Economic Determinants of Urban Spatial Scale  
—Chinese Cities in Transition

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Abstract  
The unprecedented urban economic growth in China has created a huge demand for urban land. Built upon the standard monocentric urban land model, this empirical study investigates the determinants of urban spatial scale, taking into consideration additional China-specific characteristics. Two cross sectional urban spatial scale models, assuming the cities being ‘closed’ or ‘open’, are estimated using data from 659 Chinese cities for years 2002, 2003, and 2004. The ‘closed’ city model estimates are surprisingly similar to those found for US cities with the four basic factors, population, income, commuting cost, and price of rural land explaining most of variations in urban spatial scales of Chinese cities. The ‘open’ city model estimates reveal an equilibrium pattern as a result of urban economic variables and rural-urban migration equilibration. The findings suggest that although Chinese cities may have inherited some features of urban land use planned by government, market forces today are more dominating than non-economic forces.

Keywords: urban scale; monocentric city; open city; closed city; Chinese cities.

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1. Introduction

Chinese economy has grown 10% annually over the period of 1979-2004. Most of the aggregate growth has occurred in urban areas. The growth has generated a huge demand for urban land. Nationwide, urban built-up area has expanded from 8,842 km$^2$ for 295 cities in 1984 to 23,943 km$^2$ for 287 cities in 2004 (China Statistical Year Book for Cities 1985 and 2005), nearly tripled in two decades. It is generally expected that Chinese economy will continue to grow at a similar pace and urbanization, currently accounting for 30% of the nation’s population, will accelerate for years to come. In contrast with urban expansion, arable land has shrunk from 0.15 hectare per capita in 1979 to 0.10 in 2004 (China Statistical Year Book 1981 and 2005). Given that two-third of the nation’s territory are not particularly suitable for habitation and agriculture, urban spatial expansion and security of agricultural land to support the ever growing population have caused a major concern among government officials, academic researchers, and the general public.

For a half century most Chinese cities have been built according to a long range master plan including a land use plan. Urban land use has been planned strictly based on the size of the current and projected urban population. Depending on the officially designated political, social, and economic functions, each city is permitted to use construction land of certain square meters per urban resident. Besides officially planned urban functions and population size, other economic factors such as income, commuting cost, and agricultural land price identified in the standard urban economics literature are neglected. Once the urban master plan and land use plan are approved by a superior government, the urban spatial scale is under a tight control for many years. As suggested in a study of socialist cities (Bertaud and Renaud [2]), the spatial patterns of cities without land markets were inevitably different from those in developed market...
economies and the old spatial characteristics are largely inherited by these cities today.

However, the past decade has also witnessed emergence of urban land markets in China. Since the central government enacted the *Regulation for Conveyance of State-Owned Land through Bidding, Auction, and Post* in 2002, a monopolistic urban land market in each city has been officially established and the right to urban land use for commerce\(^2\), tourism, entertainment, and residence must be conveyed through the open market mechanism. Meanwhile, restrictions on mobility have been gradually lifted and many rural residents have migrated to urban areas to look for economic opportunities. As a result, market forces have shown increasingly significant influences on urban land allocation and urban land use pattern has started to reflect not only government planning but also the equilibrium of market forces.

Given the unprecedented scale of urbanization and emergence of urban land markets, Chinese cities provide a unique case to assess the influences of economic factors on urban expansion in a transitional economy. This paper attempts to answer the following questions: To what extent do market forces explain the variation of urban spatial scales of Chinese cities and how much does government planning still determine urban land use? With a fairly significant portion of urban population being migrants, do current Chinese cities more resemble a ‘closed’ city or an ‘open’ one? To answer these questions, we perform a cross-sectional analysis of urban scales for all 660 officially designated Chinese cities. We test a set of economic variables that have been proven to be significant determinants of urban area expansion in a developed market economy, particularly in the US. Therefore, the empirical results also provide interesting comparisons to the existing literature.

This paper is organized as follows. The next section reviews background literature on urban land use. The third section proposes the main hypothesis and operational models for empirical analysis. The fourth section describes the data and the fifth presents estimates of economic determinants of urban land expansion. The final section concludes the study and briefly discusses implications of the findings.

### 2. Background literature

Alonso [1], Muth [17], and Mills [13, 14, and 15] developed the general theory of urban land market to explain urban land use pattern and land allocation among different uses within a monocentric city. Alonso [1] laid the foundation of the general theory and developed many building blocks necessary to construct a land use model. Employment, goods, and services were assumed to be concentrated in the city center. Transport cost to the city center and consumer preference for the center, along with the optimization

\(^2\) Basically this includes retail and restaurant. Other sectors such as manufacturing, warehouse, and etc. are not included.
assumptions, resulted in negatively sloped equilibrium bid price-distance curves. Given
different utility and budget functions of household and the production, cost, and profit
functions of urban firm, bid-price curves of different land users were deduced and a
spatial sequence of different land uses emerged in accordance with steepness of each
bid-rent curve. Assuming the population of a city was given and the utility a variable,
Alonso’s model was for a ‘closed’ city. Alonso proposed a trial-and-error process to
estimate the size of urban land. No formal model was developed and nor was cross
sectional analysis of multiple cities conducted.

In his pioneering analysis of spatial pattern of urban land (Muth [17]), Muth
constructed an equilibrium model for urban residential housing market and conducted
comparative static analysis of effects of wage and non-wage incomes, transport cost,
and preference for housing versus other consumption on price and density gradients. He
performed a thorough, multiple-stage empirical analysis of urban land use in 46 US
cities. Among numerous regressions, Muth estimated probably the first ever cross
sectional regression model with more than a dozen independent variables to identify the
determinants of urban spatial scale (measured by urbanized land area in square miles).
The results showed that urban population was the most significant determinant of urban
land scale; cities in the southern or western region used more land; nothing else passed
statistical test at the significance level of 0.10. Since agricultural rent was not in the
model, the coefficient of regional dummy was interpreted as a result of lower
agricultural demand for land in the regions. A distinction between ‘closed’ and ‘open’
cities was not made.

At about the same time, Mills developed urban land models with three sectors [13], two
sectors [14], and one sector [15] and explicitly introduced two key equilibrium
conditions that have become indispensable in urban spatial scale models today. One
condition states that urban spatial scale is just large enough to accommodate
exogenously determined population and the other says that urban land rent is equal to
agricultural rent at the edge of urban area. Mills also made it clear that a city was
assumed either ‘closed’ or ‘open’. Unlike in a ‘closed’ city, population in an ‘open’ city
is endogenously determined by intercity migration. He conducted now widely cited
empirical analysis of spatial distribution of land rent in Chicago over a time span of 92
years. Mills tested linear, semi-log, and log-log functional forms with the log-log form
yielding the best statistical results in most cases. His results showed that over time the
rent at the CBD increased and the price gradient decreased, implying that when
population increased and transportation improved, not only the price of urban land but
also the spatial scale of urban area increased (Mills [14]). Mills’ analysis, as well as
Muth’s, suggests that urban spatial characteristics, including spatial scale, are natural
consequences of orderly market responses to economic opportunities.

