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Longitudinal trends in equity of park accessibility in Yokohama, Japan: An investigation of the role of causal mechanisms

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Abstract

Despite an increasing interest in issues surrounding environmental equity, much research evidence to date is based on studies adopting cross-sectional approaches which do not adequately capture the processes and mechanisms generating inequities. Longitudinal studies may better inform policy measures to remedy inequity between populations, but the few that have been undertaken mostly focus solely on environmental risks, ignoring access to amenities. As a case study, we adopt a longitudinal approach in this work to investigate the association between socio-demographic indicators and public park provision over an 18 year period in the city of Yokohama, Japan. We show that inequities in park provision are present over the whole time period. Hedonic modelling shows that park accessibility is positively associated with house and land prices in the city. Our results suggested some, relatively weak, evidence of two causal processes; new parks are located in more affluent communities, yet also appear to subsequently encourage further move-in of affluent populations. We suggest park provision by administrative authorities in less affluent neighbourhoods may be required to maintain equity in access to these valuable community resources. Economic incentives, such as subsidy provision, may have role to play to encourage park provision by developers.

Keywords: Environmental equity; Longitudinal modelling; Hedonic Approach; GIS

JEL Classification: C31, R31

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1. Introduction

In recent decades, there has been an increasing interest in issues surrounding environmental equity. The concept of environmental equity particularly grew from action against environmental racism in the 1980s in the USA (Liu 2001), with a distinct focus on the siting of controversial facilities such as hazardous waste dumps in areas occupied by non-white populations (e.g. Godsil 1991). Since then the equity movement has based its efforts on the goal of achieving planning that leads to an equal sharing of environmental hazards and opportunities between communities (EPA 1992, Jones et al. 2009). Nevertheless recent findings in a range of countries suggest that inequities often still persist and are associated with diverse factors including age, ethnicity and affluence (e.g. Liu 2001, Jones et al. 2009, Yasumoto et al. 2011, Godsil 1991).

Prior studies in the environmental equity field use mostly one of two methods (Mohai 2008). A large number are cross-sectional investigations of the distribution of environmental quality between different population groups (Godsil 1991, Liu 2001). These studies are based on observations made at a single time point, generally focus on only one outcome, and hence do not adequately capture the causes and processes generating environmental inequities. An alternative is to take a longitudinal approach which focuses on time-dependent changes in the relationship between environmental qualities and population characteristics. In longitudinal studies the question of 'Which came first?' is frequently asked (Boone et al. 2009, Mohai 2008, Pastor et al. 2001). The concept being considered here is that environmental inequity may be generated through two different processes. The first is that environmental risks come into already socially disadvantaged communities or that benefits tend to be sited in affluent areas. The second is that disadvantaged or advantaged groups move into areas after the placement of environmental disamenities or amenities. Those two different processes can be principally caused by two factors; unequal political power between communities and market mechanisms (Pastor et al. 2001), both of which may be in operation and may be complementary to each other (Saha and Mohai 2005).

To support the argument of the first process, it has been suggested that disadvantaged groups have limited political power to resist the disproportionate siting of disamenities, and thus their areas attract more environmental risks (see Pastor et al. 2001, Hamilton 1993, Hamilton 1995). Conversely, more affluent or socially advantaged communities may be more politically empowered to attract new environmental amenities such as parks (Boone et al. 2009, Talen 1998). Market mechanisms are the other potential driver of disproportionate siting since developers or authorities may chose socially disadvantaged areas to site controversial facilities due to cheaper land prices and less need to provide compensation for local people (Portney 1991). For amenity siting, market mechanisms may actually sometimes be beneficial for the socially disadvantaged since cheaper land prices may encourage new amenity siting by providers, particularly for developers who have an obligation to provide amenities but where there is some flexibility on their location.

It has also been suggested that disadvantaged populations may be attracted into environmentally disadvantaged neighbourhoods by low property prices (see Been 1994, Saha and Mohai 2005), or partly by housing discrimination practices such as the limited provision of social housing (e.g. Nakagawa 2001). Conversely, the affluent may be attracted into areas with good amenities, even though property prices in such areas might be relatively high (Jones et al. 2009, Boone et al. 2009). If these processes do exist, policy makers may face a problem as policies attempting to more evenly distribute environmental quality may backfire if consequent changes in land and property prices cause people to reallocate, resulting in the re-occurrence of inequity (Liu 2001).

