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Demand for Urban Quality of Living in China: Evolution in Compensating Land-Rent and Wage-Rate Differentials

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Abstract The rapid pace of urbanization and income growth in China in the past decade, spurred in part by the liberalization of the urban housing and labor markets, resulted in considerable growth in urban land rents and wage-rates. The objective of this study is to examine the influence of urban quality of living, comprising social and environmental amenities, on the evolution of cross-city land-rent and wage-rate differentials in China. We employ the household data from the 1998 and 2004 Urban Household Survey (UHS) to compute the intercity land-rent and wage-rate differentials, inferring the rent growth in individual cities from a household housing consumption demand equation as home values were not reported in the earlier UHS. Our findings show a strong increase of urban residents' willingness to pay for local amenity qualities between 1998 and 2004.

Keywords Quality of living · Urban land rent · Urban wage rate · Labor mobility

Introduction

Free labor mobility across cities gives rise to differential land rents and wage rates necessary to clear the inter-city labor market. In equilibrium, the land rent premium of a city must be accounted for by the wage-rate premium (reflecting the differential urban productivity) and the urban amenity premium (reflecting the differential urban quality of living). A growing body of literature examines compensating differential

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land rents and wage rates across cities with respect to local amenities; see Gyourko et al. (1999) for a review. Roback (1982), Gyourko and Tracy (1991), Gabriel et al. (2003) and Gabriel and Rosenthal (2004), for example, estimate the compensating differentials for US cities. Berger et al. (2008) apply the analysis to Russian cites in the context of a transition economy. Recent studies also show widening compensating differentials reflecting the rising demand for urban amenities in Western countries (e.g. Glaeser et al. 2001; Costa and Kahn 2003; Shapiro 2006).

In the next two decades, according to UN-Habitat (2006), 95% of urban population growth in the world will be in developing economies. Yet little about the evolution of the demand for urban quality of living in these economies has been documented. We are aware of the social and environmental problems in many developing economies experiencing rapid urbanization and industrialization. China, for example, is the largest source of SO_2 emission in the world today and the health damages of air pollution cost China 3.8% of GDP (World Bank 2007). Environmental protection and sustainable growth in these developing economies requires institutional transformation (World Bank 2003). A rising demand for urban quality of living in these economies and the emergence of land-rent and wage-rate differentials compensating for local social and environmental amenities raise the prospects of environmental protection and improvement in public healthcare and education. If employees are willing to accept less pay in return for clean air or rents are higher where air is cleaner, for instance, market and political forces will act to provide cleaner air at the margin.

The objective of this study is to fill in the above knowledge gap by examining the evolution in compensating land-rents and wage-rate differentials across Chinese cities during a period of rapid urbanization and economic growth. We employ the household data from the annual Urban Household Survey (UHS) in China for estimating the intercity land-rent and wage-rate differentials. We are handicapped, however, by the absence of home value data in earlier UHS. To overcome this obstacle, we take a best-possible effort to infer the rent growth in individual cities based on a household housing consumption demand equation.

Our study period, between 1998 and 2004, coincides with China's peak phase of urbanization. 28% of Chinese population lived in cities in 1990; the urbanization level increased to 33% in 1998 and 42% in 2004 (Statistics Yearbook of China). This rapid pace of urbanization was driven by strong economic growth and the liberalization of the urban housing and labor markets. Year 1998 marked the end of the state-provided housing welfare system—a major impediment to labor mobility—and the beginning of a private housing market boom (see Zheng et al. 2006, for additional background of the housing reform in China). The rapid urbanization is accompanied by massive relocation of workers (Chen and Coulson 2002).[1] Many cities experienced significant land rent growth during our study period, reflecting possibly both urban productivity growth and the rising demand for urban quality of living.[2]

[1] According to the 2000 census, over 8.3% of the population moved within provinces between 1995 and 2000 and 3.9% moved across provinces. About 14% of the residents in Beijing, Shanghai, and Guangdong province in 2000, for example, were new arrivals after 1995.

[2] In year 2004, 2005 and 2006, the average price of new homes sold in the private housing market in 35 major Chinese cities grew by 11.5%, 12.9% and 18.9% respectively. The price appreciation may reflect both land rent growth during the period and expectations about future land rent growth.

Our analysis of the compensating variation in land rents and wage rates follows the basic framework developed in the literature (see, e.g., Roback 1982; Blomquist et al. 1988; and Kahn 2006). We show that the difference between land-rent premium and wage-rate premium reflects the willingness to pay for local amenities, i.e. the amenity premium. The local amenity indicators examined in this study include natural amenity (summer and winter temperature severity), social amenities (availability of medical doctors and average education level of the population in the city) and environmental amenities (SO_2 emission, green space and road density). We find little compensating variation in land rents and wage rates with respect to these amenity measures in 1998. However, the compensating differentials rose between 1998 and 2004. The finding is consistent with the anecdotal evidence of rising demand for urban quality of living over the past decade as household income and labor mobility grew significantly in China.[3] Such increased demand is revealed by the households' greater willingness to pay to living in cities with better quality of living.

We present our findings below in four sections. In "Estimating Land-Rent Differential and Growth", we present our estimates of the implicit housing rent differentials and growth across the Chinese cities in our sample. We describe our urban amenity measures in "Measuring Urban Amenities". Our main results regarding the change in the demand for urban quality of living as indicated by the evolution in differential land rents and wage rates differential are reported in "The Evolution in Cross-City Land-Rent and Wage-Rate Differentials". We conclude in "Conclusions".

