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Land and residential property markets in a booming economy: New evidence from Beijing

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Abstract

Beijing's housing market has boomed over the last fifteen years. The city's population grew by 40.6% and per capita income (in constant RMB) by 273.9% from 1991 to 2005. Using two geocoded data sets, we present new evidence on the real estate price gradient, land price gradient, population densities, and building densities in Beijing's recent free housing market. The classic urban monocentric model's predictions are largely upheld in Beijing. We also document the importance of local public goods, such as access to public transit infrastructure, core high schools, clean air, and major universities, most of which have exogenous locations, as important determinants of real estate prices.

JEL classification: R14; R31

Keywords: Housing market; Land market; Local public goods; Quality of life

1. Introduction

Beijing's housing market has boomed over the last fifteen years. Between 1991 and 2005, the city's population grew by 40.6% to 14 million, and annual disposable income per capita (in constant RMB) grew by 273.9% to RMB 17.7 thousand ($2,200 in US dollars).[1] To meet growing housing demand in Beijing, real estate developers have purchased the right to build on numerous land parcels from the government, first through negotiation and later through competitive auctions. In 2005, the quantity of newly completed residential construction reached 28.4 million square meters, accounting for 13.1% of the existing housing stock.

The explosive growth of new construction is remaking the face of the city. Active urban development started when China reinstated urban land and real estate markets in the late 1980s. Before that, the urban area in Beijing and other Chinese cities was typically very compact, featuring a mixed pattern of residential and non-residential land uses. Urban land was allocated to work units through a central planning system. Housing units were built near the workplace and assigned by work units to their employees, who paid very low, subsidized rent. After the reforms of the land and housing markets, vast amounts of developable land have been supplied and regulated by the government through long-term leases. At the same time, most of the work-unit

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[1] National Statistic Bureau of China (1991–2005).

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housing has been privatized. Old homes in Beijing's central urban area have been demolished to make way for new transport infrastructure, commercial developments, and high-end housing projects. Over time, the Central Business District (CBD) has greatly expanded. Massive investment in urban transport infrastructure has increased suburban residential land use and has contributed to pushing industrial activity toward outlying urban locations. New mass housing projects have been built around the fast expanding urban fringes. These new residential buildings, similar to condominiums in the United States, are built by real estate developers and sold to residents.

This paper employs two unique data sets to test the classic urban monocentric model in a rare setting where explosive new development is remaking the face of a city. The first data set, which we refer to as the "land parcel data set," includes information on all land parcels that were leased to developers by the Beijing Land Authority through open auction from 2004 until July 2006. This data set contains information on each land parcel's total price, location, size, and permitted floor-to-area ratio. The second data set, which we refer to as the "housing project data set," is a transaction database covering all new housing projects sold in Beijing in 2004 and 2005 that were built and sold by real estate developers. This geocoded data set is drawn from Beijing's Housing Transaction Registration System, which keeps the records of all new housing transaction contracts.

We use these data to provide new estimates of Beijing's land and home price hedonic gradients as a function of distance to the Central Business District. In addition, we examine how the floor-to-area ratio (FAR) and population density vary as a function of distance to CBD. We find that the monocentric model's predictions are largely upheld in Beijing.

Beijing is not a featureless plane. Communities differ with respect to access to the CBD, air quality, park access, crime, local school quality, and access to public transportation. Building on the US quality-of-life literature (see the survey by Gyourko et al., 1999), we use the housing transaction database and employ hedonic techniques to measure the capitalization of local public goods. Recent home buyers reveal their marginal willingness to pay for local public goods through their location on the hedonic price surface (Bajari and Benkard, 2005; Bajari and Kahn, 2005). We find that public goods are significantly capitalized into housing prices, indicating that Beijing residents value local quality of life. Although we find small capitalization effects for crime, we estimate larger effects for clean air and proximity to universities.

2. A brief introduction to Beijing's urban form and our data sets

2.1. A portrait of Beijing's urban form

Figure 1 shows the Beijing Metropolitan Area and also displays the spatial distribution of all 920 new housing projects in our data set. Beijing is spreading out in every direction. TianAnMen Square and the surrounding traditional hub of commercial, cultural, and administrative activities can be regarded as the city center. Another area, east and close to TianAnMen Square, called "*JianGuoMenWai*," is the so-called CBD, with a cluster of high-rise office buildings and many international companies' headquarters. Throughout this paper we define TianAnMen Square (TAM) to be the City Center. The current four ring roads circling TianAnMen were built successively from inside to outside. They are an important part of Beijing's transportation system.

Unlike many cities in the United States, where employment has been suburbanizing (see Glaeser and Kahn, 2001), Beijing is still quite monocentric, and its CBD continues to contain a large share of the metropolitan area's total employment, largely because of the centrality of various urban amenities, and also because of the concentration of government activities in Beijing, the capital of China. Over 70% of the metropolitan area's total jobs and 65.2% of the total metropolitan area's population are concentrated within 10 kilometers of TAM.[2] To calculate the population density gradient for the Beijing Metropolitan Area, we use data from Beijing's 2000 Census. This census provides information on population, land area, and distance to the City Center for 92 Beijing communities.[3] The average density is 18,088 persons per square kilometer (73 persons per acre). For the 92 communities, we run a conventional equation to estimate the population density gradient:

$$\underset{(89.07^{***})(-8.28^{***})}{\mathrm{Log}(POP_i) = 10.484 \quad - \quad 0.119^{*}DIST_i}, \qquad (1)$$

$$R^2 = 0.426$$

[2] In the year 2000, only 33% of New York City residents lived within ten kilometers of its Central Business District. This fact is generated for the set of census tracts that are within 25 miles of the CBD and are located in the New York City metropolitan area.

[3] Community ("*SheQu*") is the basic geographical unit in China's population census. Such "communities" are much larger than US census tracts. The average land area of a *SheQu* is 7 square kilometers (1730 acres), and its average population is 67,089. We measure the distance from the community's center to CBD as $DIST_i$ in Eq. (1).