Many hypotheses concerning people's migration associated with environmental quality and housing prices are underpinned by the economic theory of residential sorting (Tiebout 1956, Epple et al. 2001, Calabrese et al. 2006). This theory is derived from the work of Tiebout (1956), and describes how individuals will choose to settle in a community that best satisfies their preference for public goods. For example, Epple et al. (2001) developed a general equilibrium model which describes how people migrate between different areas until they find the one where they maximize their utility based on the available mix of public goods and housing prices. However, a limitation of many studies on residential sorting is that they rely on relatively strong assumptions about household preferences, mobility, and the cost of providing public goods. Particular issues are that it is assumed that individuals will behave rationally with respect to their perceptions of environmental goods, and that they will have perfect information, neither of which is likely to be the case (Liu 2001). Secondly, as most of these studies operate at an aggregate level, there are difficulties incorporating data on housing transactions and public good provision at a household or land parcel level. Indeed Epple et al. (2001)

themselves have highlighted the need for future research to allow for more sources of observed and unobserved heterogeneity among households.

Although several longitudinal studies have been undertaken to clarify the processes operating to generate inequities in the burden of environmental risks (e.g. Been 1994, Saha and Mohai 2005, Pastor et al. 2001, Hamilton 1993, Hamilton 1995), very little is known about the distribution of amenities. In this research we examine the potential existence of the mechanisms discussed, and what the possible policy implications of their presence may be. As a case study, we focus on the longitudinal association between the siting of an environmental amenity, public parks, and social-demographic characteristics in Yokohama, Japan, a country where rather little work on environmental equity has been undertaken.

Parks are increasingly being recognised as an important component of the urban landscape. There is good evidence that they positively affect people's physical health, providing opportunities for recreation and physical activity (Payne et al. 1998) and more generally contributing to the psychological and social health of communities (Hirata 2004). Moreover large green spaces mitigate the effect of air and noise pollution (Hirata 2004). Proximity to open spaces including parks is also expected to play a vital role for natural hazard management and protection against earthquakes and fires (Koike et al. 2010). However there is evidence from several countries that the provision of parks may be inequitable. Jones et al. (2009) examined the distribution of access to parks between populations in Birmingham, England, and found evidence of disparities in provision related to socioeconomic deprivation, whilst Wolch et al (2002) and Sister et al. (2007)

both found that communities with Latinos, non-white or low income groups have worse access to parks in American contexts.

To test the ‘which came first?’ hypothesis within framework of park provision, we focused on the different role of two park providers: The city council (municipal authority) and private developers. Those two providers are governed by different policy and regulatory mechanisms, as well as being motivated by different incentives; provision versus profit. In particular, city council parks are specified to be located in areas where provision is poor (Hirata 2004), although it is unclear if the socio-demographic characteristics of communities are often considered. On the other hand, if an area of a planned new development plan is more than 5 ha, legislation requires that 3% of the developed area has to be public parkland, and this must be funded and provided by the developers (Hirata 2004). As a consequence, private developers are also important park providers (Maruani and Amit-Cohen 2011).

Whilst the primary task of local authorities is to pursue public interests, the motivation of developers is primarily profit maximization (Maruani and Amit-Cohen 2011). Therefore developers may preferentially select areas with cheap land prices or sites that are attractive for purchasers. They may not be strongly motivated to open parks that are large or of good quality, and indeed evidence suggests that developers think that targets such as the conservation of nature are costly to achieve, and that they underestimate value of open spaces (Bowman and Thompson 2009).

This case study of Yokohama Japan, a country where little previous equity work has been undertaken, was made to describe an approach to the longitudinal modelling of park provision. We examine both the siting and move-in hypothesises discussed above. In order to investigate the potential causal role of market mechanisms, we then present a hedonic model which quantifies the association between park provision and land and property price changes. Hedonic pricing considers a land parcel or a property as a set of attributes against which price is modelled (Hidano 2002), and our hedonic models focus on park provision as the key attribute of interest. We conclude by presenting the strengths and caveats associated with our approach, as well as the potential policy implications of our findings.

2. Methodology

2.1. Study areas

The area used in this case study is Yokohama, Japan, which is located in Kanagawa Prefecture and bounded by Tokyo Bay and Tokyo, the Japanese capital. Yokohama has the second largest population in the country (3.6 million people in 2005), and is a significant economic base for manufacturing, tourism and shipping. The city is undergoing substantial population growth and it acts as a dormitory town for many people who work in the nearby Tokyo.

2.2 Data

For the purpose of this study, two main datasets were generated; a 1 km grid based on census derived population characteristics, and a set of digital maps of park provision in

Yokohama. Both were computed for a range of time points.