Estimating Land-Rent Differential and Growth

Measuring Land-Rent Differential and Growth in a Housing Demand Equation

Extant studies of compensating differential land rents and wage rates typically rely on household survey data to estimate the intercity differentials. In particular, reported home values are often relied upon for estimating the intercity housing rent differential. Data on home values are collected in household surveys only recently in China. In order to impute the changes in housing cost over our study period across individual cities, we need to model the household consumption of housing attributes as a function of income, demographic characteristics, and housing cost. We consider a system of open cities in a country with free labor mobility. Land rent premium arises through bid rent for housing by mobile households; hence housing rent differentials across cities provide a sufficient description of the land rent differentials. To estimate the housing rent differentials, we consider a household j in city k

[3] A survey of over 2,000 urban residents conducted by China Urban Studies Association in 2007 shows good urban environment to be the most popular reason for the choice of their current residing city, followed by cultural amenity, place of birth, employment opportunities, and housing affordability. The same survey finds good environment considered to be the most important characteristics of a livable city, followed by safety, low cost of living, cultural amenities, and employment opportunities. See http://ccdv.people.com.cn/GB/66982/6482999.html.

and at time t who derives CES utility u_{jkt} from the consumption of a vector of urban amenities $\boldsymbol{a}_{kt}$, housing quantity Q_{jkt} and a traded good C_{jkt}:

$$u_{jkt} = A_{kt}(a_{kt}) \cdot \left(\theta_j \cdot Q_{jkt}^{\frac{\sigma-1}{\sigma}} + C_{jkt}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $\sigma \geq 0$ is the elasticity of substitution, $\theta > 0$ reflects the strength of housing preference, and A_{kt} represents the utility derived from the quality of living comprising $\boldsymbol{a}_{kt}$. With household income Y_{jkt} and housing rental rate r_{kt} measured in units of C, the indirect utility is given by

$$v_{jt} = A_{kt}\left[\theta_j + \left(\frac{r_{kt}}{\theta_j}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}} \frac{\theta_j Y_{jkt}}{r_{kt}}, \forall k \tag{2}$$

and, by Roy's identity, the demand for housing consumption is:

$$Q_{jkt} = \frac{\theta_j^{\sigma}}{\theta_j^{\sigma} + r_{kt}^{\sigma-1}} \frac{Y_{jkt}}{r_{kt}}. \tag{3}$$

The indirect utility v_{jt} is independent of k in equilibrium to remove the incentive for mobile households to relocate between cities. We note that the housing demand increases with θ and that σ has to be less than unity for housing expenditure to rise with rent r_{kt} as we would expect.

To derive a log linear housing demand equation, we define $r_{kt} \equiv r_k \cdot \delta_{kt}$, with r_k being the base-period rent in city k (k=0 for the default city) and δ_{kt} the rent index at time t relative to the base period. We note that

$$\begin{aligned} \ln \frac{\theta_j^{\sigma}}{\theta_j^{\sigma} + r_{kt}^{\sigma-1}} &= \ln \theta_j^{\sigma} - \ln\left(\theta_j^{\sigma} + e^{(\sigma-1)\ln r_{kt}}\right) \\ &\approx \ln \frac{\theta_j^{\sigma}}{\theta_j^{\sigma} + r_0^{\sigma-1}} + \frac{(1-\sigma) r_0^{\sigma-1}}{\theta_j^{\sigma} + r_0^{\sigma-1}} \ln \frac{r_{kt}}{r_0}, \end{aligned} \tag{4}$$

where the approximation follows the first-order Tyler expansion of the left-hand side of the equation with respect to $\ln r_{kt}$ around the log base-period rent in the default city, $\ln r_0$. Applying logarithm to Eq. 3, and using Eq. 4, we obtain the log linear housing demand equation:

$$\ln\left(r_k Q_{jkt}\right) = \ln Y_{jkt} + \ln \frac{\theta_j^{\sigma}}{\theta_j^{\sigma} + r_0^{\sigma-1}} + \frac{(1-\sigma) r_0^{\sigma-1}}{\theta_j^{\sigma} + r_0^{\sigma-1}} \ln \frac{r_k}{r_0} - \frac{\theta_j^{\sigma} + \sigma r_0^{\sigma-1}}{\theta_j^{\sigma} + r_0^{\sigma-1}} \ln \delta_{kt}. \tag{5}$$

Note that the left-hand side of Eq. 5 is the real value of housing consumption measured in the base-period rent r_k. For empirical specification, we will substitute various measures of household income for Y_{jkt} and replace the second term with household attributes that influence the housing preference θ. Without loss of generality we assume θ to vary across the population around a mean value of unity and we impose the constraint that the coefficients of ln (r_k/r_0) and ln δ_{kt} reflect the mean value of $\theta=1$ so that they are invariant across households. Consequently we define

$$R_k \equiv \frac{(1-\sigma)r_0^{\sigma-1}}{1+r_0^{\sigma-1}} \ln \frac{r_k}{r_0} \tag{6}$$

and

$$S_k \equiv \frac{1+\sigma r_0^{\sigma-1}}{1+r_0^{\sigma-1}} \ln \delta_{kt} \tag{7}$$

to capture, respectively, the implicit housing rent differential (with respect to the default city) and housing rent growth (with respect to the base period) for city k. The empirical version of Equation 5 becomes:

$$\begin{aligned} \ln\left(r_k Q_{jkt}\right) = \alpha_0 + \alpha_1 \cdot \ln\left(YE_{jkt}\right) + \alpha_2 \cdot \ln\left(YP_{jkt}\right) + \alpha_3 \cdot \ln\left(YA_{jkt}\right) \\ +\alpha_4 \cdot \ln\left(AGE_{jt}\right) + \alpha_5 \cdot HSIZE_{jt} + R_k - S_k \cdot I_{2004} + \varepsilon_{jkt}, \end{aligned} \tag{8}$$

where YE, YP, and YA are, respectively, the household current employment income, household "permanent" employment income, and household income from assets; the AGE of the household head and the household size $HSIZE$ indicate differences in housing preferences θ; I_{2004} is a binary variable that turns on in the ending period (year 2004); and ε is the random error residual. The key estimates in Eq. 8 for our purposes are R_k and S_k, which can be identified respectively as the city fixed effects and the year 2004 city fixed effects. As R_k and S_k are sufficient description of the land rent differential and land rent growth across cities, we will also refer to them also as estimates of implicit log land rent differential and land rent growth respectively.

The Urban Household Survey Data

We employ the official Urban Household Survey (UHS) data in this study. We have a sample of 85 cities representing all provinces (and provincial level cities) except Tibet, which are included in the UHS in both year 1998 and 2004 and have the city-level data necessary for our cross-city hedonic analysis. The UHS sampling method is described in the Appendix, where Table 4 lists the 85 cities. On average the sample size (excluding the observations with household head retired or unemployed) for each city is about 100 households in 1998 and is about twice as big in 2004. The households in the UHS do not necessary overlap across the survey years. The variables measuring household income, demographic characteristics and housing attributes, based on the UHS data, are summarized in Table 5.