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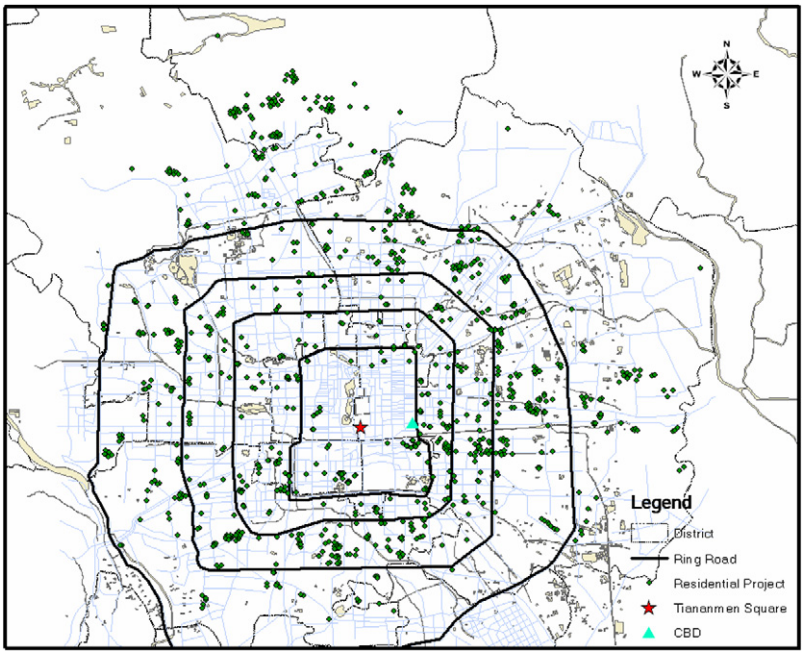

Fig. 1. The location of 920 new housing projects in Beijing.

where POP_i is the population density in community i expressed as the number of people per square kilometer, and $DIST_i$ is that community's distance to the City Center in kilometers. T-statistics are reported in parentheses. The population density gradient is −0.119 and is statistically significant. This means that a community's population density decreases by 12% for each kilometer of distance from the City Center. This gradient is more than twice as large in absolute value as the US year 2000 population gradient coefficient of −0.048 per kilometer of distance from the CBD.[4]

Within Beijing, high-income residents locate near the city center (Zheng et al., 2006a). This urban form seems more similar to European cities than to American cities, with the exception of a few older US cities such as Boston, New York City, and San Francisco (Brueckner et al., 1999; Glaeser et al., in press; Glaeser et al., 2001). The relative centralization of the high-income residents in Beijing is due to the concentration of high-paying jobs and cultural and consumer amenities near the CBD.

[4] This US estimate is based on year 2000 Census tract data; see Baum-Snow and Kahn (2005). The regression coefficient mentioned in the text is based on a census tract level regression that includes metropolitan area fixed effects.

2.2. Descriptive analysis of housing project data set

The 968 projects in our housing project data set are all the projects that were supplied on the new Beijing housing market between 2004 and 2005. Within each project, there are several residential buildings. Each building has many housing units, similar to a condominium building in the United States. The average project in our sample has 791 housing units. A common phenomenon in China's housing market, called "presale," is that developers start to sell the units before the buildings are completed, or even before construction is started. For developers, the presale is a critical financing tool. Although developers can borrow from commercial banks, the capital market remains underdeveloped. Therefore 88% of the projects in our sample are presale projects. Below, when we discuss the timing of sales, these dates refer to when a developer started to sell housing units in the projects on the market, rather than construction dates for housing projects.

We are confident that our data set, with its complete coverage of new housing towers, is representative of the housing units purchased by recent Beijing home buyers. The housing resale market is very thin. Previous public housing was privatized before 1998 and sold to incumbent tenants, who had been permanent employees in those state-owned enterprises, at very low subsidized prices. Therefore the owners of the privatized public housing units are always Beijing's original and

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elder residents, and their children. The owners of these housing units are not able to sell their units freely to other buyers because of flaws in the property rights law that limit buying and selling this type of housing stock (Bertaud et al., 2006). In addition, the immature brokerage industry also limits the development of the housing resale market. The transaction volume of resale housing units accounts for only 20% of the total housing transactions in 2005. Beijing workers who did not have access to an apartment from the previous public housing regime or did not inherit an apartment from their parents have few housing options other than purchasing a new housing unit in one of the projects in our data base.

We exclude projects that had entered the market before 2004 and also the economy-housing projects whose prices were set by government. After data cleaning, we have included 900 projects in our analysis.[5] Figure 1 shows that our 920 new housing projects are spatially distributed quite evenly across the whole urban area. Table 1 provides the descriptive statistics of this data set. The mean sale price is about RMB 7340 per square meter (USD 85.46 per square foot), with an average unit size of 130 square meters. An average housing project has 791 housing units and is 10.64 kilometers from TianAnMen square.

2.3. Descriptive analysis of land parcel data set

A necessary first step for building a new housing project is to acquire the use right of a land parcel from the Beijing Land Authority. All urban land is owned by the state in China. Starting in 1988, the Chinese government began to offer long-term leases of land parcels.[6] Any party who wants to acquire the land-use right in the pursuit of profit must pay a lease fee as a lump sum at the beginning of the lease period.

Before 2004, the conventional way to lease out land was through negotiation. After 2004, the Chinese Central Government required that all land leases must be privatized though an open auction process. This switch is mainly due to the concern that possible corruption during the negotiations might result in less revenue for the state. The "Land Reservation Center" (LRC), a department of the Beijing Land Authority, was established to implement land auctions. After acquiring land parcels from rural villages as well as original urban occupants, and removing the previous occupants, the LRC engages in such urban land improvements as providing basic road access and connecting the parcel to electricity and water. The LRC then puts the land parcels on the market for an open and competitive auction. The developer who bids the highest acquires the parcel, and local government receives the revenue.

In our land parcel data set, we have all the 145 open-auction land parcels from the start of this auction arrangement in 2004 until June 20, 2006. In Fig. 2, we graph their spatial distribution. These parcels are not limited to residential use. Table 2 presents descriptive statistics of the variables in the land data set. The average parcel size is 55,940 square meters (13.8 acres).

2.4. Descriptive analysis of local public goods

Given that a large fraction of Beijing workers, roughly 52%, commute to their CBD jobs using public transit, access to public transit is an important urban amenity.[7] In Fig. 3 we provide an overview of Beijing's transportation infrastructure. More than 30 major bus stops are displayed in the figure.[8] Each of these is an important transportation hub. Today, Beijing has four subway lines. Line 1 and Line 2 are old lines built in the 1970s in the central area, with 39 stops. Line 13 and Line Batong are quite new lines, built in the new suburban areas after the year 2000. Using GIS software, we have calculated the distance of each new housing project from these four subways and major bus stops.

We also examined several other local public goods, including access to core high schools,[9] proximity to major universities, safe streets, and environmental amenities. Almost all high schools had been established before the Economic Reform took place in the 1980s. There is no residential property tax in China. These schools have been continuously funded by the local government, whose education budget comes partly from the Central Government and partly from local general tax

[5] We exclude some outliers that may be due to recording errors, such as those projects whose average unit sizes are larger than 400 square meters or project sizes are bigger than 5000 housing units.