However, it is not until Wheaton [22] and Brueckner [5] that a general yet rigorous
one-sector model of urban land use emerged. The models related urban rents, density, and spatial scale to changes in urban population, income, commuting costs, and agricultural rent in a more concise and well organized form. Comparative static analysis predicted the relation for each endogenous-exogenous pair. The qualitative results have paved a way to extend the analysis of urban spatial scale from the *intracity* setting to an *intercity* context because response of urban scale to each exogenous shock has an unambiguous direction. The model also distinguished between ‘closed’ and ‘open’ cities, with the former suitable to developed countries and the latter to developing nations. More sophisticated comparative statics that included multiple resident classes have been studied by Miyao [16] and Hartwick *et al* [10].

Brueckner and Fansler [4] performed the first cross-sectional analysis based on the one-sector framework. They investigated determinants of urban spatial sizes of 40 US cities using non-linear Box-Cox regression and linear regression. Their empirical model explained four-fifth of variations in urban spatial scales. The effect of population on urban spatial size is overwhelming; income and agricultural rent have significant and much smaller positive and negative impacts, respectively; commuting cost, measured by two proxies—percentages of households using public transit and owning an automobile, does not seem to matter much. Subsequent studies (e.g., McGrath, [12], Song and Zenou, [19]) that used the same framework but different samples and functional forms found similar results: urban population and, to a lesser extent, income, commuting cost, and agricultural rent explained most differences in urban spatial scale among US cities. It appears safe to say the four variables, especially urban population, are primary determinants of urban spatial scale in the ‘closed’ city scenario and other factors, if relevant, tend to have but marginal impacts on urban expansion in a market economy.

Although the theory has distinguished between ‘closed’ and ‘open’ cities, almost all empirical studies have focused on the ‘closed’ cities in the US probably owing to the researchers’ interests or data availability. A notable exception is Brueckner’s study [6] of third world urbanization. Brueckner performed a cross-sectional analysis of 24 largest cities in 24 developing countries. Urban scale was measured by urban population of the largest city of each country and total urban population of the country. Assuming real income equilibration existed between rural areas and cities, the model predicted that three ratios (i.e., rural-urban income ratio, commuting cost-urban income ratio, and agricultural rent-urban income ratio) should determine an equilibrium city size. The empirical findings showed that rural-urban income ratio was inversely related to urban population scale, supporting the real income equilibration hypothesis, and the other two theoretically important ratio variables were statistically insignificant. Very

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3 However, the land prices in the urban center and a distant area may respond differently to a change in an exogenous factor.
recently, Deng et al., [8] attempted to use a ‘closed’ monocentric city model to explain the roles played by economic growth, population, value of agricultural land, and transportation costs in China’s urban expansion. In the study the unit of analysis was a county and 2348 units were included. The dependent variable was measured by core part of urban built-up area and the exogenous variables were measured for the whole county including all rural area. For majority of Chinese counties the core of built-up area is several km² and the size of the whole county is several thousands km². The study basically estimated the effects on urban scale of gross GDP, population, and highway density in rural areas. Given the unique dataset and large sample, the findings are informative and interesting, but are not comparable to a typical monocentric model.

3. Models of Urban Spatial Scale of Chinese Cities

A vast majority of Chinese cities have developed one urban center and remained so for hundreds of years. During the recent years, urban centers in most cities have expanded, but an extended center area is still a dominant spatial feature of most Chinese cities. The Alonso-Muth-Mills monocentric model appears to fit this historical spatial structure reasonably well. Although a handful of fast growing cities have built secondary centers in the past decade or two, it has been unheard that a secondary center is ready to rival the primary center in any Chinese city. Moreover, Mills has conceptually justified that even if a city’s employment is decentralized, assuming that non-CBD employment is local and the wage function is decreasing with distance to CBD, households are indifferent between CBD and non-CBD jobs and, thus, the monocentric model is still applicable to a non-monocentric context (Mills, [14]). Wheaton and Brueckner have demonstrated that the urban boundary conditions, along with consumer and land owner optimization assumptions, determine the spatial scale of urban land and a change in a relevant exogenous factor leads to a specific change in urban scale regardless of intracity distribution of density or rent. This empirical study focuses on the variations of spatial scale across cities rather than spatial distribution of any other feature within a city. Therefore, presence of secondary centers will not invalidate the monocentric model in this study.

To simplify, we first assume that Chinese urban residents and land owners act rationally and labor market and urban population as well as allocation of land between urban and rural agriculture are in equilibrium. Under these assumptions the typical urban resident maximizes her utility, \( u = u(q, c) \), with \( q \) and \( c \) being consumptions of land and

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4 The study did not provide descriptive statistic of urban built up area. China Statistical Yearbook for Urban Construction 2003 shows that the built-up area of 376 officially designated county-level cities ranges from 4.4 to 71 km², with a mean of 16.8 km². The remaining 1600 or so counties that have no officially designated city have smaller central towns where a county seat locates. Another 350 or so analytical units in the study are higher level cities with proportionately smaller rural area than counties.
everything else, respectively, subject to the budget constraint, \( y = pq + kz + c \), with \( y \), \( p \), \( k \), and \( z \) being income, land price, unit commuting cost, and distance to the urban center, respectively. In equilibrium, the land owner sells the land to the highest bidder at the price, \( p = (y - kz - c)/q \), subject to the utility level the typical resident can achieve for the given income, i.e., \( u_0 = u(q, c) \), where \( u_0 \) is the utility for income \( y \).

The first order conditions define \( q \) and \( c \) as functions of the four variables \((y, k, z, u_0)\).

Substitution of \( q \) and \( c \) in \( p = (y - kz - c)/q \) yields the bid price, \( p = p(y, k, z, u_0) \). The urban land market equilibrium requires two boundary equilibrium conditions, (1) price equilibrium between urban and agriculture uses at the urban boundary and (2) overall quantity equilibrium between demand of population for urban land and supply of land within the city. The first boundary condition is \( p(y, k, z_{\text{max}}, u_0) = p_{\text{agri}} \), where \( p_{\text{agri}} \) and \( z_{\text{max}} \) are, respectively, the price of agricultural land at the city edge and the distance from city edge to the urban center. The second condition is \( \int_{0}^{\max} \phi(y, k, z, u_0)2\pi zdz = N \), where \( N \) is population and \( \phi = 1/q \).