For the purpose of this study, several variables need to be constructed from the UHS data. We first construct the real value of housing consumption $r_k Q_{jkt}$ for the left-hand side of Eq. 8. We do so by converting the observed bundle of housing attributes of individual households into a market value measure, MV_{jkt}, using the 2004 implicit prices of these housing attributes as our metric. We assume $r_k Q_{jkt}$ to be proportional to MV_{jkt}. UHS began to report the market value of home for homeowners in 2002; the value is estimated by UHS surveyors using a simple sales comparison approach. We employ the sample of homeowners in 2004 UHS to estimate the implicit prices of the housing attributes. The bundle of housing attributes used in the hedonic regression include dwelling size, dwelling types (by the number of bedrooms), building types (old house, single family house, and others), and dwelling amenities (bath, air conditioning, kitchen facilities). These variables are described in Table 5 in the Housing Attributes section. A separate hedonic regression for each province, with city fixed effects, is estimated so that the implicit prices are allowed to vary by provinces to reflect climate differences (there are 29 province-specific hedonic regressions with an average sample size of 593 observations from the 2004 UHS). These implicit price estimates, not reported here but available from the authors upon request, are applied to the observed bundle of housing attributes to compute the market value estimate MV_{jkt} for all households in the 1998 and 2004 UHS samples. The sample statistics of the MV_{jkt} estimates are reported in Table 5 at the end of the Housing Attributes section.

The hedonic housing price estimates described above are admittedly very rough, as the limited sample size of homeowners in individual cities necessitates the assumption of invariant implicit hedonic prices across the cities within each province. Furthermore, we do not observe the intra-city location of the individual households (a common problem for intercity housing rent differential estimates in extant studies). To the extent that the hedonic housing attributes vary systematically by locations within individual cities, the implicit price estimates would reflect the marginal contribution of both the hedonic attributes and the location to the market value; hence the resulting measure of the real consumption value MV_{jkt} would implicitly reflect the location value as well. The use of 2004 implicit hedonic prices to compute the quantity of housing consumption in both years is called for by Eq. 5, where the dependent variable is the value of housing consumption in fixed price. Shifts in the implicit prices between 1998 and 2004 would be reflected by the rent index δ_{kt}. We are not concerned with the relative shifts among the implicit prices of various dwelling attributes that may occur over time, as our focus is on the choice between housing and non-housing consumption rather than the choice of different housing attributes. The use of the implicit prices in 2004 instead of those in 1998 as the metric of real housing consumption value is due to the availability of the market value estimates.

To assess the possible influence of the measurement errors in the 2004 hedonic price estimates on the coefficient estimates of the demand equation, we denote $r'_k Q_{jkt}$ the real housing consumption value computed using the estimated hedonic prices as the metric and $\mu_{jkt} \equiv \ln r'_k Q_{jkt} - \ln r_k Q_{jkt}$ the measurement error. Equation 5 can be rewritten as:

$$\ln\left(r'_k Q_{jkt}\right) = \ln Y_{jkt} + \ln \frac{\theta_j^\sigma}{\theta_j^\sigma + r_0^{\sigma-1}} + R_k - S_k \cdot I_{2004} + \mu_{jkt}. \quad (9)$$

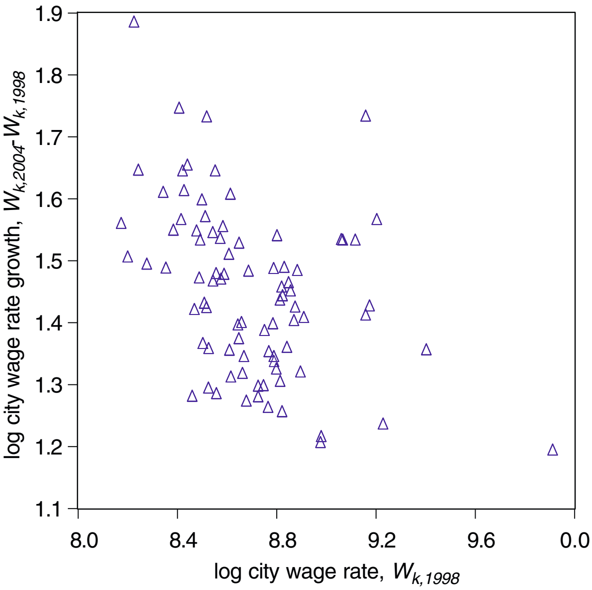
Thus the estimates of the city fixed effects R_k and S_k would not be biased as long as the condition $\sum_j \mu_{jkt} = 0$ holds for the individual cities in each period. We assume such condition to be sufficiently satisfied for our sample due to the randomization in UHS sampling in individual cities.

The second key variable to be constructed from the UHS data is a measure of permanent income for the individual households, YP_{jkt}. This variable is necessary for the estimation of the housing demand equation, as rational households who expect a reasonably long tenure in their current home would choose their housing consumption quantity based on their expected earnings as opposed to their current earnings. We follow the standard labor economics literature to predict expected earnings according to households' human capital and demographics. The Mincerian wage equation, augmented with industry and city fixed effects, is:

$$\begin{aligned}\ln\left(YE_{jkt}\right) &\equiv \ln\left(YP_{jkt}\right) + \omega_{jkt} \\ &= \left[\gamma_{0t} + \gamma_{1t}GENDER_{jt} + \gamma_{2t}\ln\left(AGE_{jt}\right) + \gamma_{3t}YSCH_{jt} + \gamma_{4t}HSIZE_{jt} \right.\\ &\quad \left. + \gamma_{5t}EMP\_TER_{jt} + \gamma_{6t}EMP\_PRV_{jt} + \gamma_{7t}EMP\_PRP_{jt} + W_{kt}\right] + \omega_{jkt}.\end{aligned} \tag{10}$$