[6] The lease terms are 70 years for residential use, 40 years for commercial use, 50 years for industrial and institutional use, and 50 years for mixed use.

[7] A survey was conducted by Wenzhong Zhang at Institute of Geographical Sciences and Natural Resource Research, Chinese Academy of Science, in Beijing, during August and September 2005. The sample size is 4326 respondents. See details in Zheng et al. (2006b).

[8] Local community bus stops are not considered in this study.

[9] In Chinese cities, high schools are grouped into two categories: common high schools and core high schools. The list of core high schools was determined before the free market reforms and has not been changed since then. Roughly 15% of Beijing's high schools are core high schools. They receive more funding from local governments and are allowed to set more stringent entry requirements to recruit excellent students.

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Table 1
Descriptive statistics of housing project data set ($N = 900$)

Variable	Description	Mean (Std. dev.)
P_PRICE	The average price per sq. meter of floor area of the sold housing units in the project (RMB/sq. meter).	7343.57 (3324.09)
UNIT_SIZE	The average size of housing units in the project (sq. meters).	129.67 (58.03)
PRO_SIZE	The number of housing units in the project, indicating the size of the project.	791 (559)
SOE	Binary: project being developed by a state-owned real estate developer.	0.23 (0.42)
D_CENTER	The distance between TianAnMen Square and the project (kilometers).	10.64 (4.56)
D_SUBA	The distance from the project to the closest subway A (Line 1 and Line 2) stop (kilometers).	5.66 (4.04)
D_SUBB	The distance from the project to the closest subway B (Line 13 and Line Batong) stop (kilometers).	5.47 (4.01)
D_BUS	The distance from the project to the closest main bus stop (other than a subway stop) (kilometers).	3.45 (2.55)
D_PARK	The distance from the project to the closest park (kilometers).	2.79 (2.08)
D_SCHOOL	The distance from the project to the closest core high school (kilometers).	3.81 (2.47)
D_UNIV	The distance from the project to the closest major university (kilometers).	3.58 (2.06)
UNIV_SCORE	The entry score of the closest university in the 2005 National University Entrance Examination.	556.00 (25.86)
UNIV_3KM	Binary: project within 3-kilometer distance from a university.	0.439 (0.497)
CRIME	Binary: project in a high-crime-rate area.	0.26 (0.44)
AIRBAD	An indicator of air quality, noting the concentration of PM10 in air (see text for detailed explanation). ($\mu g/m^3$).	212.53 (17.61)
QD1	Binary: located in the first quadrant (Northeast). TianAnMen as the origin point.	0.31 (0.46)
QD2	Binary: located in the second quadrant (Northwest). TianAnMen as the origin point.	0.28 (0.45)
QD3	Binary: located in the third quadrant (Southwest). TianAnMen as the origin point.	0.23 (0.42)
QD4	Binary: located in the fourth quadrant (Southeast). TianAnMen as the origin point.	0.18 (0.39)
Y04Q1	Binary: project entering market in the first quarter in 2004.	0.10 (0.30)
Y04Q2	Binary: project entering market in the second quarter in 2004.	0.17 (0.37)
Y04Q3	Binary: project entering market in the third quarter in 2004.	0.17 (0.37)
Y04Q4	Binary: project entering market in the fourth quarter in 2004.	0.15 (0.35)
Y05Q1	Binary: project entering market in the first quarter in 2005.	0.07 (0.26)
Y05Q2	Binary: project entering market in the second quarter in 2005.	0.13 (0.33)
Y05Q3	Binary: project entering market in the third quarter in 2005.	0.14 (0.35)
Y05Q4	Binary: project entering market in the fourth quarter in 2005.	0.07 (0.26)

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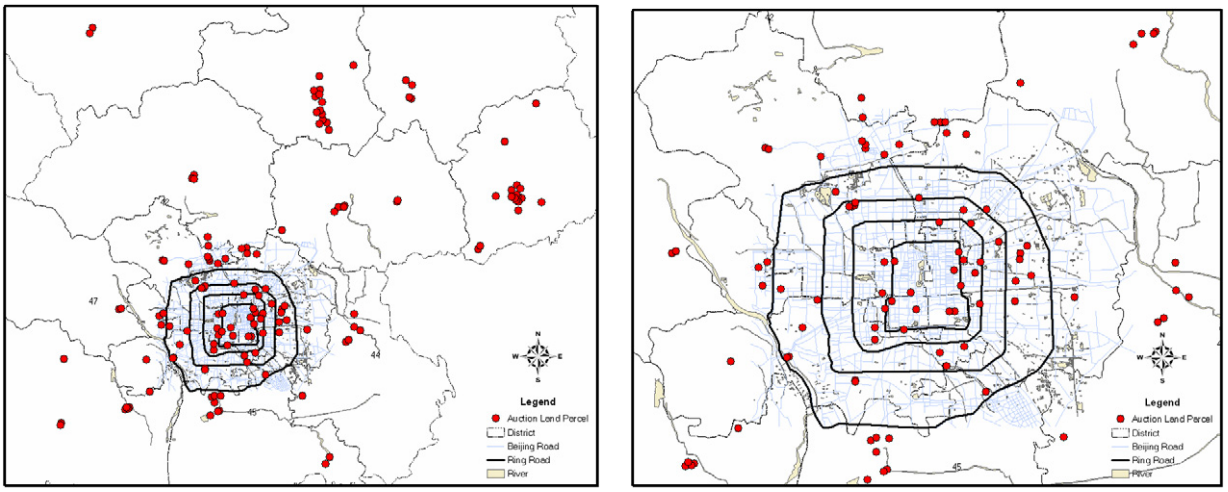

Fig. 2. Spatial distribution of land parcels in Beijing.