The census data was extracted from the Population Census Grid Square Statistics published by the Ministry of Internal Affairs and Communications (MIAC 2011). The census is conducted every five years, and for this study, the results of surveys conducted in 1990, 1995, 2000 and 2005 were employed. This analysis focussed on two socio-demographic indicators. The first was the percentage of pensioners, defined as individuals aged 65 years or older, in grid cells. The elderly are often regarded as a socially disadvantaged group due to their poorer health, and reduced mobility and social activity (Sexton et al. 1993). Since our research interest is whether socially advantaged communities attract park provision, or advantaged people move into areas after the siting of parks, we also extracted the percentage of professional and managerial workers as an indicator of population affluence for each cell. Ten 1 km grids were excluded from the analysis since their information on population characteristics were not released due to their small population.

To measure accessibility to public parks for each 1 km census grid, we firstly generated maps of park locations using the ArcGIS 9.3 (ESRI Inc.) Geographical Information System (GIS). A database of urban parks was obtained from Yokohama City Council, supplying information on the name, address, park area, and the opening year of each park located within the city. For the purposes of map production, we differentiated parks which were larger than 2 ha in area from those which were less. For the larger parks, we depicted the park boundaries on our map using outlines present in the 2005 edition of the ‘Digital Map 2500’ (1:2500) digital cartographic product produced by the

Japanese Geographical Survey Institute. Manual checking of this dataset highlighted a number of parks which were not present, and the boundaries of these were subsequently digitised from a local paper atlas. Small parks of less than 2 ha in area were represented as circles with an area equal to that of the corresponding park. The circles were located using address-matched latitude and longitude coordinates from on-line lookup tables produced by the Centre for Spatial Information Science at the University of Tokyo (CSIS 2011).

Using the information on park opening dates held in the database, the mapping procedure was repeated 18 times to produce a map of park locations for every year between 1988 and 2005, the most recent period for which data was available. The maps were additive because no park was recorded as being closed during this period. The city of Yokohama also provided information on whether each park was opened by a private developer or the city council, and this was added to the database. For each 1km grid cell for which census data was available, access to parks was measured using four metrics; firstly the number of parks within the cell, secondly the park area, and thirdly the park area per capita. The computation of these metrics is known as the 'container' method (see Talen and Anselin 1998). The fourth metric was whether or not a park was opened in a given year. Parks provided by the city council and by private developers were differentiated in these metrics due to the different policies governing them.

A range of covariates which were hypothesised to potentially to be associated with park provision were also considered (Table 1). The two population characteristics of interest, percentage pensioners and percentage professional and managerial workers, were computed from census records and classified into quartile groups. Population density was also computed based on census records, since highly populated areas may have more demand for parks. However, since the Japanese census data is collected every five years, it is not possible to model annual changes in population characteristics against annual changes in park provision. Therefore, we took a time-period based approach and examined the changes in population characteristics at a time which was as temporally coincident as possible to that of park provision (see Saha and Mohai 2005).

As new park provision may depend on existing provision, the number of parks that were already present within each 1 km grid was extracted from the previously described park database. Cheaper land prices may attract park provision, and hence in order to include a consideration of land prices in the analysis, estimated land values that are annually published by the Ministry of Land, Infrastructure, Transport and Tourism were considered. This data consists of point based estimates; for example, there were around 900 estimation points in 2005, and each point represents a specific estimated land price produced by professional assessors (see Hidano 2002). The land price of each estimation point is estimated by considering actual transaction price or rent of neighbouring land parcels which have similar characteristics. In order to estimate land prices for each grid cell, we created Thiessen polygons (Johnston 1998) for each year based on the locations of the points whose land price data was estimated, and these were overlaid with the grid cell boundaries to estimate the average land price within each cell.

Table 1. Explanatory variables for the siting analysis, move-in analysis and hedonic analysis