Equation 10 explains the household annual income from employment *YE* in terms of the household head's human capital attributes (*GENDER*, *AGE*, and years of schooling *YSCH*); household size (*HSIZE*), which controls for the quantity of labor supply; the employment sector of the household head (*EMP_TER*, *EMP_PRV* and *EMP_PRP* for tertiary industry and public institutions, private sector, and sole proprietorship, respectively), allowing for differential wage rates to compensate differential employment risks across sectors; and the city fixed effects W_{kt}, reflecting urban wage rate differentials due to urban productivity differences. ω_{jkt} is a random error term. Equation 10 is estimated separately for year 1998 and 2004, to allow the coefficients to vary over time. The expression in the square brackets determines the log permanent income *YP* for individual households. The sample statistics of the estimated *YP*, its determinants, and the city fixed effects on wage rate W_{kt} are reported

Fig. 1 Estimates of city wage rates $W_{k,1998}$ and wage rate growth $W_{k,2004}-W_{k,1998}$



in Table 5 in the Appendix. The coefficient estimates of Equation 10 are reported in Table 6 in the Appendix. Figure 1 plots $W_{k,2004} - W_{k,1998}$ against $W_{k,1998}$ across the cities and Fig. 3 shows the correlation between $W_{k,1998}$ and city size across cities.

The relatively small sample size for individual cities, again, necessitates the assumption of invariant γ coefficients across cities (extant studies of intercity wage rate variations tend to assume invariant returns to individual attributes). Our experiments to allow γ coefficients to vary by regional or size groups of cities result in no material differences in the estimates of R_k and S_k.

The Estimates of the Housing Demand Equation

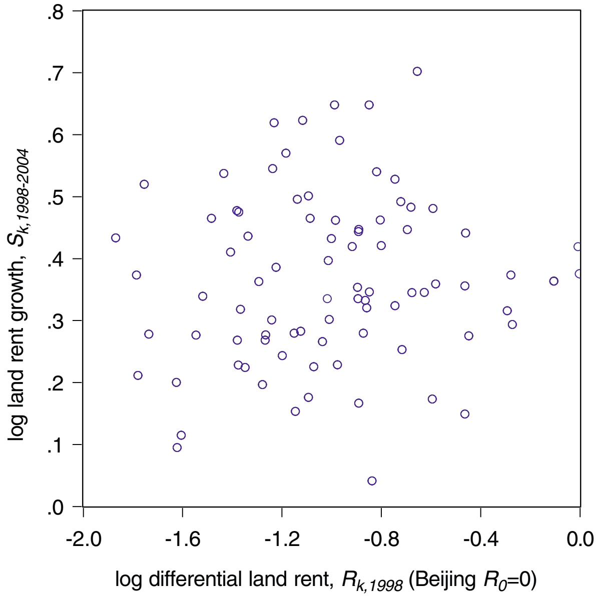
With our measure of the real housing consumption value MV_{jkt} (which are assumed proportional to $r_k Q_{jkt}$) and the household permanent income YP_{jkt} and the other variables directly observed in the UHS data, we can now estimate the housing demand Eq. 8 to obtain the implicit land rent differential and land rent growth measures R_k and S_k. One concern is that the observed household income measures YE_{jkt}, YP_{jkt} and YA_{jkt} may not fully reflect the differential purchasing power of the households in different cities due to possible variations in in-kind payments by local governments. As a result, R_k and S_k estimates may pick up the differential in-kind payments in addition to the land rent differential. To mitigate such bias, we construct a variable $CNSMPR_{kt}$, defined as the ratio of per capita consumption over per capita gross income in city k and time t. We assume this variable to be negatively correlated with in-kind payments across the cities—households receiving more in-kind payments would be able to save more of their take-home income. Unfortunately the coefficient of $CNSMPR_{kt}$ cannot be identified in the housing demand regression when we include city fixed effects for both years in the regression. We deal with this identification problem by simply setting its coefficient to −1.[4]

The coefficient estimates for Eq. 8 are reported in Table 7 in the Appendix. Generally, housing demand increases with both the current income and permanent income measures. Asset income also raises housing demand. The significant influence of the current income measure on housing demand is indicative of credit constraints faced by the majority of Chinese urban households. We find that housing demand increases with the age of the household head and household size; each additional household member increases housing consumption by about 5.3%.

The estimates of the implicit land rent differential and growth are displayed in Fig. 2. Beijing (the default city) appears to have the highest land rent in 1998; but it does not have the highest land rent growth between 1998 and 2004. We observe a fairly wide range of land rent differential and land rent growth across the 85 cities. Figure 3 shows that the implicit land rent differential is positively correlated with city size, as expected.

[4] This coefficient value of −1 is close to its estimate when we include $CNSMPR_{kt}$ on the right-hand side of Eq. 8 but replace $S_k \cdot I_{2004}$ with the urban amenity variables defined in the next section.

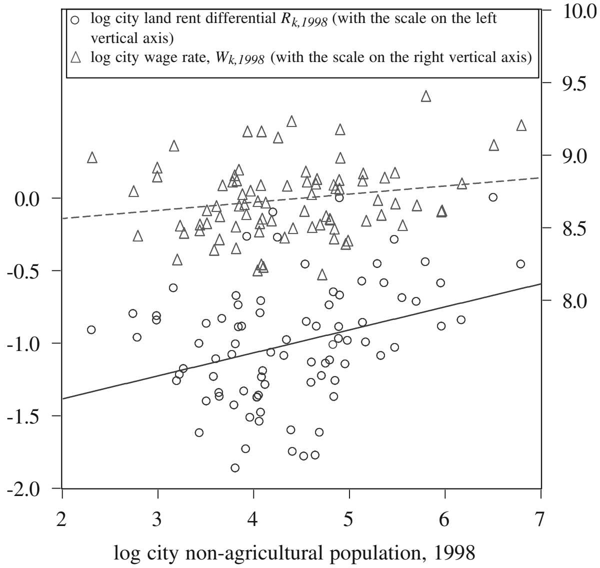
Fig. 2 Estimates of implicit land rent differential R_k and land rent growth S_k (subject to a scale) across 85 cities



Measuring Urban Amenities

We construct three groups of urban amenity measures for year 1998 based on data published in China Urban Statistics Yearbook: the natural amenity conditions, social amenity conditions and physical amenity conditions. The computation and the sample statistics of these amenity indicators are provided in Table 5 in the Appendix.