Assuming the urban population is endogenously determined through rural-urban migration, the city is considered ‘open’, while the level of equilibrium utility is exogenously given and equal to the rural utility level. For an ‘open’ city, the first boundary condition implicitly defines the urban spatial scale \( z_{\text{max}} = z(u_0, y, k, p_{\text{agri}}) \).

Assuming urban population is exogenous and urban utility is endogenous, the city becomes ‘closed’. The two boundary conditions jointly define a ‘closed’ city spatial scale \( z_{\text{max}} = z(N, y, k, p_{\text{agri}}) \). Wheaton [22] conducted a comparative static analysis and qualitatively predicted the effects of the exogenous variables on urban land scale and other endogenous variables. For the effects of agricultural rent, commuting cost, and income on urban spatial scale we only need to note that each of them is qualitatively the same between a ‘closed’ city and an ‘open’ city although the general equilibrium mechanism differs somewhat. These theoretical propositions have been tested and confirmed in several empirical studies. However, with few exception (i.e., Brueckner, [6]), the empirical studies have focused on the ‘closed’ city model. In the remainder of this section, we first discuss how we consider several China-specific characteristics and modify the empirical model accordingly. We then discuss the rationales for
development of both ‘closed’ and ‘open’ city models for Chinese cities. The effects of urban population and equilibrium utility level differ between ‘closed’ and ‘open’ cities.

3.1. Incorporating China-specific Characteristics

First, the impact of urban population on urban spatial scale needs more clarification. Urban population used to be the only determinant of urban land scale when the other economic factors were disregarded in urban planning. Statistically this variable should be even more dominant in China than in US. Overtime, as other economic factors become increasingly important in Chinese urban economic system, the estimated weight of urban population should decrease proportionately. In addition, many cities have temporary workers who cannot be completely excluded from using certain urban infrastructure and living space even if they tend to consume smaller space than do urban permanent residents. Therefore, the two groups should be considered separately in the empirical analysis.

Second, there is no agricultural land market in China. The government owns the urban land and farmers collectively own farmland. If a city’s need for more land is approved by an appropriate level of authority, the government may acquire farmland at the price equal to 6-15 times average annual revenue on the farmland (The Land Management Act of People’s Republic of China 1986, amended 1998 and 2004). Although the market mechanism to optimize land allocation is distorted, prices of land more or less reflect the productivities of rural land. Furthermore, it is legally not viable for a city to expand its urban area beyond its jurisdictional border without an extraordinary action by a superior government. On a theoretical basis, assuming farmers are rational, the value of marginal product of land is equal to the cost of land service, i.e., \( p \frac{dQ}{dL} = r_L \), with \( p \) and \( r_L \) being price of agricultural product and rent of farm land, respectively. In practice, when the government acquires farmland for urban use, the acquisition price is based on land productivity, reflecting a similar economic principle. The higher the acquisition price, the less likely the government will convert the agricultural land for urban use. Thus, instead of agricultural rent, productivity of rural land is used in this analysis.

Third, urban physical structure, once formed, changes slowly. The previously central-planned economy may have left the cities with a long lasting impact of planned features on urban land use. The national standard for urban land use divides all cities into four classes, permitting 60.1-75 m\(^2\), 75.1-90 m\(^2\), 90.1-105 m\(^2\), or 105.1-120 m\(^2\) of land per urban resident, respectively. Except for the national capital and several cities in the special economic zones, most cities are officially instructed to use 60-90 m\(^2\) per urban resident (The Standards of Urban Land Classification and Land Use in Urban Planning and Construction, National Standards GBJ 137-90, 1991). The national standard, which has never been officially abolished, also instructs that only 18-28 m\(^2\) of the gross area is designated for residential purpose. These standards have profound
implications for the spatial scales of Chinese cities. A city with more non-residential activities (such as industrial production and intercity transfer activities) tends to have a larger gross area per capita. Many Chinese cities have a disproportionate share of urban land for non-residential uses planned by government. In explaining intercity variation of urban scale, the impacts of non-residential uses, especially manufacturing and warehouse, should be controlled.

Finally, there are a few more deviations of Chinese cities from the standard monocentric model. The national and provincial capital cities need more land to accommodate non-economic activities. The national land use standard for these cities is more generous as described previously. Below the level of capital cities are two other levels of cities — prefecture-level and county-level cities. Each prefecture-level city holds certain jurisdictional, administrative, and even economic decision power over a number of county-level cities and counties. In addition, there is a group of resource extraction cities. Most of them locate in the areas with vast coal mine or oil fields. The construction land of these cities is dispersed in extended areas and urban spatial structure is quite different from the monocentric model. Lastly, economic development and market reform have experienced different stages in different regions. As a result, forces that drive urban land use and spatial expansion may differ between the Eastern coast area and the Central/Western hinterland.

Taking these Chinese characteristics into account, we modify and add several variables to reflect the reality and reduce biases of model estimates. In the empirical model, the agricultural rent is replaced with productivity of rural land; the temporary urban population is included along with the registered permanent urban residents. Recognizing the impact of industrial and trading activities on urban land use, industrial and warehouse areas per resident are controlled. Several dummy variables are used to control different types of cities just described. With these modification and statistical controls, the empirical study will reveal whether or not the economic factors not considered in the urban planning process, such as urban income, price of rural land, and commuting cost, can help explain differences in urban spatial size across Chinese cities.

3.2. Developing a ‘closed’ city model for Chinese cities

5 There are sixteen cities in this group: Datong, Yangquan, Suozhou, Wuhai, Bengxi, Fushung, Hegang, Shuangyashan, Qitahe, Huainan, Panzhihua, Yuling, Yichung, Dongying, Daqing, and Kelamayi.

6 The Eastern region consists of twelve provinces and equivalents: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, Hainan; the Central has nine provinces and equivalents: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hebei, and Hunan; the Western has the remaining ten provinces and equivalents: Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Ningxia, Qinghai, and Xinjiang.

7 These different types of cities may have different parameter estimates, but the number of records is not large enough to estimate separate models.
In a ‘closed’ city model, urban utility is an endogenous variable within the urban system and unrelated to the level of rural welfare. Because the urban utility is endogenous, it does not appear in the reduced ‘closed’ city model. Following Mills [14] who tested linear, semi-log, and log-log functional forms with the log-log regression showing the best statistical results, we employ the following log-log functional form to estimate the ‘closed’ city model.

$$\ln z_i = \beta_0 + \beta_1 \ln L_i + \beta_2 \ln T_i + \beta_3 \ln y_i + \beta_4 \ln k_i + \beta_5 \ln p_{agri} + \beta_6 \ln I_i + \beta_7 \ln W_i + \sum_j \gamma_j C_{ji} + \epsilon_i$$ (1)

where $z_i, L_i, T_i, y_i, k_i, p_{agri}, I_i,$ and $W_i$ are, respectively, distance to urban center, urban population, temporary urban population, average urban salary, commuting cost, price of agriculture land, amount of industrial land use and amount of warehouse/storage land use and $C_{ji}$ is dummy for the $j$th type of cities (i.e., capital, county-level, resource extraction, Central, and Western cities), and error term $\epsilon_i$ is assumed to meet the classical assumptions.