Table 2
Descriptive statistics of land parcel data set ($N = 145$)

Variable	Description	Mean (Std. dev.)	
		All land parcels	Residential land parcels
L_PRICE	The price per square meter of the auctioned land parcel (RMB/sq. meter).	7343.57 (9845.65)	4311.60 (6198.07)
L_SIZE	The size of the land parcel (thousand sq. meters).	55.94 (83.31)	66.92 (89.55)
L_FAR	The permitted FAR on the land parcel (the ratio of building space to lot area).	2.36 (1.76)	1.93 (1.08)
D_CENTER	The distance between TianAnMen Square and the land parcel (kilometers).	30.13 (22.76)	31.65 (20.89)
LRES	Binary: land parcel for residential use.	0.49 (0.50)	–
QD1	Binary: located in the first quadrant (Northeast). TianAnMen as the origin point.	0.48 (0.50)	0.27 (0.44)
QD2	Binary: located in the second quadrant (Northwest). TianAnMen as the origin point.	0.19 (0.40)	0.10 (0.30)
QD3	Binary: located in the third quadrant (Southwest). TianAnMen as the origin point.	0.21 (0.41)	0.16 (0.37)
QD4	Binary: located in the fourth quadrant (Southeast). TianAnMen as the origin point.	0.12 (0.32)	0.09 (0.29)
LY2004	Binary: land parcel auctioned in year 2004.	0.41 (0.49)	0.39 (0.49)
LY2005	Binary: land parcel auctioned in year 2005.	0.33 (0.47)	0.35 (0.48)
LY2006	Binary: land parcel auctioned in year 2006.	0.26 (0.44)	0.25 (0.44)

revenue. Core high schools receive more funding and attract excellent students. Because of historical factors, we view the location of core high schools as exogenously determined. From the Beijing Municipal Commission of Education (BMCE), we have acquired the list of Beijing's 40 core high schools and their locations, as shown in Fig. 4.[10] Proximity to core high schools is val-

[10] Each high school contains a junior section (three grades, for students ages 13 to 15) and a senior section (three grades, for students ages 16 to 18). The junior section belongs to the compulsory education period, but the senior section does not. Beijing has school zones

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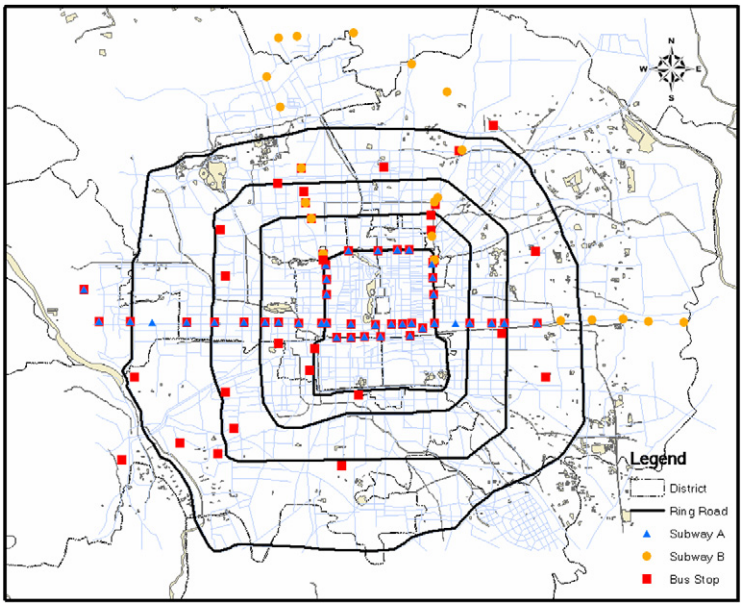

Fig. 3. Major transportation infrastructure in Beijing.

ued for two reasons. First, according to China's compulsory education policy, households living in the school zone of a core high school are eligible to have their children attend the junior section in that school. Second, parents will have a shorter commute to their child's school if the child attends a local school. Because each high school contains junior and senior sections, we cannot explicitly distinguish the two forces. We calculate each project's distance to its closest core high school.

Figure 4 also reports the spatial distribution of 14 high-crime-rate areas, which were reported by the Beijing Municipal Public Security Bureau in 2005. We can see that most of these crime areas are located at the city fringe, where new and low-skilled migrants from rural area always live.

Environmental amenities are another important set of local public goods. Beijing is known for having very high ambient particulate levels.[11] Within Beijing, there is significant spatial variation in particulate levels, with the southern part of the city featuring much higher pollution levels. The major causes of these emissions are transportation, power creation, and heating (Ho and Jorgenson, 2003).[12] We use data from eleven air-quality monitors located in the Beijing metropolitan area. The Beijing Municipal Environmental Protection Bureau (BMEPB) reports daily air pollution indices (API) by monitoring station. We translate this index into more standard units of $\mu g/m^3$ (micrograms per cubic meter) of particulate matter (PM10).[13] We assign to

for compulsory education (primary school plus the junior section in high school), similar to the school districts in the United States. Each school zone contains several high schools. Most of them are common high schools, and one or two are core high schools. Primary schools and the junior sections in high schools recruit all the eligible students in the corresponding school zones. This regulation does not apply to the senior sections in high schools.

[11] Data from the Chinese government website http://www.zhb.gov.cn/english/air-list.php3 from April 1, 2006, until June 25, 2006, reveal that Beijing has much higher particulate levels than Shanghai (another mega-city in China). The data show that over these 84 days in Beijing, 89% of Beijing's PM10 readings and 64% of Shanghai's PM10 readings were over 100 micrograms per cubic meter.

[12] Particulate exposure significantly raises mortality rates (Chay and Greenstone, 2003) and is negatively correlated with US home prices (Chay and Greenstone, 2005).

[13] The index value is based on the ambient pollutant that exceeds the daily standard by the greatest amount. This is usually particulate matter (PM10), but on some days it can be sulfur dioxide or nitrogen oxide. Although we can infer PM10 levels for more than 95% of the days of the year from the each day's API level, there are some days when we do not have this information. To obtain a reliable measurement of the PM10 level, we picked the first day and the 15th day of each month in 2004 and 2005 (24 days altogether) and examined whether all the indexes of the eleven monitors over these 24 days referred to PM10. If the daily index was not based on PM10, we replaced that day by the day after, and followed this procedure iteratively. This method yields a pure PM10-index day. Public health research has emphasized that people are especially susceptible to high pollution days. To measure severely high pollution levels, we averaged the PM10 values from the top 3 days of the total of 24 days for each monitor. We then assigned the PM10 value of the closest monitor to each housing project.