Fig. 3 Estimates of city land rent differential R_k (*solid regression line*) and city wage rate W_k (*dashed regression line*) against city population size, 1998



The natural amenity is represented by the city temperature discomfort index, defined as:

$$TEMPDX_k = \sqrt{\begin{array}{c}(Winter\_temperature_k - max\,(Winter\_temperature))^2 \\ +(Summer\_temperature_k - min\,(Summer\_temperature))^2.\end{array}} \quad (11)$$

It is the distance of the city's winter and summer temperature from the most mild of the winter and summer temperature across the 85 cities (this measure is based on 2004 data, as 1998 data is not available). A higher *TEMPDX* means a more harsh winter or a hotter summer, which makes the city a less pleasant place to live. Although other climate conditions, especially the humidity level, would also affect the comfort level, the local humidity level in China tends to be closely correlated with local temperatures.

We choose the availability of healthcare service and the average education level of the city residents as the social amenity indicators; they are defined respectively as the number of doctors per 1,000 city residents (*DOCTOR*) and average years of schooling of the city's adult population (*EDU*). Public healthcare is very much in short supply in China, more so in rural areas than in cities (*The Economist* 2007). We expect a higher *DOCTOR* to raise the urban quality of living. Higher *EDU* enhances learning opportunities in cities through non-market interactions, which is a major benefit provided by cities (Glaeser and Mare 2001; Rauch 1993). *EDU* can also be correlated with the supply of cultural amenities in the city (Shapiro 2006).

The environmental amenity indicators include the annual SO2 emission per GDP, *SO2GDP*; green space per capita, *GREEN*; and road space per capita, *ROAD*. One potential problem with the per capita conditions *GREEN* and *ROAD* is that they can be correlated with omitted amenity measures; for example, a lower road space per capita, undesirable by itself, could be to the result of the city's popularity. Thus the effect of these per capita amenity conditions can be underestimated when there are omitted city popularity attributes in the cross-city regression. Both *GREEN* and *ROAD* are desirable amenities; to make the cross-city regression parsimonious, we combine them in to one composite measure: $GREEN\_ROAD \equiv GREEN/\text{stdev}(GREEN)+ROAD/\text{stdev}(ROAD)$.

Table 1 Correlation between city amenity variables (84 cities)

ID	Variables	1	2	3	4	5	6	7	8
1	*TEMPDX*								
2	*DOCTOR*	−0.09							
3	*EDU*	−0.06	0.04						
4	*SO2GDP*	0.13	−0.03	0.00					
5	*GREEN*	−0.18	0.04	0.12	−0.14				
6	*ROAD*	−0.03	0.26	0.12	−0.20	0.35			
7	*GREEN_ROAD*	−0.13	0.18	0.14	−0.20	0.82	0.82		
8	W_{1998}	−0.41	0.16	0.14	−0.33	0.34	0.45	0.48	
9	ln(*POP*)	0.20	−0.07	0.10	−0.08	−0.06	−0.11	−0.11	0.16

Table 1 shows the correlation among the amenity indicators and their correlation with urban size ln(*POP*) and income W_{1998}. Note that *GREEN_ROAD* is highly positively correlated with *GREEN* and *ROAD* but negatively correlated with ln(*POP*). We note also that cities with a higher *TEMPDX* index (often in more arid regions) tend to be more industrialized (higher *SO2GDP*) and with a lower urban wage rate. Cities with higher human capital (a higher *EDU*) tend to be richer, larger, and greener and have more road space per capita. The number of doctors per resident tends to be higher in richer but not necessarily larger cities.

The Evolution in Cross-City Land-Rent and Wage-Rate Differentials

To examine the determinants of the cross-city land rent differentials, we apply log difference to Eq. 2 with respect to a representative household. Since we are concerned with the willingness to pay for the land rent across cities for a given individual, we assume $\theta=1$. Differencing the log indirect utility, and using the approximation in Eq. 4, we have:

$$\begin{aligned}\Delta \ln v_{jt} &= \Delta \ln A_{kt} + \Delta \ln \left(1 + r_{kt}^{\sigma-1}\right)^{\frac{1}{\sigma-1}} - \Delta \ln r_{kt} + \Delta \ln Y_{jkt} \\ &\approx \Delta \ln A_{kt} - \frac{1}{1 + r_0^{\sigma-1}} \Delta \ln r_{kt} + \Delta \ln Y_{jkt}\end{aligned} \tag{12}$$

which gives the cross-city hedonic price equation:

$$\frac{1}{1 + r_0^{\sigma-1}} \Delta \ln r_{kt} = \Delta \ln A_{kt} + \Delta \ln Y_{jkt} - \Delta \ln v_{jt}. \tag{13}$$

Equation 13 informs us about the determinants of the land rent premium in two respects. Let Δ_k denote differencing with respect to the default city and Δ_t, with respect to the base period. First, across cities at a particular time t, the land rent differential $\Delta_k \ln r_{kt}$ reflects (1) the differential amenity utility $\Delta_k \ln A_{kt}$ due to the quality-of-living variations across cities and (2) the differential urban wage rate $\Delta_k \ln Y_{jkt}$ due to urban productivity differences. Second, between time periods, the land rent growth $\Delta_t \ln r_{kt}$ reflects (1) increase in amenity utility $\Delta_t \ln A_{kt}$ due to changes either in the taste for quality living or in the urban amenity conditions and (2) the growth in urban wage rate $\Delta_t \ln Y_{jkt}$ due to urban productivity growth. Note that $\Delta_k \ln v_{jt}=0$ and $\Delta_t \ln v_{jt}$ is constant across cities as a result of free labor mobility. Accordingly, using the implicit land rent differential and land rent growth estimates obtained in "Estimating Land-Rent Differential and Growth," we have:

$$\frac{R_k}{(1-\sigma) r_0^{\sigma-1}} - \Delta_k \ln Y_{jkt} = \Delta_k \ln A_{kt}, \tag{14}$$

$$\frac{S_k}{1 + \sigma r_0^{\sigma-1}} - \Delta_t \ln Y_{jkt} = \Delta_t \ln A_{kt} - \Delta_t \ln v_{jt}. \tag{15}$$