Variable	Reference source	Hypothesised relationship	Data source	Descriptive statistics Min	Mean	Max	SD
Variables for the move-in analysis (logistic regression)							
Quartile groups of pensioners (%)		DEV: NS CC: NS	Census	-	-	-	-
Quartile groups of professional & managerial workers (%)	Robinson & Robinson (1985)	DEV: + CC: NS	Census	-	-	-	-
Population density (people/km^2)		DEV: NS CC: +	Census	13	8612	22162	4564
Number of parks pre-existing	ibid	DEV: + CC:—	DM, MP	0	5.9	22	3.8
Estimated land price (100,00 yen)		DEV:— CC:—	ELP	9.8	41.2	773.4	50.6
Distance to Yokohama centre (km)		DEV:— CC: NS	DM	0.4	9.7	19.8	3.9
Distance to Tokyo centre (km)		DEV:— CC: NS	DM	17	29.1	41	6.2
Variables for the move-in analysis (multiple regression)							
Park provision by developers	Jones et al. (2009)	PEN: — P&M: +	DM, MP	-	-	-	-
Park provision by city council	ibid	PEN: — P&M: +	DM, MP	-	-	-	-
Population density (people/km^2)		PEN: — P&M: —	Census	13	8612	22162	4564
Distance to Yokohama centre (km)		PEN: —P&M: —	DM	0.4	9.7	19.8	3.9
Distance to Tokyo centre (km)		PEN: —P&M: —	DM	17	29.1	41	6.2
Quartiles of pre-existing pensioners (%)		PEN: +	Census	-	-	-	-
Quartiles of pre-existing profess -ional & managerial workers (%)		P&M: +	Census	-	-	-	-
Quartiles of park area pre-existing		variable	DM, MP	-	-	-	-
Variables for the hedonic analysis							
Structural variables							
Ground area (m^2)		+	RIW	13.8	136.6	991.7	64.9
Floor space (m^2) (detached house only)		+	RIW	0	80.1	1840.4	45.3
Width of front road (m)	Shimizu (2004)	+	RIW	0	5.4	45.0	2.5
Private road dummy	ibid	—	RIW	-	-	-	-
Residential zoning dummy		+	RIW	-	-	-	-
South-facing dummy	Gao & Asami (2001)	+	RIW	-	-	-	-
Reinforced concrete dummy (detached house only)	Shimizu (2004)	+	RIW	-	-	-	-

Table 1. (continued)

Neighbourhood variables							
Professional & managerial workers (%)	Shimizu (2009)	+	Census	0	5.2	22.0	3.9
Accessibility variables							
Distance to Yokohama centre (km)	Hidano (2002)	—	DM	0.4	9.4	20.3	4.3
Distance to Tokyo centre (km)	ibid	—	DM	16.2	29.1	42.0	6.0
Distance to elementary school (km)	Pacione (1989)	—	DM, SL	0	0.4	1.4	0.2
Travel time to closest rail station (min)	Shimizu (2009)	—	RIW	0	12.6	38.0	4.9
Using bus dummy	ibid	—	RIW	-	-	-	-
Environmental variables							
Quartile groups of park area		+	DM, MP	-	-	-	-
Variables related to transaction							
Year 2000 dummy		—	RIW	-	-	-	-
Year 2005 dummy		—	RIW	-	-	-	-
Market reservation time (month)	ibid	variable	RIW	0	2.6	50.4	2.6

-Hypothesized relationship with dependent variables: DEV - developers; CC - city council; PEN - temporal change in pensioners (%); P&M - temporal change in professional and managerial workers (%)
-Positive relationship (+) and; negative relationship (—); and no statistically significant relationship (NS)
-Key to reference and data source: RIW - Residential Information Weekly; Census - Japan Census (Tabulation for 1 km grid) in 1990, 1995, 2000 and 2005; DM - Digital Map 2500; SL - Yokohama Municipal School List of Names; and MP - Map of Parks and Green Spaces in Yokohama

Private developers may be more likely to develop land close to city centres. Therefore, to determine the level of accessibility to the centres of Yokohama and Tokyo (the capital city of Japan), we calculated the Euclidean distance from the centroid point of every 1 km grid to the centres of both cities using ArcGIS.

In order to test the move-in hypothesis, we investigated the association between park provision and temporal changes in two demographic characteristics: the absolute change in the percentage of pensioners and of professional and managerial workers between two different points of time. Again, we differentiated between parks provided by the city council and those from developers. Another potential factor influencing population change could be the percentage of the given population already existing in the year of siting of parks, because a predominant population may attract more of the same owing to the similar residential preferences, life patterns (Cutler et al. 1999), or, partly, the effects of housing discrimination (Nakagawa 2001). Therefore, quartiles of the percentage of pensioners and of the percentage of professional and managerial workers at baseline were computed. Finally, if a community already has a large number of parks or a large park area, an additional park may have little effect. Therefore, to differentiate between the potential effect of pre-existing parks and that of a newly opened park, we also incorporated the park area at baseline into our analysis.

For our hedonic pricing analysis, data on the prices of land parcels and detached houses in Yokohama were extracted from the *Residential Information Weekly* publication (RECRUIT., CO.). This weekly magazine describes the characteristics and asking prices of both residential properties and plots of land. Although only 40% of Yokohama residents live in detached houses, data on rents of apartments are unfortunately not published. It was assumed that the price recorded when the property or land was removed from the magazine (normally at the point of sale) was the actual transaction price, an assumption that previous empirical research has tested and found to be appropriate (Shimizu 2004). The two metrics chosen were selected to measure the current (house prices) and future (land prices) potential of areas for move-in. We used land and detached house price data from three survey years; 1995, 2000, and 2005. The address of each transaction point was converted into a latitude and longitude and the location points were recorded in the GIS.