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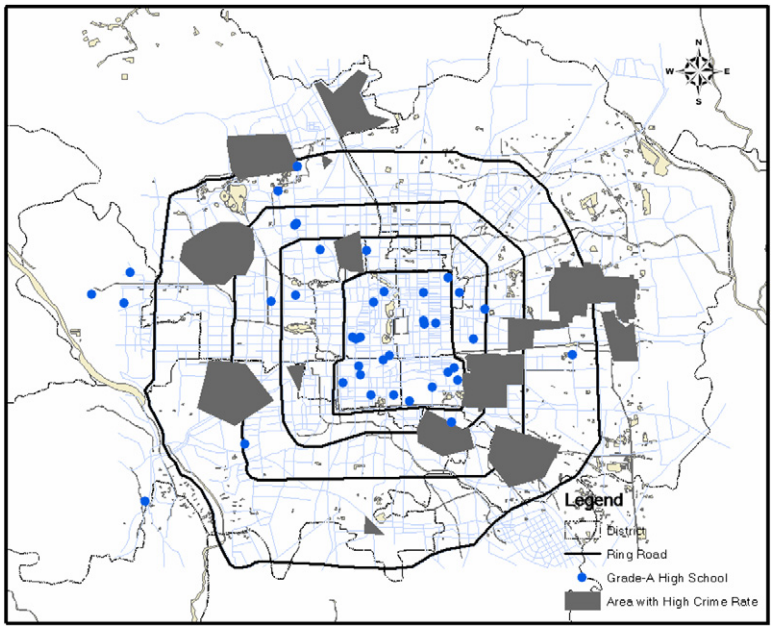

Fig. 4. Crime and school quality in Beijing.

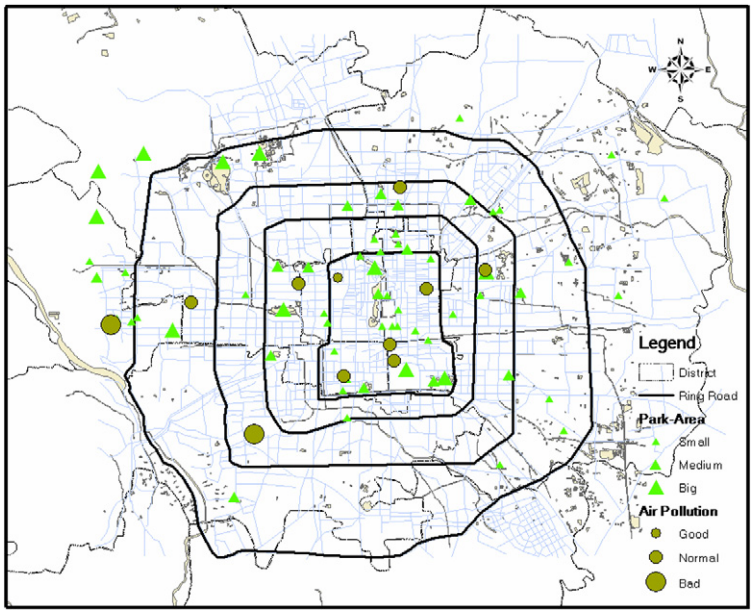

Fig. 5. Environmental amenities in Beijing.

each housing project the air pollution level of the closest monitoring station within the city.

In addition to examining air quality, we also have data on the spatial location of Beijing's 64 large parks. Previous research using data from Seoul, South Korea, has documented the effects of green space on real estate prices (see Lee and Linneman, 1998). Figure 5 maps their locations. As with the other spatial amenities, we calculate each new housing project's distance to the closest park.

We also study whether proximity to a major university is reflected in housing prices. We have geocoded all of the 33 major universities in Beijing. Most of them are located in Haidian District. This district has been a center of research activities since the former central-planning era (Fig. 6). Housing prices are likely

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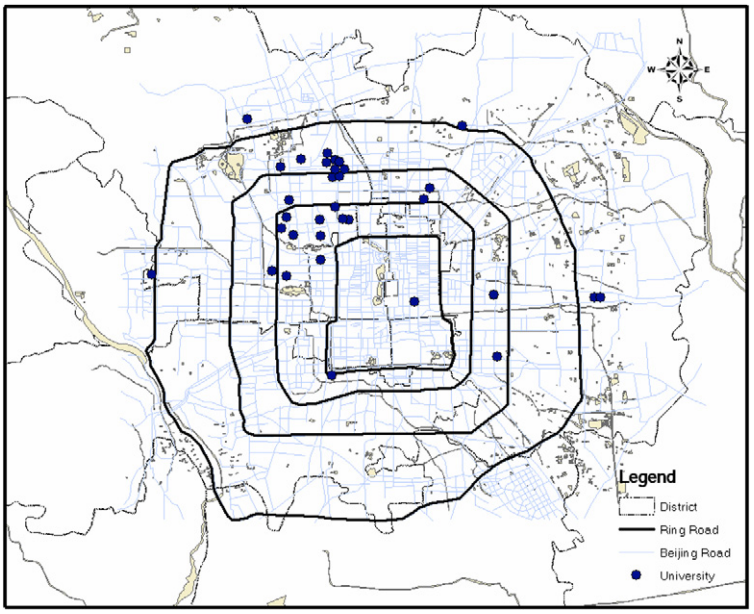

Fig. 6. Major universities in Beijing.

to be higher in university towns for several reasons. In such communities, beneficial peer effects and networking opportunities may be available, as university graduates remain in the nearby community. Residents of well-educated communities enjoy high levels of consumer amenities, such as fancy stores, restaurants, coffee shops, and pubs. In Chinese cities, residents living close to universities can easily gain access to large open spaces, exercise facilities, libraries, and the Internet at low cost.

3. Testing the monocentric models in Beijing

3.1. Land parcel and housing project price gradients

We begin our empirical analysis by estimating hedonic pricing regressions. The results are reported in Table 3. For land parcels, the unit of analysis is a parcel j at location q in year t. For the housing projects, the unit of analysis is a project j at location q in year t. In columns (1) and (2), the dependent variable is the log of the price per square meter of land. In column (3), the dependent variable is the log of the average price per square meter of floor area of the sold housing units in the project. Equation (2) presents the estimation equation:

$$\text{Log}(Price_{jqt}) = B * Distance\ to\ City\ Center_{jqt} + \text{controls} + U_{jqt}. \quad (2)$$

In all three of the regressions, we include controls for the region of Beijing in which a land parcel (or a housing project) is located and for when the parcel was auctioned (or the date when the project started to sell). We partition the whole metropolitan area into four quadrants using TianAnMen Square as the origin point (see Tables 1 and 2 for detailed definition). The omitted category is a land parcel (or a housing project) sold in 2004 (or the first quarter in 2004) in the Northeast region. In column (1), we include all 145 land parcels. Because all these parcels were vacant and were undeveloped green fields at the time of auction, land quality is constant across space, and therefore any difference in pricing represents location-specific effects. We estimate a land gradient coefficient of −0.048. An extra kilometer of distance away from the CBD reduces the land price per square meter by 4.8%. In column (2), we limit the sample to include only residential parcels. In this case, our estimate of the land price gradient with respect to distance to the City Center shrinks to −0.043. This differential is intuitive because of agglomeration economies in the commercial sector (see Rosenthal and Strange, 2004)—land closer to the City Center is more valuable for non-residential users. The results in column (1) of Table 3 also reveal the continuing large price appreciation over time in the Beijing land market. Between 2004 and 2006, land prices had increased by 76%. Controlling for distance from the City Center, we find that there are large differences in land prices by quadrant. The South is considered to be a less desirable