These two equations allow us to estimate the willingness to pay, in terms of the land rent and wage rate differentials, for urban amenity conditions. If we assume housing expenditure in the default city (Beijing) accounts for a quarter of the household total consumption, Eq. 3 suggests that $r_0^{\sigma-1} = 3$for θ=1. Furthermore, for housing demand to be inelastic, σ would be less than unity. At σ=1/3, for example, we have

$$\begin{aligned} \frac{R_k}{2} - \Delta_k \ln Y_{jkt} &= \Delta_k \ln A_{kt}, \\ \frac{S_k}{2} - \Delta_t \ln Y_{jkt} &= \Delta_t \ln A_{kt} - \Delta_t \ln v_{jt}. \end{aligned} \tag{16}$$

Extant studies of compensating differential land rents and wage rates often estimate the effects of the amenity variables on land rents and wage rates separately and merge the estimates according to Eqs. 14 and 15 to compute the amenity premium (people's willingness to pay for the urban amenities). Such approach requires the inclusion of urban productivity variables in addition to the amenity variables in the respectively land-rent and wage-rate regressions to prevent the omitted variable bias in the amenity effect estimates. In contrast, Eqs. 14 and 15 are independent of the urban productivity variables, as their effects on the land rent differentials are always offset by their effects on the wage rate differentials. We will estimate the amenity premium directly using Eqs. 14 and 15 at different values of σ.[5] The cross-city regressions are based on a sample of 84 cities (Nanchong city is excluded due to its undue influence on the estimates).

The Estimates of the Willingness to Pay for Urban Amenities in 1998

We first estimate the amenity premium—the willingness to pay for the amenity conditions described in "Measuring Urban Amenities"—according to Eq. 14. We include the log city population size as an additional explanatory variable to control for potential measurement errors in R_k due to possible variations in the MV-to-$r_k Q_{jkt}$ ratio by city size. The estimates are reported in Table 2 and appear consistent under alternative values of the elasticity σ. Overall, the marginal willingness to pay for the amenity conditions is either insignificant (*DOCTOR*, *EDU*) or of the wrong sign (*TEMPDX*, *SO2GDP* and *GREEN_ROAD*). In summary, we find little compensating variation in land rents and wage rates across the Chinese cities in 1998 with respect to differences in local amenity qualities.

The Estimates of the Change in the Willingness to Pay for Urban Amenities

We further examine the change in the amenity premium between 1998 and 2004 according to Eq. 15. We include the initial land rent R_k in the equation to account for possible disequilibrium in the initial rent level. The estimates are reported in Table 3 and, again, appear fairly robust under the alternative values of σ.

[5] Shapiro (2006) reports the estimates of an amenity premium based an equation similar to Eq. 15. Many extant studies include urban amenity variables but not urban productivity variables in estimating the intercity land-rent and wage-rate differentials respectively; these estimates would suffer the omitted variable bias.

Table 2 Estimates of the amenity premium in 1998

Columns	1	2	3
CES σ assumption	σ=1/6	σ=1/3	σ=1/2
Constant	−9.06 (19)***	−9.27 (19)***	−9.64 (18)***
TEMPDX	0.008 (2.7)***	0.007 (2.1)**	0.005 (1.3)
DOCTOR	0.003 (0.3)	0.006 (0.5)	0.011 (0.8)
EDU	0.000 (0.0)	0.003 (0.1)	0.009 (0.2)
SO2GDP	0.006 (2.2)**	0.005 (1.6)	0.003 (0.8)
GREEN_ROAD	−0.055 (2.4)**	−0.051 (2.2)**	−0.044 (1.8)*
ln*(POP)*	−0.013 (0.5)	0.006 (0.2)	0.037 (1.3)
R squared	0.302	0.237	0.152

The dependent variable is $\frac{R_k}{(1-\sigma)r_0^{\sigma-1}} - W_{k,1998}$. $r_0^{\sigma-1} = 3$. *t*-statistics based on white heteroskedasticity-consistent standard errors and covariance are in parentheses. The number of observations is 84
*p=0.10, **p=0.05, ***p=0.01

Overall the estimates show significant increases in the willingness to pay for the urban amenity qualities. The most significant increases are in the willingness to pay for good climate (a low *TEMPDX*), for good human capital environment (a high *EDU*), for clean air (a low *SO2GDP*), and for good built-up environment (a high *GREEN_ROAD*). There is relatively marginal increase in the willingness to pay for *DOCTOR*.

One question is whether the increased willingness to pay is due to changes in the urban amenity conditions or due to increased demand for the quality of living as household income increases. Unfortunately, due to changes in city political boundaries and the statistical definitions over time, comparison of the urban amenity indicators between 1998 and 2004 is not reliable and we find no evidence that changes in these indicators significantly influence the changes in the willingness to pay. We believe that the changes in the willingness to pay largely reflect the increased demand for urban quality of living in China; after all, the natural amenity indicator *TEMPDX* would have changed little during our sample period. Costa and Kahn (2003) also find increased valuation of climate over time in USA. Glaeser et

Table 3 Estimates of amenity premium change between 1998 and 2004

Columns	1	2	3
CES σ assumption	σ=1/6	σ=1/3	σ=1/2
Constant	−2.47 (6.7)***	−2.46 (7.0)***	−2.45 (7.1)***
TEMPDX	−0.007 (4.0)***	−0.006 (4.1)***	−0.006 (4.1)***
DOCTOR	0.013 (2.0)**	0.010 (1.8)*	0.009 (1.5)
EDU	0.108 (3.5)***	0.101 (3.4)***	0.096 (3.3)***
SO2GDP	−0.005 (1.9)*	−0.005 (2.2)**	−0.005 (2.3)**
GREEN_ROAD	0.012 (1.9)*	0.014 (2.2)**	0.015 (2.3)**
R_k	−0.062 (1.9)*	−0.064 (2.1)**	−0.066 (2.3)**
R squared	0.387	0.394	0.392

The dependent variable is $\frac{S_k}{1+\sigma r_0^{\sigma-1}} - \left(W_{k,2004} - W_{k,1998}\right)$. $r_0^{\sigma-1} = 3$. *t*-statistics based on white heteroskedasticity-consistent standard errors and covariance are in parentheses. The number of observations is 84 (Nonchong city excluded).
*p=0.10, **p=0.05, ***p=0.01

al. (2001) find that land rent grew faster than wage rates in high-amenity cities in USA and Europe in the 1990s. Shapiro (2006) finds concentration of college graduates positively correlated with the land rent growth in excess of wage rate growth in US cities. This study shows that, with rapidly rising urban income in China, the demand for the quality of living rose; consequently the land rents in high-amenity cities are found to grow faster than the wage rates.