Although the focus of the hedonic analysis was on the association between market prices and park provision, it was important to control for all factors that may influence both. Bateman et al. (2001) suggested that there are four major groups of relevance; structural, neighbourhood, accessibility, and environmental variables. Structural variables are characteristics of pieces of land and the houses themselves, such as floor space and the width of the road in front of the building. Neighbourhood variables (e.g. population density) are characteristics of neighbourhoods that will influence desirability. Accessibility variables are indicators of the ease by which local amenities (e.g. distances to rail stations and schools) may be reached, whilst environmental variables encompass measures of the quality of the surrounding environment.

The suite of variables generated is listed in Table 1. In terms of structural characteristics, those computed were measures of ground area, floor space (for detached houses only), the width of the road in front of the property, whether the road was private or public, whether the parcel or property fell inside a zone which was designated for residential purposes, whether the entrance of the land parcel or property was south-facing (for good access to sunlight), and if the house was constructed from reinforced concrete and hence more highly valued due to better earthquake resistance (Shimizu and Karato 2007) were computed.

A neighbourhood deprivation variable was generated from the Population Census Grid Square dataset for the years 1995, 2000 and 2005. As no readily accepted index of deprivation exists in Japan, the percentage of professional and managerial workers was used a measure of area affluence. In order to capture elements of accessibility, we created a set of variables which measured the proximity from each transaction point to the city centres of both Yokohama and Tokyo, closest public elementary schools, and closest railway stations. Accessibility to the centres of Yokohama and Tokyo as well as elementary schools was computed based on Euclidean distances in the GIS. Railway accessibility was measured considering the time required to walk to the nearest bus stop and then make a bus journey to the nearest railway station, except in cases where it was faster to directly walk to the station, where only the walking time was considered. As distances would differ by mode, a dummy variable representing a bus journey was defined, and then the cross term between it and travel time was fitted.

The key environmental variable studied, and the exposure of interest in the hedonic study, was the accessibility of parks. To compute this, the same 'container' method as described earlier was employed, this time using a 500 m circular distance buffer. This distance was chosen because, in a Japanese context, Aoyama and Kondo (1986) found that the propensity to visit parks declined steeply amongst populations living further than this distance away. Using the GIS we identified public parks that fell both partially and completely within each buffer, and then summed the total area of each park. Each transaction point was then classified according to the quartile of park area that fell within the buffer.

As the transaction dataset was collected for three time periods, dummy variables for the survey years were fitted into the equations to adjust effect of change in prices over time. Next, the market reservation time was also recorded because properties or land parcels that had been on the market for a long time might have been so because their original selling prices were largely unmatched with the market equilibrium price or because they were a unique type of property (Shimizu 2009), such as one designed for handicapped people. Finally, to include fixed effects for unmeasured differences in outcomes between neighbourhoods, we allocated the samples of land parcels and detached houses to 18 wards (administrative units) in the city.

2.4. Analytical methodology

Descriptive statistics and tests for trend were initially used to examine how park access varied by population characteristics over the time periods analysed. For tests for trend, Spearman's rank-order correlation analysis was undertaken to clarify the association between quartiles of each population characteristic and the number of parks, the park area, and park area per capita within the census grid cells.

Next, to test the siting hypothesis, logistic regression analysis was conducted to examine how population characteristics of each community were associated with park provision in each year over the 18 year-time timescale adopted. The dichotomous dependent variable measured weather or not parks were provided in each 1km grid cell in each year. The 1990 census record was considered to examine the effect of population characteristics on park provision between 1988 and 1992. Likewise population characteristics extracted from the 1995 census data were used to test park provision between 1993 and 1997, the 2000 census was used for the park siting between 1998 and 2002, and finally the 2005 census was considered for the park siting between 2003 and 2005.

In order to test the move-in hypothesis, multiple regression models were developed to test how park provision was associated change in population characteristics in each census grid. The dependent variable was the absolute change in the percentage of pensioners and of professional and managerial workers between the current and previous modelled time points. As there would be expected to be a lag time between park provision and population change, and the nature of that lag is not known, we investigated three different spans. First, we examined how changes in census characteristics between 1990 and 2005 were associated with park provision between 1988 and 1992. Similarly, we related population change between 1995 and 2005 to park provision between 1993 and 1997, and population change from 2000 to 2005 to parks built between 1998 and 2002.