3.3. Developing an ‘open’ city model for Chinese cities

In an ‘open’ city, the population is endogenous and determined in the system through a rural-urban welfare gap induced migration. The migration process continues until the urban population gets so large and price level of land so high that urban utility is pushed down to the rural baseline level and the urban spatial equilibrium is reached. Conversely, if the equilibrium utility level increases because of a rise in rural level of utility, someone must move out for the city to transition to the new equilibrium with a smaller population. This type of out-migration has been observed in some Chinese cities where migrant workers are crowded and wages are stagnant with a backdrop of improved rural life.

However, by assuming migration is costless and the equilibrium urban utility equals the rural baseline, this simplified model has ruled out important factors. In the real world a migrant has to overcome many difficulties, most notably two types of costs. First, a prospective migrant needs to search information about economic opportunities. Second, he needs transportation to the destination city. The urban equilibrium utility will be higher than the rural level by these costs. Other things being equal, the information and moving costs are positively related to the urban equilibrium utility level and negatively
related to the urban equilibrium size. Even if all cities in the same country face the same rural baseline utility, the equilibrium urban utility varies across the cities. Moreover, each city has a unique combination of endowment, location, and other advantages/disadvantages that constitute a unique level of pre-equilibrium utility for the city. The pre-equilibrium urban utility level is positively related to urban equilibrium size.

To estimate an ‘open’ city model for Chinese cities, we need variables to measure the information cost and moving cost. Migrant workers in cities are an important information source of economic opportunities because most Chinese rural migrants collect job information from their hometown folks working in the city. We use temporary-permanent population ratio to measure information cost because this ratio captures the presence of migrant workforce but does not introduce a proxy for population. A lower information cost means a smaller gap between the urban equilibrium utility and the rural levels and therefore a larger urban size. Unfortunately, no data are available to measure moving cost. We use three accessibility variables—express highways, major regional railway station, and commercial airport—as (inverse) proxies of moving cost. Other things being equal, the lower the migration cost, the smaller is the gap between the urban equilibrium utility and the rural baseline level and the larger is the city. Moreover, accessibility also contributes positively to the pre-equilibrium utility level by attracting transfer oriented firms and creating more economic opportunities. The higher the pre-equilibrium utility level, the larger is the city in the equilibrium. Because the accessibility variables tend to measure both moving cost and the pre-equilibrium utility, empirical estimates tend to be reinforced, but we cannot separate the two components. It should be noted that accessibility can change as a city grows. To alleviate the endogeneity issue, lagged measures of accessibility variables should be used. With these modifications the hypothesized ‘open’ city model is following.

\[
\ln z_i = \beta_0 + \beta_1 \ln (T / L)_i + \beta_2 \ln y_i + \beta_3 \ln k_i + \beta_4 \ln p_{agr} + \beta_5 \ln I_i + \beta_6 \ln W_i + \sum \alpha_k \ln G_{ki} + \sum r_j C_{ji} + \varepsilon_i
\]

(2)

where \((T / L)_i\) is urban temporary-permanent population ratio and \(G_{ki}\) is the \(k\)th urban accessibility variables (express highway, railway, or airport).

4. Data

To carry out analyses for the specified models described in section 3, we need to collect following information: urban spatial scale, permanent and temporary population, urban income, price of agriculture land, commuting cost, land used for industry and warehouse, type of cities (i.e., capital, county-level, resource extraction, Central, and Western cities), and urban accessibility. The main sources of the data are the China
**Statistical YearBook for Cities and the China Statistical YearBook for Urban Construction.** We use the yearbooks 2003, 2004, and 2005 to compile a dataset for this empirical analysis. By 2004 there have been 660 officially designated cities in China. Excluding observations with missing data on key variables, 1944 records for 659 cities for years 2002, 2003, and 2004 are retained.

The dependent variable, urban spatial scale, is measured by square kilometers of urban built district. The measurements of urban permanent and temporary population are straightforward. Income is measured by average urban salary. To measure agricultural land rent, we use productivity of rural land which is GDP in rural area divided by area of rural land, with the numerator being the difference between GDP for a city’s jurisdictional territory and GDP for the city’s urban economy and the denominator being the difference between total area inside the city’s jurisdictional boundary and area of urban built district. This measure is comparable to the one used in an earlier study of third world urban economy (Brueckner, [6]). To account for commuting cost, we use road surface area per resident.\(^9\) To measure and control for the impacts of government planned urban functions, urban industry land and warehouse/storage land, both on a per capita basis, were calculated.\(^10\) To classify types of cities, dummy variables are assigned to each city based on their administrative status and location. We only assign dummies of Resource Center to prefecture-level cities only because information required to code county-level cities is difficult to get and hard to judge for accuracy. So all county-level cities is assigned zero on dummy variable Resource Center. As a result, the effect of being a resource extraction city on the scale of urban land use is likely to be underestimated. In addition, several different variables are constructed for the ‘open’ city model. Temporary-permanent resident ratio is urban temporary population divided by urban population, with the two data elements mutually exclusive in the yearbooks. For the accessibility variable, we employ information on express highways, railways, and commercial airport for each city. The

\(^9\) Commuting cost is traditionally difficult to measure. Among the proxies used, average bus fare and auto registration are frequently used and tested (Muth, [14], Brueckner and Fansler, [4], etc.). To identify an appropriate yet feasible measure for Chinese cities, we considered multiple transportation modes including walk, bicycle, bus, subway, and private auto. However, consistent data for all cities are available only for city bus per thousand residents. We turned to road infrastructure on per unit land area basis or per resident basis. We tested three proxies for commuting cost—number of city buses per thousand residents, density of city street network, and area of paved city street surface per resident. It appears that road surface area per resident is a more complete measure for commuting cost, including time and money, because it takes into account population size and various transportation modes—walking, busing, bicycling, and others. It turned out this measure is statistically most significant among the three proxies tested.