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Table 3
Land parcel and housing project price gradients

Variables	Land price Dependent variable = Log(L_PRICE)		Housing price Dependent variable = Log(P_PRICE)
Sample:	All land parcels	Residential	Residential
	(1)	(2)	(3)
Constant	8.574***	8.268***	8.841***
	(42.96)	(31.13)	(181.10)
D_CENTER	**−0.048*** **	**−0.043*** **	**−0.020*** **
(in kilometers)	**(−13.91)**	**(−9.02)**	**(−6.69)**
QD2	-0.024	−0.012	−0.002
(Quadrant II)	(−0.12)	(−0.05)	(−0.06)
QD3	−0.747***	−0.525**	−0.185***
(Quadrant III)	(−3.89)	(−2.40)	(−5.28)
QD4	−0.893***	-0.568**	−0.101***
(Quadrant IV)	(−3.79)	(−2.26)	(−2.81)
Y2005	0.463***	0.123	
	(2.91)	(0.78)	
Y2006	0.565***	0.451**	
	(3.30)	(2.57)	
Y04Q2			0.210***
			(4.25)
Y04Q3			0.101***
			(2.05)
Y04Q4			0.242***
			(4.75)
Y05Q1			0.328***
			(5.43)
Y05Q2			0.390***
			(7.33)
Y05Q3			0.490***
			(9.38)
Y05Q4			0.386***
			(6.25)
R^2	0.648	0.589	0.175
No. of obs.	145	89	900

The omitted category is quadrant I (Northwest) in the group of quadrant dummies, year 2004 in the group of year dummies, and first quarter in 2004 in the group of quarter dummies. See Table 2 for variable definitions.

** Significance at the 5% level.

*** Idem, 1%.

area to live in, which may be because the South has traditionally been a leading manufacturing area. We find that relative to the Northeast, the average land parcel auctioned off in the Southeast is 41% cheaper. Given our interest in exploring the explanatory power of the monocentric model for Beijing, it is interesting to note that our parsimonious model presented in column (1) can explain 65% of the variation in the dependent variable.

In column (3) of Table 3, we examine the residential project price gradient. We estimate −0.020 as the residential price gradient, indicating that an extra kilometer of distance away from the CBD reduces housing price per square meter by 2%. The R^2 for this housing price gradient equation is only 0.175. Comparing columns (2) and (3), we find the land price discount in the 3rd and 4th quadrants (the southern part of Beijing) is much larger than the housing price discount.

3.2. Land parcel zoning and dwelling sizes

We now examine how the size of new buildings and apartment units varies across Beijing. In columns (1) to (3) of Table 4, we examine the distance gradient of the land parcel's zoned density (denoted by the permitted floor-to-area ratio (FAR) on that parcel). The FAR is predetermined by the Land Authority. The Land Authority mainly considers the land's location value and consults Beijing's Master Plan. There is some opportunity for developers who have strong negotiation power with government agencies to build taller building than

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Table 4
Land parcel and housing project density gradients

Variables	Land parcel's zoned density Dependent variable = L_FAR			Dwelling size Dependent variable = Log(UNIT_SIZE)
Sample:	All land parcels	Commercial	Residential	Residential
	(1)	(2)	(3)	(4)
Constant	3.204***	3.138***	2.516***	4.809***
	(7.81)	(5.27)	(5.26)	(95.02)
D_CENTER	**−0.031*** **	**−0.038*** **	**−0.010**	**−0.003**
(in kilometers)	**(−4.35)**	**(−3.67)**	**(−1.15)**	**(−1.02)**
QD2	0.094	0.728	−0.226	0.069**
(Quadrant II)	(0.24)	(1.19)	(−0.53)	(2.02)
QD3	−0.392	−1.029	0.109	−0.131***
(Quadrant III)	(−0.99)	(−1.34)	(0.28)	(−3.60)
QD4	−0.981**	−1.391	−0.239	−0.034
(Quadrant IV)	(−2.02)	(−1.38)	(−0.53)	(−0.92)
Y2005	0.511	2.143**	−0.439	
	(1.57)	(3.51)	(−1.44)	
Y2006	0.405	1.392**	−0.111	
	(1.15)	(2.06)	(−0.35)	
Y04Q2				0.021
				(0.41)
Y04Q3				−0.022
				(−0.43)
Y04Q4				−0.002
				(0.03)
Y05Q1				0.031
				(0.49)
Y05Q2				0.082
				(1.48)
Y05Q3				0.117**
				(2.16)
Y05Q4				−0.002
				(−0.03)
R^2	0.146	0.417	−0.005	0.035
No. of obs.	145	56	89	900

The omitted category is quadrant I (Northwest) in the group of quadrant dummies, year 2004 in the group of year dummies, and first quarter in 2004 in the group of quarter dummies. See Tables 1 and 2 for variable definitions.

** Significance at the 5% level.

*** Idem, 1%.

their permitted FAR, but the difference in most cases is minor. For all land parcels, the results in column (1) show that the FAR declines with distance from the City Center. Taller buildings are built closer to the City Center. Column (2) shows that the FAR gradient for 56 commercial land parcels is also significantly negative. Perhaps surprisingly, the result in column (3) shows that the residential FAR does not decline with distance from the City Center.

To further investigate how apartment sizes vary across space, in column (4) we report regression results where the dependent variable is the log of the average dwelling's size in a residential project. We again find that dwelling size does not change significantly from the city center to the suburbs. The population density in Beijing, however, sharply declines with respect to distance from the city center (see Eq. (1)). This apparent inconsistency is presumably due to the fact that the land parcel's zoned density and dwelling size regressions apply only to new development, whereas population density reflects past development as well.

Urban planning principles specified by Beijing local government may help to explain our findings of a flat new construction density, which appears to be a significant deviation from the standard predictions from the monocentric model. TianAnMen Square is a political landmark in China, and the Forbidden City behind it is the most important historical heritage. To keep these

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landmarks prominent, Beijing's urban planning commission set rigid restrictions on the height of buildings near TianAnMen Square in the downtown center. The urban planners also follow another planning principle: as distance to the TianAnMen Square and the Forbidden City increases, buildings' heights should also go up to create a skyline for Beijing. Planning edicts that encourage increasing building height with distance from the CBD, combined with market forces leading to building heights declining with respect to distance from the CBD, may yield a flat density gradient.