Two hedonic pricing models, a land price model and a detached house price model, were fitted to identify how additional park accessibility potentially affects both land and property prices. Based on the work of Doguchi and Kubo (2006), these models took the form:

$$\ln P_t = \alpha + \beta_{it} X_{it} + \delta_t d_t + \varepsilon_t$$

Where P_t is the land price i or property price i, α is the intercept, X_{it} is the matrix of independent variables and β_{it} is the vector of parameters to be examined. δ_t indicates to what extent prices change over time when all other variables are controlled. d_t is a dummy variable of time, and ε_t is an error term. All analyses were undertaken in PASW statistics 18.

3. Results

Figure 1 illustrates spatial distributions of parks and population characteristics in 1990 and 2005. In 1990, as Figure 1 (c) shows, most communities with retired populations were concentrated around the city centre, but by 2005 they had spread towards southern-western parts. Moreover, the percentage of the population who were pensioners doubled between 1990 and 2005. In both periods, areas with high percentage of professional and managerial workers are situated in northern part of Yokohama, reflecting at least partially the role of the city as a dormitory town of Tokyo.

Between 1988 and 2005, the city council opened 556 parks (total park area 1702 ha), whilst developers provided 472 parks, but an area of only 212 ha. This shows that parks built by developers are likely to be smaller than ones provided by the city authority. Areas categorised into the most aged communities (census grids in the top quartile of pensioners) were provided 95 parks by developers with a total area of 18 ha, whereas developers constructed 105 (117 ha) parks in the least aged communities (lowest quartile). For the same period, developers opened 125 parks (117 ha) in the most affluent communities, while in the least affluent communities only 59 parks (20 ha) were provided. The city council opened parks almost equally between communities regardless of the population characteristics across the 18 years.