Conclusions

We have presented an analysis of the evolution in land-rent and wage-rate differentials across cities in China between 1998 and 2004 using China's Urban Household Survey (UHS) data. The period is characterized by major liberalization of the urban housing and labor markets and the ensuing increase in labor mobility, urbanization, and household income. We show that land rents grew faster than wage rates in cities with more desirable amenity conditions during the period, reflecting a strong increase in the willingness to pay for the quality of living in Chinese cities.

Our analysis, however, is subject to important limitations arising from the employment of several untested assumptions necessary to infer the changes in housing rent cost across cities based on a household housing demand equation, as home values in the earlier periods are not reported in the UHS. The findings reported here thus are the results of a best-possible first effort to examine the evolution in cross-city land-rent and wage-rate differentials in the context of a fast developing economy, where reliable data on historical home values are often nonexistent due to the immaturity of the urban land market in earlier time periods. Given such reality of data limitations, future studies to corroborate the robustness of our method of estimating the cross-city rent growth would be useful. Our rent growth estimates S_k reflect the price incentives for housing consumption for individual households, who respond to the price changes by either adjusting the housing quantity through moving or adjusting their household size. The estimates thus reflect the change in the willingness to pay for housing consumption by the urban residents.

Finally, we hope that this study will motivate more research on the evolution of the demand for urban quality of living in developing economies, where rapid urbanization is expected in the next few decades (UN-Habitat 2006). More evidence is needed to strengthen our knowledge of the link between income growth and the demand for urban amenities. A growing willingness to pay for urban social and environmental quality in developing economies, and the capitalization of such willingness to pay in urban land-rent and wage-rate differentials, would raise the prospects of environmental protection and sustainable economic development to the benefit of not only the local communities but also the global economy.[6]

[6] Chinese congress enacted Property Law in March 2007, providing enhanced property rights to homeowners, and the fiscal reform is in underway to enable the local governments to tax urban land rents. With the quality of living capitalized in local land rents, the local governments would be more motivated to raise the local quality of living in order to increase local revenue.

Appendix. The Urban Household Survey Sample and Variables

Urban Household Survey is conducted annually by the Urban Survey Department of the National Statistic Bureau of China. It covers about 200 cities representing all provinces and population-size groups. Within each group, cities are sorted by average wages and are sampled at fixed distances. In each city, households are selected through a three-stage random sampling. Streets and neighborhoods are sorted and sampled at fixed distance, followed by the sampling of households within the selected neighborhoods. Table 4 lists the 85 cities included in this study, where the number of observations for each city excludes those with household head retired or unemployed.

Table 4 UHS sample size across 85 cities

City	City ID	Number of observations		City	City ID	Number of observations		City	City ID	Number of observations	
		1998	2004			1998	2004			1998	2004
Beijing	110100	299	1,587	Xuzhou	320300	68	201	Zhuzhou	430200	80	87
Tianjin	120100	335	1,199	Nantong	320600	61	152	Shaoyang	430500	91	84
Shijiazhuang	130100	91	294	Yangzhou	321000	78	155	Yueyang	430600	97	67
Tangshan	130200	50	150	Hangzhou	330100	75	239	Changde	430700	92	76
Qinhuangdao	130300	69	145	Ningbo	330200	84	345	Guangzhou	440100	254	278
Handan	130400	91	151	Wenzhou	330300	83	77	Shenzhen	440300	94	92
Baoding	130600	73	78	Jinhua	330700	70	101	Zhanjiang	440800	94	91
Taiyuan	140100	128	172	Hefei	340100	74	161	Nanning	450100	87	165
Datong	140200	77	155	Wuhu	340200	90	103	Liuzhou	450200	75	74
Jincheng	140500	78	62	Bengbu	340300	58	110	Guilin	450300	84	80
Huhehaote	150100	74	264	Huainan	340400	78	178	Wuzhou	450400	79	83
Baotou	150200	66	301	Fuzhou	350100	74	251	Beihai	450500	89	79
Chifeng	150400	78	141	Xiamen	350200	78	136	Haikou	460100	74	152
Shenyang	210100	239	397	Sanming	350400	80	92	Chongqing	500100	375	256
Dalian	210200	123	433	Quanzhou	350500	69	88	Chengdu	510100	159	321
Anshan	210300	86	175	Nanchang	360100	70	231	Zigong	510300	85	75
Fushun	210400	81	141	Jiujiang	360400	80	75	Nanchong	511300	84	75
Jinzhou	210700	82	162	Jinan	370100	89	281	Guiyang	520100	52	222
Changchun	220100	132	258	Qingdao	370200	92	323	Zunyi	520300	76	104
Jilin	220200	57	260	Jining	370800	89	84	Kunming	530100	88	408
Siping	220300	51	74	Dezhou	371400	96	95	Yuxi	530400	90	76
Haerbin	230100	173	379	Zhengzhou	410100	90	343	Xian	610100	126	172
Qiqihaer	230200	58	211	Kaifeng	410200	67	72	Hanzhong	610700	66	85
Hegang	230400	54	111	Pingdingshan	410400	89	81	Lanzhou	620100	89	261
Daqing	230600	77	78	Xinxiang	410700	57	98	Xining	630100	59	191
Jiamusi	230800	58	68	Wuhan	420100	180	383	Yinchuan	640100	68	222
Shanghai	310100	226	840	Yichang	420500	88	92	Wulumuqi	650100	71	348
Nanjing	320100	139	364	Xiangfan	420600	89	95	All		8,386	17,920
Wuxi	320200	77	227	Changsha	430100	90	177				