To summarize our results in this section: land prices and real estate prices decline with respect to distance from the Center City. The commercial land pricing gradient declines more steeply with distance from the CBD than does the residential land pricing gradient. Unlike in major US cities, the land parcel's zoned density and dwelling size of newly constructed residential projects do not decline with distance from the CBD.

4. Local public goods capitalization

Using our housing project data set, we now seek to examine the determinants of the pricing of new residential buildings as a function of physical attributes and access to various local public goods. A major research agenda has encouraged measurement of real estate capitalization for non-market local public goods using hedonic methods in the United States and around the world (Rosen, 2002; Berger et al., 2003).

We build on this literature by measuring local public goods capitalization in Beijing. Homeowners in Chinese cities do not pay residential property tax. Transportation infrastructure and urban amenities, such as parks and schools, are financed either by the Central Government or the Beijing Municipal Government. Therefore local amenity capitalization effects should be more visible than in cities with property taxes (see Gyourko et al., 1999), because the developers or buyers implicitly purchase those public goods by buying land parcels or housing units.

We use standard hedonic methods to estimate capitalization effects for a broad set of local public goods. Using ordinary least squares, we estimate Eq. (3). In this equation the dependent variable is the log of the price per square meter of housing in project j located in community q at time t:

$$\mathrm{Log}(Price_{jqt}) = B_1 * X_{1\mathrm{j}} + B_2 * X_{2\mathrm{q}} + U_{jqt}. \qquad (3)$$

In Eq. (3), $X_{1\mathrm{j}}$ represents the physical attributes of the average unit within a new project. We have data on project size (how many units) and average unit size (in square meters). We include a dummy variable called "SOE" that equals one if the project is built by a state-owned development enterprise.[14] In Eq. (3), the $X_{2\mathrm{q}}$ vector represents location q's spatial attributes.

An advantage of studying capitalization effects in Beijing is that the location of many local public goods (such as core high schools, parks, universities, and also local pollution to some extent) is exogenously determined in Chinese cities, because of the former planning economy and path dependency. These public goods were built long ago in the central-planning economy by the Central Government or cities' local governments, who had decided the location of such facilities without considering market forces at all. Schools, parks, and universities seldom change their locations after they are built.[15] Therefore, although the residents are mobile and can choose to live in housing projects with varying access to these amenities, the locations of the local public goods have been largely unchanged. We recognize that there are other amenities, such as fancy restaurants, that will cluster near where high-income, educated people gather (Waldfogel, 2006).

We report our capitalization estimates in Table 5.[16] At first glance it might appear that we can control for few physical housing attributes (the $X_{1\mathrm{j}}$). In our defense, we note that all of these housing units are condominiums that are quite similar in building structure, internal space, and decoration, and the dependent variable is price per square meter of housing unit space.[17] In addition, it is important to note that we have implicitly

[14] State-owned development enterprises are projects in which the state is the largest shareholder. State-owned developers had originally been construction firms during the 1980s. After the land market reforms, some of these state-owned construction firms transformed into real estate developers seeking market opportunities. Such state-owned developers have several unique features. They produce many units of housing, their high-level managers are still appointed by governments, and they have an inflexible manager wage system that is regulated by government.

[15] Although some polluting firms have been relocated, their new addresses are always in the same district as old ones in the city, so the list of bad air quality sub-areas in the Beijing Metropolitan Area has not changed much.

[16] We have also estimated Eq. (3) using a variety of different functional forms, such as a log-level hedonic regression with respect to distance from the CBD. We have also experimented with using dummy variables, such as whether a housing project is within two kilometers of a park. In Table 5, we report several of the amenity capitalization estimates using the log of distance to specific attributes. This approach reduces potential concern over measurement error with respect to measuring the distance between housing towers and specific geographical attributes.

[17] Our data set does not include single-family houses or townhouses.

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Table 5
Hedonic capitalization estimates of local public goods. Dependent variable: Log(P_PRICE)

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	8.491***	8.805***	9.843***	10.046***	10.252***	8.945***
	(110.15)	(127.39)	(19.95)	(30.13)	(43.60)	(19.12)
D_CENTER	−0.019***	−0.011***	−0.008***	−0.007***	−0.007***	−0.007***
(in kilometers)	(−7.67)	(−4.81)	(−4.01)	(−3.55)	(−3.82)	(−3.98)
UNIT_SIZE	0.003***	0.003***	0.002***	0.002***	0.002**	0.002**
(in square meters)	(4.46)	(4.78)	(3.74)	(2.67)	(2.65)	(2.52)
$UNIT\_SIZE^2$	−2.09E − 6***	−1.24E−6***	2.53E−7	4.40E−7***	1.60E−7	8.93E−7
	(−1.03)	(−0.72)	(0.10)	(0.18)	(0.06)	(0.38)
PRO_SIZE	−0.164***	−0.132***	−0.131***	−0.110***	−0.115***	−0.100***
(in 000 units)	(−4.32)	(−4.07)	(−3.36)	(−3.64)	(−3.56)	(−3.63)
PRO_SIZE^2	0.025**	0.022**	0.022***	0.018***	0.020***	0.017***
	(2.15)	(2.27)	(4.40)	(4.16)	(4.76)	(3.75)
SOE	−0.091**	−0.077**	−0.100***	−0.098***	−0.100**	−0.087**
	(−3.64)	(−3.64)	(−3.46)	(−3.21)	(−2.87)	(−2.88)
Log(D_SUBA)		−0.161***	−0.113**	−0.089**	−0.082**	−0.108***
(in kilometers)		(−14.25)	(−3.25)	(−2.70)	(−2.54)	(−3.80)
Log(D_SUBB)		−0.038***	−0.014	−0.014	0.021	0.023
(in kilometers)		(−3.43)	(−0.90)	(−0.67)	(0.84)	(1.11)
Log(D_BUS)		−0.079***	−0.074**	−0.074*	−0.051*	−0.035
(in kilometers)		(−5.21)	(−2.43)	(−2.13)	(−1.94)	(−1.01)
Log(D_PARK)			−0.104***	−0.086**	−0.041	−0.057*
(in kilometers)			(−3.46)	(−2.51)	(−1.57)	(−2.06)
AIRBAD			−0.0041**	−0.0049***	−0.006***	−0.005***
($\mu g/m^3$)			(−2.44)	(−4.40)	(−6.93)	(−5.85)
Log(D_SCHOOL)				−0.065**	−0.066**	−0.054**
(in kilometers)				(−2.56)	(−2.87)	(−2.45)
CRIME				−0.024	−0.055	−0.051
				(−0.64)	(−1.19)	(−1.55)
Log (D_UNIV)					−0.104***	
					(−3.68)	
UNIV_3KM						0.106***
						(3.60)
UNIV_SCORE						0.002***
						(3.28)
Quarter dummies	yes	yes	yes	yes	yes	yes
R^2	0.356	0.533	0.569	0.578	0.597	0.601
No. of obs.	900	900	900	900	900	900

