table 4 (continued)

	Minimum	Maximum	Mean	S.D
D_HOSP	4.173	8.918	7.432	0.896
D_FM	3.617	8.733	7.432	0.716
D_DS	3.689	8.474	7.017	0.792
D_KG	-2.924	8.222	6.278	0.962
D_PS	3.785	8.404	6.922	0.773
D_JHS	3.953	8.505	7.019	0.885

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