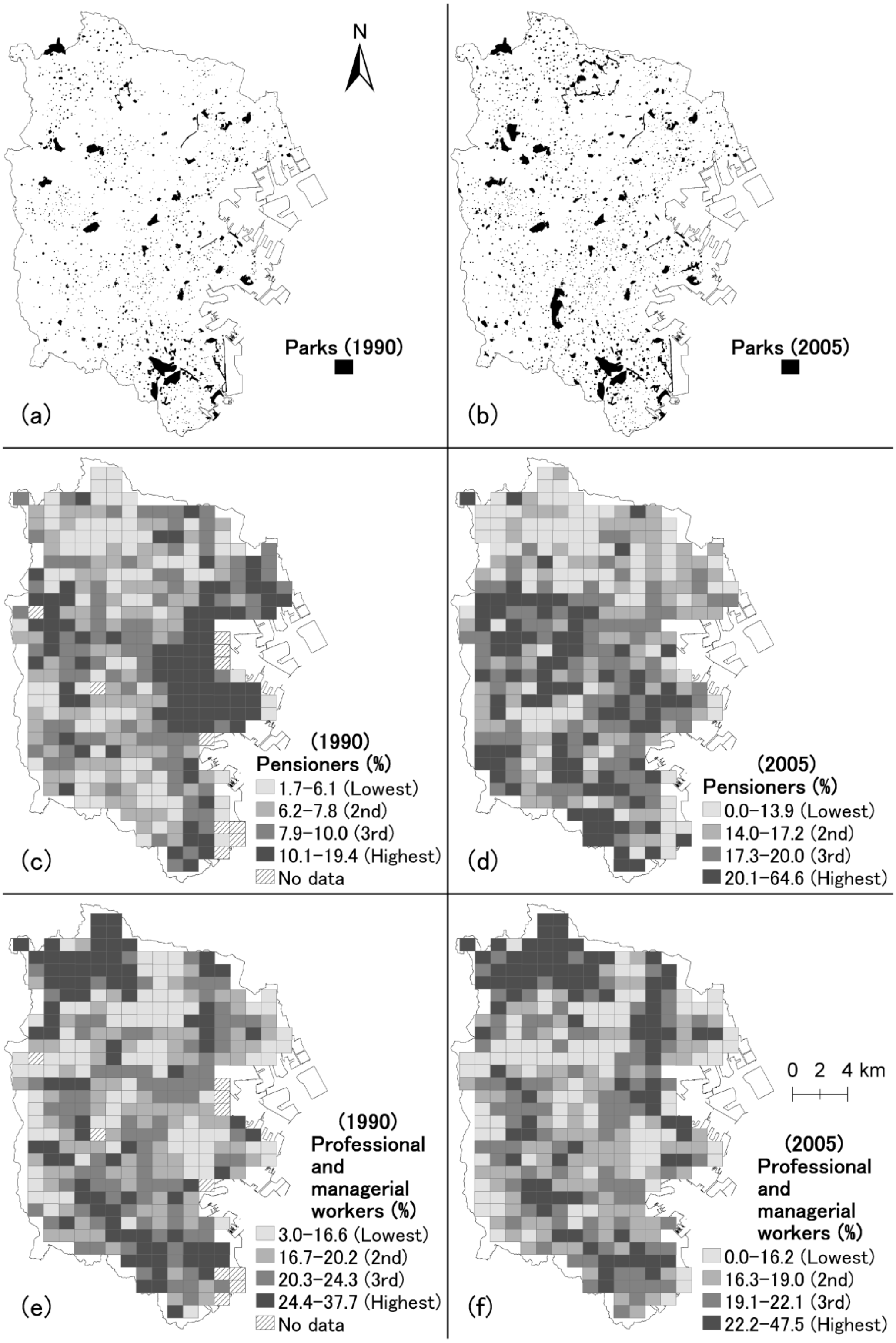

Figure 1. Spatial distributions of (a) public parks in 1990; (b) public parks in 2005; (c) pensioners (%) in 1990; (d) pensioners (%) in 2005; (e) professional and managerial workers (%) in 1990; and (f) professional and managerial workers (%) in 2005

Table 2 shows associations between park accessibility and quartiles of the two demographic groups in Yokohama for the years 1990, 1995, 2000 and 2005. There was no evidence of any trends in inequity associated with the percentage of pensioners at any time period, but there was evidence of inequity in access to parks associated with the percentage of professional and managerial workers in census grid cells, with the most affluent areas tending to have better access to parks in all time periods. The trend is particularly apparent when the overall area of parks is considered. The mean value of the park area per capita shows a less clear trend, partly due to some census grids that have small populations but large park areas and consequently high per capita values. The median per capita values are thus more reliable.

Table 3 reports the results of multiple logistic regression analyses conducted to examine the factors associated with park provision. After adjustment, it is evident that developers tend to open parks in more affluent and less aged communities. Population density and the number of parks already present also have a statistically significant and positive association with the probability of developers opening new parks, whereas distance to the city centre has a negative association. These factors are likely a result of the fact that land provided by developers needs to be attractive to customers (Robinson and Robinson 1986). Meanwhile, land price has a significant and negative association. The model thus suggests that park provision by developers is at least partially driven by market mechanisms.

Table 2. Relationship between demographic indicators and park area at different time points (1990, 1995, 2000 and 2005)

		Pensioners (%)						Professional and managerial workers (%)					
		Number of parks		Park area (ha)		Park area per capita (m^2)		Number of parks		Park area (ha)		Park area per capita (m^2)	
	Quartiles of demographic indicator	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
1990	Lowest	4.5	4	11.5	2.0	114.4	2.6	2.7	2	4.8	0.4	110.6	0.9
	2nd	4.7	4	8.4	1.4	25.4	1.8	4.5	4	8.1	1.8	12.3	1.8
	3rd	4.8	4	8.6	1.2	14.7	1.6	5.7	6	10.1	1.5	31.3	2.2
	Highest	5.1	4.5	9.1	3.0	48.9	2.3	5.9	6	13.8	2.5	53.9	3.0
	Test for trend	+		+		—		+**		+**		+**	
1995	Lowest	5.3	5	10.9	3.0	86.9	4.1	3.3	2	4.9	0.6	29.1	1.4
	2nd	5.4	5	7.6	2.3	15.8	2.8	5.8	5	9.5	3.2	73.8	3.1
	3rd	5.8	5	13.7	2.3	90.9	2.8	6.6	7	10.5	2.3	35.9	2.4
	Highest	6.2	5	9.9	3.4	24.8	2.6	6.6	7	16.4	3.7	77.1	4.2
	Test for trend	+		+		—		+**		+**		+**	
2000	Lowest	6.2	6	11.6	3.6	62.3	5.2	3.9	3.5	9.3	2.0	393.1	2.6
	2nd	6.1	5	10.1	2.4	61.6	2.8	6.8	6.5	11.3	3.5	32.0	3.8
	3rd	7.0	7	13.3	3.4	21.5	3.5	7.8	8	12.2	3.3	43.2	3.0
	Highest	6.9	6.5	16.2	4.9	352.1	4.6	7.0	7	17.7	4.8	83.9	5.1
	Test for trend	+		+		—		+**		+**		+**	
2005	Lowest	6.7	7	13.8	4.3	282.3	5.0	4.7	4	10.9	2.6	286.5	3.3
	2nd	6.9	7	9.4	3.0	12.4	3.2	7.2	7	9.0	3.3	27.7	3.2
	3rd	7.5	7	10.2	3.8	22.4	4.2	8.2	8	15.8	4.8	34.6	5.0
	Highest	6.7	7	21.0	4.7	115.3	5.4	7.4	7	17.9	4.9	108.3	4.5
	Test for trend	+		+		+		+**		+**		+**	