\(^10\) We also calculated industry land and warehouse area as percentages of total area of built district. Since market forces can also contribute to variation of industry and warehouse land use across cities, we recognize that the statistical estimates will not separate the two original forces. Inclusion of these variables helps estimate the effects of population, income, commuting cost, and agricultural rent more consistently across cities with different, planned functions.
number of express highways for each city is manually collected from the provincial maps (mostly based on data for year 2000). The number of railway passengers is divided into seven size groups, 0, 1-1000 thousands, 1000-2000, 2000-4000, 4000-8000, 8000-15000, and >15000 thousands, and assigned ordinal values, 0, 1, 2, 3, 4, 5, and 6, respectively. This assignment gives up certain amount of information in the original data. However, this conversion cuts off noises considerably. Likewise, the number of airline passengers is converted to a set of ordinal values, 0, 1, 2, 3, 4, and 5, with breaking points, 0, 100, 500, 1000, and 5000 thousands per year. These two variables are named Rail Road Center and Commercial Airport in the ‘open’ city model. For the county-level cities that have no railway and airline passenger data, the rail road center variable is assigned 1 if there is a railway station within a distance of 30 kilometers from the urban center, 0 otherwise. For commercial airport variable, number of daily flight departures from the airport within 100 kilometers is collected from each city on-line and four breaking points, 0, 200, 300, 500, are used to assign five ordinal values, 0, 1, 2, 3, and 4. Inconsistence of data sources between county-level and higher level cities may cause the parameter estimates less accurate or even biased, which can be a serious problem if the estimates are marginally significant. However, if these variables are important determinants of urban spatial size, overall pattern should emerge unchanged.

Table 1 shows descriptive statistics for all the variables described. The descriptive statistics shows that size of urban land use varies widely with standard deviation of 76 km² much greater than the average of 43 km², the maximum size of 1182 km² for Beijing being 400 times the minimum of 2.6 km² for Baoshan, Yunnan province. Size of urban population has similar distribution. Given the average sizes of land and population, average density is 10,000 residents per km² or 100 m² per resident. Apparently, most cities are using land equal to, or in excess of, the maximum size instructed by the official national standards. Urban temporary population and GDP per unit of rural land show a pattern of even greater dispersion, judged by the ratio of deviation to mean. Other variables also show substantial variations. It is clear that there are significant disparities across Chinese cities in income, inherent price of agricultural land, and urban transport infrastructure, among other things. We want to know to what extent these differences explain the spatial scales of these cities and we present the findings in the next section.

5. Model estimates

5.1. Estimate of ‘Closed’ city model

Given the log-log specification, each coefficient is an elasticity of equilibrium urban
spatial size with respect to change in an exogenous factor. Two equations are estimated with the first being the baseline version with four variables, urban population, income, commuting cost, and price of agricultural land, and the second with additional variables, including urban temporary population, urban industry land use and warehouse land use per resident, and dummies for different types of cities. Table 2 displays the OLS estimates.

The estimates of the baseline model are surprisingly similar to those in the previous analyses using US data (Muth, [14], Brueckner and Fansler, [4], McGrath, [12], and Song and Zenou, [19]). The same four variables explain nearly four-fifth of variation in urban spatial size among the 659 Chinese cities. All coefficients have the signs identical with those in the early studies and confirm the urban land use theory. Once again, population is overwhelmingly significant and dominant. Roughly speaking, other things being equal a ten percent increase in urban population size tends to lead the equilibrium urban spatial size to a three or four percent increase among these cities. The other three variables also play significant roles. In terms of significance and size, average urban income is a distant second behind population. From market standpoint, it is not surprising that income is directly related to scale of urban land use. The last decade has witnessed a majority of Chinese urban residents have bought increasingly larger homes as average income rises and many upper middle class residents have owned multiple housing units. This is definitely not what government planners had in mind. GDP per unit of rural land, a proxy for agricultural rent, has a significant and negative sign. As described earlier, acquisition cost is real although no official agriculture land market exists in China. Probably more importantly, GDP is one of the most important performance measures for the government at every level and GDP on rural land is part of total GDP of a city. In its very own interest, the government has to consider the opportunity cost of converting highly productive rural land for urban use. Together these two factors likely explain the significant negative relationship between GDP per unit of rural land and the size of urban built area. The fourth variable, city road surface per resident is a proxy for commuting cost. The significant and positive estimate suggests that, the more road surface per resident, the less is the congestion and the lower the commuting cost in terms of time and money, resulting in locational equilibrium more distant to the CBD for the typical residents. We may also compare our findings to those in the early studies. The estimated population elasticity of urban expansion (0.39) is almost exactly the same as that (0.38) in McGrath [12].

---insert Table 2 about here---

11 Industry warehouse land uses as percents of total area of urban built district are also tested. The estimates are qualitatively the same but significance levels are slightly lower.
12 Some of the rural land may be used by farmer-run enterprises in various industrial and service sectors. Their output, however, is counted as part of city’s GDP.
13 Brueckner and Fansler (1983) used a smaller sample and a more flexible functional form. Then they
The estimated income elasticity (0.14) is one-tenth of the estimate (1.49) in Brueckner and Fansler [4], seeming to reflect the income difference between the two countries as well as a restrictive effect of government land use planning. In short, the statistical results display strong evidence that the economic factors identified in urban land use theory have similar impacts on urban spatial size of both US and Chinese cities.

The second model in table 2 is intended to capture more historical textures of Chinese cities. The additional variables explain more variation in urban spatial size. Parameter estimates of the four main variables are largely unaltered in the presence of the additional, significant variables. Urban population is still dominating, nevertheless, the size of the coefficient is noticeably smaller and significance level lower. The size of the coefficient of income is also reduced somewhat. The significant coefficients of the new variables suggest additional, interesting findings. Although statistically quite significant, temporary population has a parameter estimate of 0.015, less than one-twentieth of 0.325 for permanent urban population. Given that the average temporary population is 56 thousands, about one-seventh of 403 thousands for urban permanent population (see Table 1), an average temporary resident uses about one-third of the land space that an urban resident uses. The estimated elasticities of urban scale with respect to industrial and warehouse/storage land uses both are significant, with the former much larger than the latter, reflecting more land industrial sector occupies (see Table 1). The estimates are combination of the legacy of planned urban economic function and market forces. Unfortunately we cannot make a clear cut between the two. The significant dummy for capital cities indicates that national and provincial capital cities use more land than other variables have explained. This is mainly because these cities host various government branches and the governments have the authority to acquire land from farmers. Other things being equal, these capital cities are about thirteen percent larger in spatial scale. The other parameter estimates suggest that county-level cities, the cities with least power, are about fifteen percent smaller if holding everything else constant; cities in the Central region use about four percent more land than their counterparts in the Eastern region, probably reflecting a lower level of price of land in the central region.

The large and very significant coefficient of county-level city suggests that the other variables may also affect spatial sizes of cities at different levels differently. To investigate the differences, the two groups of the cities are modeled separately and the estimates are presented in Table 3.