This table reports six OLS estimates of Eq. (3) in the text. In columns (3), (4), (5), and (6), the standard errors are clustered by the eleven air quality monitors (see Fig. 5). See Table 1 for variable definitions.

controlled for the unit's age, because all of our observations represent new housing construction.[18]

An interesting project-specific variable we observe is a dummy variable (called SOE) that indicates whether the project is built by a state-owned development enterprise. Table 1 shows that 23% of the housing projects in our data set are built by SOEs. SOEs are owned by the state. The wages of the marketing personnel and managers in SOEs are not well linked with the revenue from the project, so SOE managers may have little incentive to charge a high project price. The results in Table 5 support this claim. Holding other variables constant, the price of projects built by SOEs are 10% cheaper than privately developed projects.[19]

[18] There still may be some building-quality attributes that buyers recognize but that we do not observe in our data set. We know that the income/distance gradient is negatively sloped (Zheng et al., 2006a). It is possible that housing price rises as distance to the CBD declines partly because the closer buildings feature nicer units. This would lead us to overestimate the true price gradient with respect to distance to CBD. Nevertheless, we believe that this is a minor effect, because we also observe a statistically significant and negatively sloped price gradient for vacant and green-field land parcels.

[19] In ongoing research, we are studying how Beijing developers compete and the role of developer reputation for building high-quality structures and the resulting price markups.

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In column (1) we estimate the residential distance to City Center gradient controlling for no other local public goods. We find a distance gradient of -0.019. In column (2), we estimate the same specification but augmented with a number of measures of local public goods.

Recent studies have documented the capitalization effects of proximity to public transit in cities such as Chicago and London (see Bowes and Ihlanfeldt, 2001; McMillen and McDonald, 2004; Gibbons and Machin, 2005). Transit differs in quality across Beijing; we therefore divide public transit into bus, city subway, and suburb subway. City subway (Subway A) consists of Line 1 and Line 2, and suburb subway (Subway B) comprises Line 13 and Line Batong. We find very different capitalization effects for these two types of subways. The distance elasticity for Subway A indicates that a 10% increase in distance to it reduces home prices by 1.6%. The estimate for Subway B is much smaller (0.4%). This differential suggests that transportation infrastructure alone, without the corresponding decentralization of jobs and other urban amenities, is not valued by new home buyers. Proximity to major bus stations has a slight effect on increasing home prices. Controlling for these variables shrinks the distance gradient down to -0.011.

In column (3), we further augment the specification to include environmental variables, namely proximity to major parks and local particulate matter levels. Given that Beijing has 11 active monitoring stations, we cluster the standard errors grouped by the nearest monitoring station. All else equal, a 10 microgram per cubic meter increase in PM10 reduces home prices by 4.1%. This coefficient estimate is highly significant and is surprisingly close to an estimate reported by Chay and Greenstone (2005) using US county data. We also find evidence that proximity to parks increases real estate values. This distance elasticity equals -0.10.

In column (4), we estimate Eq. (3) including measures of local crime and access to core high schools. To our surprise, the crime indicator variable is statistically insignificant. Figure 4 shows that most of these crime areas are located at the city fringe, where urban expansion encroaches into rural areas. At such locations, informal residences are provided by farmers to house new and low-skilled migrants. Such mixed communities contribute to the high crime rate there. The insignificant sign of the crime variable may indicate that the strong flow of migrants and huge demand for living in such communities reduces the negative capitalization effect of crime. As expected, proximity to good schools does raise real estate prices, but the elasticity is small (-0.065).

In column (5), we examine how distance to the closest level-one university affects housing prices. This variable has a negative statistically significant coefficient. A 10% reduction in distance to the nearest major university increases home prices by 1%. As we discussed above, a proximity to a university bundles many desirable attributes together. These include access to open space, peers, libraries, the Internet, and high-end shopping. In an attempt to further disentangle these various attributes, we introduce a measure of the quality of the closest university to each housing project. This variable is called UNIV_SCORE. It represents each university's 2005 average entry score on the National University Entrance Examination. The entry score can be regarded as a proxy for student excellence. Top-scoring universities attract the leading professors and research teams. We also create a dummy variable, UNIV_3KM, indicating whether the project is within 3 kilometers of a university. In column (6), we include UNIV_SCORE and UNIV_3KM in our hedonic equation. These two variables are both significant at the 1% significance level. All else equal, increasing a university's entrance exam score by one standard deviation raises local home prices by 5%. This finding is consistent with the US literature's findings on human capital capitalization (Rauch, 1993; Bajari and Kahn, 2005).

The bottom row of Table 5 reports each regression's R^2. Controlling for proximity to local public goods sharply increases the regression's explanatory power.

5. Conclusion

Over the last fifteen years, Beijing has made a dramatic transition from a major city in a communist nation to a booming city in a transition economy. As the market economy has taken root, Beijing's urban form has also evolved. This study builds on previous studies that have examined urban form in transition nations (see Bertaud and Renaud, 1997 and Dale-Johnson et al., 2005). Two unique micro-data sets allow us to examine the pricing and densities gradients of newly leased land parcels and newly constructed housing projects throughout Beijing.

Our results indicate that the monocentric model can explain much about Beijing's current urban form. Population density declines with distance from the City Center, as do land prices and real estate prices. One surprising discovery is that residential building heights and housing unit sizes do not decline with distance from the City Center. This finding may be due to binding urban planning policies that do not reflect market forces.

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Similar to others who have studied US local public goods capitalization, we find evidence that proximity to fast public transit, clean air, high-quality schools, major universities, and environmental amenities are capitalized into real estate prices. These capitalization estimates are useful for informing an ongoing debate in Beijing concerning whether new migrants to Beijing actually value local quality of life or are drawn to Beijing solely in pursuit of income maximization.

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