Table 5 Variable description and summary statistics

Variable	Description	Year 1998		Year 2004	
		Mean	SD	Mean	SD
Household characteristics					
YE	Household annual labor income (Yuan)	6,271	3,726	33,295	23,825
YP	Household permanent income estimate (Yuan)	5,826	2,345	29,822	11,943
YA	Household asset income (Yuan)	151	469	493	3,523
GENDER	Binary, 1=household head is male.	0.677	0.468	0.719	0.449
AGE	The age of household head	41.9	7.9	32.5	9.2
HSIZE	Number of people in the household	3.15	0.62	3.06	0.71
YSCH	Household head's years of schooling	11.93	2.78	12.42	2.71
EMP_TER	Binary, 1=household head is employed in tertiary industry or public institutions	0.539	0.499	0.551	0.497
EMP_SOE	Binary, 1=household head is employed in a state- or collective-owned enterprise	0.939	0.240	0.737	0.440
EMP_PRV	Binary, 1=household head is employed by a private or foreign-joint-venture enterprise	0.026	0.158	0.114	0.318
EMP_PRP	Binary, 1=household head is employed in sole proprietorship	0.003	0.059	0.026	0.158
Housing attributes					
H_AREA	Dwelling size (sq. meter)	46.1	20.4	52.3	24.2
HTYPE1	Binary, 1=one-bed-room dwelling	0.102	0.303	0.084	0.277
HTYPE2	Binary, 1=two-bed-room dwelling	0.495	0.500	0.569	0.495
HTYPE3	Binary, 1=three-bed-room dwelling	0.180	0.385	0.216	0.412
HTYPE4	Binary, 1=four-bed-room dwelling	0.019	0.135	0.027	0.161
BLD_OLD	Binary, 1=old house	0.115	0.319	0.043	0.203
BLD_SF	Binary, 1=single-family house	0.005	0.073	0.008	0.088
FULLBATH	Binary, 1=dwelling containing toilet and bath	0.434	0.495	0.703	0.457
NOBATH	Binary, 1=dwelling without toilet	0.093	0.290	0.036	0.186
HALFBATH	Binary, 1=dwelling with toilet but no bath	0.396	0.489	0.227	0.419
AIRCON	Binary, 1=dwelling with air-conditioning	0.101	0.301	0.197	0.397
HEAT	Binary, 1=dwelling with heating	0.347	0.476	0.467	0.499
HEATO	Binary, 1=dwelling with other heating devices	0.147	0.355	0.099	0.298
GAS_L	Binary, 1=dwelling with liquefied petroleum gas	0.477	0.499	0.395	0.489

Table 5 (continued)

Variable	Description	Year 1998		Year 2004	
		Mean	SD	Mean	SD
GAS_N	Binary, 1=dwelling with natural gas	0.429	0.495	0.556	0.497
COAL	Binary, 1=dwelling with only coal cooker	0.080	0.271	0.030	0.171
MV_{jkt}	Housing consumption quantity constructed based on province-specific 2004 hedonic implicit prices	103,374	81,379	151,218	118,103
City attributes (with respect to 84 individual cities, Nanchong city excluded)					
R_k	Estimates of 1998 log housing rent differential (Beijing is the default city, with $R_0=0$)	−1.006	0.41		
S_k	Estimates of 1998–2004 log rent growth			0.363	0.14
$W_{k,1998}$	Estimated city fixed effect on wage rate in 1998, in log	8.70	0.28		
ΔW_k	Estimated log city wage rate growth $W_{k,2004}-W_{k,1998}$			1.45	0.13
POP	City non-agricultural population in 1998 (million people)[a]	1.20	1.39		
Summer_ temperature	City's summer temperature in 2004 (centigrade)[a]			37.0	3.13
Winter_ temperature	City's winter temperature in 2004 (centigrade)[a]			9.8	9.9
TEMPDEX	City's temperature discomfort index, defined by Eq. 10			19.59	8.32
DOCTOR	Number of doctors per 1,000 people in 1998[a]	4.11	1.82		
EDU	Average years of schooling of adults in 1998[a]	11.63	0.54		
SO2GDP	SO2 emission per GDP, 1998 (ton/million Rmb)[a]	3.33	4.77		
GREEN	Green space per capita (sqm.), 1998[a]	2.70	2.85		
ROAD	Road space per capita (sqm), 1998[a]	5.25	2.35		
GREEN_ROAD	*GREEN*/Stdev(*GREEN*) +*ROAD*/Stdev(*ROAD*)	3.18	1.64		
CNSMPR	Ratio of per-capita consumption expenditure over per-capita income in the city	0.741	0.066	0.659	0.054

The variables are observed or constructed from the UHS data, except for those marked by superscripted a, which are obtained from China Urban Statistics Yearbook

Table 6 Estimates of Mincerian wage equations

Variables	Year 1998	Year 2004
Constant	8.11 (93)***	8.90 (124)***
GENDER	−0.008 (1.0)	0.032 (4.1)***
ln(AGE)	0.254 (12)***	0.084 (5.2)***
YSCH	0.041 (26)***	0.071 (51)***
HSIZE	0.144 (22)***	0.142 (29)***
EMP_TER	0.114 (13)***	0.081 (11)***
EMP_PRV	0.194 (7.3)***	−0.017 (1.5)
EMP_PRP	0.011 (0.5)	−0.107 (9.7)***
No. of city fixed effects (the estimates are W_{kt}–W_{0t})	84	84
R squared	0.460	0.371
Number of observations	8,386	17,918

The dependent variable is log household income from employment ln(YE). t-statistics in parentheses are based on white heteroskedasticity-consistent standard errors and covariance. Sample excludes households whose head was unemployed. Beijing is the default city (k=0)

***p=0.01 level

Table 7 Estimates of housing demand equation with city fixed effects

Variables	Coefficient (t-statistic)
Constant	7.36 (56)***
ln(YP)	0.247(19)***
ln(YE)	0.272 (44)***
ln(YA+1)	0.009 (7.9)***
HSIZE	0.053 (13)***
ln(AGE)	0.176 (15)***
I_{2004} (the estimate is $-S_0$)	−0.374 (13)***
No. of city fixed effects (the estimates are R_k)	84
No. of 2004 city fixed effects (the estimates are $-S_k + S_0$)	84
R squared	0.668
Number of observations	26,304

The dependent variable is ln(MV_{jkt})+$CNSMPR_{kt}$, where MV_{jkt} is based on 2004 implicit hedonic prices and $CNSMPR_{kt}$ accounts for cross-city variations in in-kind payment. t-statistics are based on white heteroskedasticity-consistent standard errors and covariance. Sample excludes households whose head was unemployment. Beijing is the default city (k=0)

***p=0.01

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