--insert Table 3 about here--

used the parameter estimates and the sample means to calculate elasticities. Their population elasticity was much larger. On the other hand, McGrath used an equation with log-log form for urban scale and population and linear for all other variables. Therefore, we can’t compare our income elasticity to his.
The county-level city model has an adjusted $R^2$ of 0.601, much lower than the adjusted $R^2$ of 0.884 of the prefecture-level city model. The four most important economic variables (urban population, salary, GDP per unit of rural land, and road surface per resident) in the county-level model have less significant and smaller coefficients. Given that data are from the same sources, the difference in the goodness-of-fit implies the market forces that equilibrate returns and allocate land resource in the county-level, smaller cities are not as powerful as in the prefecture and higher level cities. This is not surprising because economies in capital cities and prefecture cities are more open than in smaller, lower level ones and, as a result, market forces and urban land equilibrium manifest itself more clearly in the group of larger, more market oriented cities.

Nevertheless, all variables seem to have effects qualitatively the same as in the previously combined model. Urban population again dominates everything else in significance level and size, while most other variables also have significant and expected signs. Industry and warehouse land uses are more significant in the county-level model than in the prefecture-level model, likely to suggest the smaller cities have been more influenced by planned land use structure.

Comparing the county-level and prefecture-level models, one can find the coefficient of temporary population in the county-level model is noticeably larger and more significant than in the prefecture-level model, bucking the trend just described. Since the average temporary population is 17.4 thousands or one ninth of 156 thousands of urban population in the county-level cities (not listed on a table to preserve space) and the coefficients of the two populations are 0.0192 and 0.3144, respectively, we estimate that an average temporary resident uses about one half of urban land area that an urban resident uses. By contrast, the average temporary population is 108 thousands or one seventh of 735 thousands of permanent urban population (not listed) in the prefecture- or higher level cities and the two respective coefficients are 0.0114 and 0.3849, a temporary resident occupied merely one fifth of land area used by an urban resident. Although the quantitative estimates may be debatable, it seems undeniable that temporary population has influenced urban land use substantially more in smaller cities than in larger ones. An important reason for the difference may be the differences in origin of temporary population and involvement of the temporary residents in socioeconomic life of the city where they live. Casual observations reveal that the temporary residents in a small city are more likely from nearby rural area and many of them are small business owners or work for business with local ties; geographic proximity and similar culture make them easier to be assimilated with city permanent residents; smaller scales of these cities make their efforts easier to be felt and make them more empowered. All these factors make income, consumption, and other preferences of migrants more comparable to those of permanent urban residents in small cities. By sharp contrast, most temporary residents in large cities are from across the country and mostly take construction jobs or other hard-working, low-paying jobs.
that most urban residents and even residents in nearby rural areas do not bother to
consider; they do not share the same urban culture with urban residents and they are
basically isolated from mainstream urban life. As a result, majority temporary
population in a large city is a ‘floating population’ (it used to be an official term) which
is generally restricted from an urban housing market (Song and Zenou, [20]), thus
demanding a more limited land space during their temporary stay.

Overall, the estimates of prefecture-level model are statistically more reliable and
resemble more with the full sample model in Table 2. It appears the two separate
models add more elaborated evidence that confirms explanatory power of the urban
land economics theory and the analytical model.

5.2. Estimate of ‘open’ city model

The ‘open’ city model is estimated with two regression equations. The first is a baseline
version with four basic variables and several city dummys. The second includes two
industrial and warehouse land use variables to control planned features of
non-residential land use, as well as three accessibility variables. The two models are
presented in Table 4.

--insert Table 4 about here--

Although trailing the ‘closed’ version model in goodness-of-fit statistic, the equations
appear reasonably good with adjusted R² of 0.633 and 0.723, respectively, suggesting
there is an equilibrium pattern in the data. The first four economic variables have
significant and expected signs. Without population variable in the reduced form
equation, urban income and value of rural land become the most significant economic
factors. The coefficients of the city dummys seem to tell a new story. The county-level
cities have a much larger and significant fixed effect. In the context of an ‘open’ city,
an urban spatial equilibrium is reached through migration. If the county-level cities
present fewer economic opportunities than do the larger cities (an obvious observation
in Chinese cities), disproportionately more migrants are attracted to larger cities,
resulting in more expansive urban areas in the larger cities. If population variables are
controlled (i.e., the ‘closed city’ case), this county-level effect will drop by about
two-third immediately. Similar interpretations apply to the other two regional
dummys—cities in the Central and Western regions. Both coefficients changed sign
from positive to negative with the Western become very significant, reflecting
rural-urban migration disproportionately more east-bound. Again, with population
controlled (‘closed’ city scenario), these dummys will switch sign right back to the
positive side. In short, these city dummys tend to capture part of effect of migration
and utility equilibration process, which is hard to be fully captured.
As discussed in section 3, temporary-permanent population ratio is a proxy of information cost for the migrants. The significant and positive coefficient supports the theoretical proposition that relatively more migrants in a given city means lower information cost that drives down the urban utility; in equilibrium the lower utility is related to a larger urban spatial scale. The smaller than expected coefficient reflects the fact that the cities are not completely open and instead they may be dominated by the permanent population who always stay in urban areas. The permanent population creates a ‘closed’ portion of a city. Migration induced by the pre-equilibrium rural-urban utility gap explains the variation in city size, but only a fraction of it. To be clear, this closedness of Chinese cities is a result of the longstanding residence registration system rather than a high level of urbanization as observed in a developed free market economy. Nonetheless, the statistical evidence suggests that rural-urban migration contributed to an equilibrium size at least of the ‘open’ portion of Chinese cities.

Three accessibility variables measure migration cost and equilibrium urban-rural utility gap. They are all expected to be inversely related to migration cost, the equilibrium rural-urban gap, the equilibrium utility level, and therefore positively related to urban spatial scale. The three coefficients are all positive and significant, indicating that express highway, regional railway center, and commercial airport services all facilitated migration-equilibration process and contributed to a larger size of urban spatial area. The much larger and more significant coefficients of express highway and railroad station are consistent with the fact that rural migrants use only these two transport modes, while intercity migrants travel by not only the two modes but also by air. As discussed early, the accessibility conditions attract transfer oriented firms, contributing to pre-equilibrium urban utility to begin with. Therefore, the estimated effects of the three variables are combination of a higher pre-equilibrium urban utility and a smaller equilibrium rural-urban utility gap. With these variables controlled, the dummy for capital cities is much smaller and now comparable to that in the ‘closed’ city equation. Obviously, three accessibility variables in combination are more substantial determinants of urban spatial scale than is the capital city status in ‘open’ cities. Lastly, planned urban non-residential land uses appear less important in the ‘open’ city model. Industrial land use may contribute to urban scale positively, but not as much as in the ‘closed’ city model; different size of warehouse land use does not seem to matter anymore.

Overall, the ‘open’ city model estimates support the notion that cities of a developing economy are ‘open’ to migrants and the rural-urban welfare gap induces migration until the city economic opportunities are exhausted and an equilibrium population size and hence an equilibrium spatial scale are reached. The model estimates show a general pattern of urban spatial equilibrium in the ‘open’ city context. By comparison, however, the ‘closed’ version equation explains the variation in urban spatial size better.
6. Caveats and Concluding Remarks

It is important to note two caveats before drawing conclusions. The first stems from the assumption of cities being either ‘closed’ or ‘open’. This assumption may not characterize Chinese cities very well, even if the literature suggests cities in developing countries, which China belongs to, are ‘open’ due to population migration. On one hand, rural-city and intercity gaps of income have attracted millions of migrant workers from rural areas to cities and from one city to another. On the other hand, average urban income has risen about ten percent annually in the recent years while average rural income has increased only about six percent per annum. As a result, urban-rural income gap has been widening. The mechanism that rural-urban migration raises urban land price and drives down urban standard of living to equilibrate rural-urban welfare has not manifested itself in Chinese economy. This is to some degree attributable to China’s very restrictive residence registration system. Even if the restriction has been gradually lifted, rural-to-urban migrants are still treated very differently. For example, a migrant is ineligible for many urban amenities. It seems more appropriate to place Chinese cities somewhere between the two ends and more toward the ‘closed’. We leave this for a future study. The second limitation stems from our use of several urban access variables in the ‘open’ city model. As briefly mentioned earlier, it is likely that number of highways and access to a major railway station and a commercial airport are endogenously determined with urban size. The only data available at this time are lagged measures of the access variables. Although we lag the urban access variables by three years, it may only reduce, not eliminate, endogeneity bias of the coefficients. Future analysis using instrumental variable(s) is needed to correct endogeneity bias completely.

With these caveats we conclude this analysis with a few remarks. The breathtaking expansion of urban areas in the past two decades, along with continuous shrink of arable land, has rightfully caused a major concern about seemingly unstoppable rural-urban land conversion. Built upon the standard monocentric urban land model, this empirical study investigated the determinants of urban spatial scale, taking into consideration several China-specific characteristics—temporary population within the residence registration system, designated non-residential urban land uses as a result of government planning, and different legal and administrative powers of cities within a hierarchical system. Two cross sectional urban spatial scale models, assuming the cities being ‘closed’ and ‘open’ respectively, were estimated using data from 659 Chinese cities for years 2002, 2003, and 2004.

The ‘closed’ city model estimates show that overall, market forces are the main determinants of urban size. Specifically, the four basic factors, urban population, urban income, commuting cost measured by city street surface per resident, and price of rural
land measured by GDP per unit of rural land, have explained nearly four-fifth of variation in urban spatial scales of Chinese cities. The findings are surprisingly similar to those found for US cities. The statistical evidence suggests that although Chinese cities may have inherited some features of urban land use planned by government, market forces today are dominating. If government planning do have significant effects on urban land use, they do not differ too much from those of market forces, implying either the urban plans are not as rigid as was commonly thought or the plans generally take market factors into account. With quite different goodness-of-fit statistics, it appears that the market mechanism has encountered far less resistance in allocating land between urban and rural uses in the prefecture or higher level cities than in the county-level cities.

The ‘open’ city model has not yet been tested extensively in the literature. To our knowledge this is the first such effort with nearly complete cross sectional city level observations in one country. The model shows income, price of rural land, and commuting cost all matter greatly in determining urban size. In the absence of exact measure of the equilibrium utility and in recognition of migration cost and variation in the equilibrium utility level due to the cost, temporary-permanent population ratio and accessibility measures—express highway, regional railway center, and commercial airport—were used to capture the effect of equilibrium utility. The statistical evidence supports the proposition that presence of migration workers in urban areas and urban accessibility reduce the migration cost and, therefore, drive down urban utility level and expand urban areas. Moreover, the accessibility factors explain sizes of the capital cities more than does the political/administrative status per se, an evidence of market forces that play a role more dominating than do non-economic forces.

We conclude that Chinese cities display a pattern of spatial equilibrium in urban land use. This pattern results not only from government planning but also, and more importantly, from market responses to economic opportunities. To the extent urban planning determines size of urban land use, the effect tends to be coincident with the market forces. Nevertheless, the magnitude of market effects on urban spatial scale in Chinese cities may be lower when compared to the estimated results from U.S. cities. For example, the elasticity of urban expansion with respect to income in Chinese cities is only one-tenth of that in US cities (Brueckner and Fansler, [4]), reflecting China’s economic status as a developing country.

The rapid expansion of urban spatial scale, a seemingly disturbing fact in the world’s most populous and fast growing country, generally reflects an optimization process of urban markets to allocate land to the most economical uses. However, lack of a formal agricultural land market must have distorted the equilibrium scale. This distortion can be corrected only by establishing a unified urban-rural land market and only after this correction is made, can we find out how much of the arable land shrinkage is
attributable to inefficient rural-urban land allocation. Moreover, market failures addressed in the literature (Brueckner, [7]) all apply to Chinese cities. These empirical issues call for different and more specific analyses.
References


Table 1. Data Source and Descriptive Statistics of 659 Cities

<table>
<thead>
<tr>
<th>Variable (unit) (Data Source)*</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban_area (km2) (U)</td>
<td>640.69</td>
<td>1259.93</td>
<td>7.00</td>
<td>12909.67</td>
</tr>
<tr>
<td>Built district (km2) (C)</td>
<td>43.01</td>
<td>76.22</td>
<td>2.60</td>
<td>1182.30</td>
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<tr>
<td>Urban Population (10,000) (C)</td>
<td>40.30</td>
<td>76.63</td>
<td>0.90</td>
<td>1080.00</td>
</tr>
<tr>
<td>Temporary popu. (10,000) (U)</td>
<td>5.63</td>
<td>27.24</td>
<td>0.00</td>
<td>536.15</td>
</tr>
<tr>
<td>Average Salary (1,000 yuan) (C)</td>
<td>11.67</td>
<td>3.84</td>
<td>3.26</td>
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<tr>
<td>GDP/FarmLand (10k yuan/km2) (C)</td>
<td>18129</td>
<td>92265</td>
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<td>2568291</td>
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<td>Road Surface (m²)/Resident (U)</td>
<td>10.23</td>
<td>5.24</td>
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<tr>
<td>Industry Area (m²)/Resident (U)</td>
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<td>Warehouse Area (m²)/Resident (U)</td>
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<td>5.19</td>
<td>0.02</td>
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<td>Industry Area % (C)</td>
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<td>7.65</td>
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<td>Warehouse Area % (C)</td>
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<td>Temporary Permanent Ratio (C)</td>
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<td>0.48</td>
<td>0.00</td>
<td>10.54</td>
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<tr>
<td>Express Highways (M)</td>
<td>1.29</td>
<td>1.16</td>
<td>0.00</td>
<td>9.00</td>
</tr>
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<td>Rail Road Center (C, M)</td>
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<td>1.36</td>
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<td>Commercial AirPort (C, M)</td>
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<td>1.05</td>
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<td>County-level City (C)</td>
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<td>Central Region (C)</td>
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<td>Western Region (C)</td>
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<td>0.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

* For data sources, U stands for China Statistical YearBook for Urban Construction; C stands for China Statistical YearBook for Cities; and M stands for the usage of maps for collection of information.
Table 2. ‘Closed’ City Regression Model Estimates of Chinese Urban Spatial Scales
Dependent variable: Natural log of radius of built district, mean: 1.063 km

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Baseline model</th>
<th>Model with additional controls</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Parameter Est.</td>
<td>Std Err.</td>
</tr>
<tr>
<td>Intercept</td>
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<td>0.04346</td>
</tr>
<tr>
<td>lnUrban Pop</td>
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<td>0.00505</td>
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<tr>
<td>lnTemporary Pop</td>
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<td></td>
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<tr>
<td>lnAverage Salary</td>
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<td>0.01661</td>
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<tr>
<td>lnGDP_Farmland</td>
<td>-0.01768</td>
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<tr>
<td>lnRoadSurface_Resident</td>
<td>0.05344</td>
<td>0.00933</td>
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<tr>
<td>lnIndustryArea_Resident</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnWarehouseArea_Resident</td>
<td></td>
<td></td>
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<tr>
<td>Capital city</td>
<td></td>
<td></td>
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<tr>
<td>County-level city</td>
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</tr>
<tr>
<td>Resource Center</td>
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<td></td>
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<tr>
<td>Central Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Region</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.  County-level versus Prefecture-level ‘Closed’ City Regression Estimates

| Independent variable | Parameter Est. | Std Err. | t-ratio | P>|t|  | Parameter Est. | Std Err. | t-ratio | P>|t|  |
|----------------------|----------------|----------|---------|------|----------------|----------|---------|------|
| Intercept            | -0.24866       | 0.05375  | -4.63   | <.0001 | -0.33426       | 0.06639  | -5.03   | <.0001 |
| lnUrban Population   | 0.31441        | 0.00878  | 35.80   | <.0001 | 0.38488        | 0.00825  | 46.63   | <.0001 |
| lnTemporary Population | 0.01916     | 0.00270  | 7.10    | <.0001 | 0.01139        | 0.00232  | 4.90    | <.0001 |
| lnAverage Salary     | 0.03112        | 0.01660  | 1.88    | 0.0610 | 0.05748        | 0.02316  | 2.48    | 0.0133 |
| lnGDP_FarmLand       | -0.01024       | 0.00282  | -3.63   | 0.0003 | -0.01721       | 0.00302  | -5.70   | <.0001 |
| lnRdSurface_Resident | 0.03975        | 0.00879  | 4.52    | <.0001 | 0.04093        | 0.01164  | 3.51    | 0.0005 |
| lnIndustryArea_Resident | 0.00412   | 0.00023  | 18.19   | <.0001 | 0.00342        | 0.00030  | 11.49   | <.0001 |
| lnWarehouseArea_Resident | 0.00981  | 0.00084  | 11.71   | <.0001 | 0.01284        | 0.00141  | 9.12    | <.0001 |
| Capital City         | -----          | -----    | -----   | ----- | 0.07339        | 0.02186  | 3.36    | 0.0008 |
| Resource Center      | -----          | -----    | -----   | ----- | 0.03893        | 0.02238  | 1.74    | 0.0824 |
| Central Region       | 0.03121        | 0.01108  | 2.82    | 0.0050 | 0.03814        | 0.01256  | 3.04    | 0.0025 |
| Western Region       | 0.05425        | 0.01354  | 4.01    | <.0001 | -0.01029       | 0.01481  | -0.70   | 0.4872 |
Table 4. ‘Open’ City Regression Model Estimates of Chinese Urban Spatial Scales
Dependent variable: Radius of Built district mean: 1.063

| Independent variable          | Parameter Est. | Std Err. | t-ratio | P>|t|  | Parameter Est. | Std Err. | t-ratio | P>|t|  |
|------------------------------|----------------|----------|---------|------|----------------|----------|---------|------|      |
| Intercept                    | 1.06211        | 0.06770  | 15.69   | <.0001 | 0.74758        | 0.06188  | 12.08   | <.0001 |      |
| lnTemp_Permanent Ratio       | 0.00861        | 0.00302  | 2.85    | 0.0044| 0.00613        | 0.00265  | 2.31    | 0.0212|      |
| lnAverage Salary             | 0.19006        | 0.02339  | 8.13    | <.0001| 0.10579        | 0.02105  | 5.03    | <.0001|      |
| lnRdSurface_Resident         | 0.04796        | 0.01251  | 3.83    | 0.0001| 0.04224        | 0.01089  | 3.88    | 0.0001|      |
| lnGDP_FarmLand               | -0.02935       | 0.00367  | -8.00   | <.0001| -0.02951       | 0.00321  | -9.18   | <.0001|      |
| lnIndustryArea_Resident      | ------         | ------   | ------  | ----- | 0.06642        | 0.00772  | 8.60    | <.0001|      |
| lnWarehouseArea_Resident     | ------         | ------   | ------  | ----- | 0.00361        | 0.00543  | 0.67    | 0.5056|      |
| Express Highway              | ------         | ------   | ------  | ----- | 0.08468        | 0.00602  | 14.07   | <.0001|      |
| Rail Road Center             | ------         | ------   | ------  | ----- | 0.07242        | 0.00577  | 12.55   | <.0001|      |
| Commercial Airport           | ------         | ------   | ------  | ----- | 0.03174        | 0.00737  | 4.31    | <.0001|      |
| Capital city                 | 0.68122        | 0.03112  | 21.89   | <.0001| 0.17628        | 0.03771  | 4.68    | <.0001|      |
| County-level city            | -0.51041       | 0.01324  | -38.55  | <.0001| -0.37681       | 0.01534  | -24.57  | <.0001|      |
| Resource enter               | 0.14836        | 0.04046  | 3.67    | 0.0003| 0.17841        | 0.03530  | 5.05    | <.0001|      |
| Central Region               | -0.01202       | 0.01479  | -0.81   | 0.4165| -0.00054       | 0.01317  | -0.04   | 0.9676|      |
| Western Region               | -0.15957       | 0.01728  | -9.23   | <.0001| -0.09392       | 0.01527  | -6.15   | <.0001|      |