Lowest = Least aged / affluent quartile group, Highest = Most aged / affluent quartile group
Direction of trend (+ positive – negative) **: $P < 0.01$ *: $P < 0.05$ NS: No statistical significance

Table 3 shows no consistent association between the two demographic indicators and the odds of parks being provided by the city council, nor were land prices associated with provision. The number of parks already present had a negative association with the probability of the city of Yokohama opening a new park, illustrating that the city council tends to provide parks in areas with fewer existing parks.

Table 3. Logistic regression model for new park provision between 1988 and 2005 by developers and city council

	Developers		City council	
	β	95% CI	β	95% CI
2nd quartile of pensioners (%)	0.024	0.770 , 1.363	- 0.237	0.600 , 1.038
3rd quartile of pensioners (%)	- 0.065	0.699 , 1.256	- 0.084	0.700 , 1.209
4th quartile of pensioners (%)	- 0.446**	0.456 , 0.898	- 0.064	0.696 , 1.265
2nd quartile of professional and managerial workers (%)	0.427*	1.086 , 2.162	0.331*	1.045 , 1.856
3rd quartile of professional and managerial workers (%)	0.484**	1.150 , 2.289	0.073	0.794 , 1.456
4th quartile of professional and managerial workers (%)	0.455*	1.096 , 2.267	0.026	0.749 , 1.408
Population density (100,00 people / km^2)	0.480**	1.208 , 2.162	0.334*	1.065 , 1.831
Number of parks pre-existing	0.047**	1.016 , 1.080	- 0.040*	0.929 , 0.994
Estimated land price (100,00yen)	- 0.005*	0.990 , 0.999	- 0.004	0.993 ,1.000
Distance to Yokohama centre (km)	- 0.050**	0.920 , 0.983	0.047**	1.016 , 1.080
Distance to Tokyo centre (km)	0.016	0.998 , 1.034	- 0.035**	0.950 , 0.981
N	6476		6476	
Cox & Snell R Square	0.023		0.022	

95%CI = 95% confidential interval
**: P < 0.01 *: P < 0.05
- 17 dummy variables measuring year (between 1989 and 2005) were incorporated into the model, but the results of them are omitted from the table for brevity.

Table 4 shows the results of the model fitted to investigate changes in population characteristics following park provision. Controlling for other characteristics, park provision by the city council was associated with increases in the percentage of professional and managerial workers at both 10 years and 15 years following siting, suggesting the presence of move-in, although the effect sizes are small. No evidence was found that park provision was associated with a change in the percentage of pensioners. No associations were apparent for parks provided by developers possibly because, as previously noted, developers' parks are generally much smaller than those from the city council.

Table 5 reports the results of the hedonic pricing models of land and property prices. Both models illustrate that, when all other variables are controlled for, accessibility to parks has positive and significant association with land and property prices. This provides some evidence that park provision may cause land and property prices to rise.

Table 4. Multiple regression analysis for changes in population characteristics after provision of parks

	Change in pensioners (%)						Change in professional and managerial workers (%)					
	(1988-2005)		(1993-2005)		(1998-2005)		(1988-2005)		(1993-2005)		(1998-2005)	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
(Constant)	0.46	- 2.72, 3.65	- 1.52	- 4.22, 1.18	- 3.27*	- 5.78, - 0.76	6.41**	4.08, 8.47	3.44**	1.72, 5.17	- 0.06	- 1.26, 1.14
Park Provision by developers	- 0.17	- 1.27, 0.93	- 0.29	- 1.26, 0.67	0.14	- 0.79, 1.07	0.13	- 0.73, 0.98	- 0.14	- 0.76, 0.49	- 0.05	- 0.50, 0.40
Park Provision by city council	- 1.05	- 2.12, 0.02	- 0.39	- 1.28, 0.51	0.46	- 0.40, 1.31	1.31**	0.48, 2.13	0.70*	0.11, 1.29	- 0.003	- 0.42, 0.41
Population density (100,00/km^2)	0.26	- 1.00, 1.52	- 0.56	- 1.67, 0.55	0.09	- 0.89, 1.07	- 1.52**	- 2.50, - 0.54	- 0.70	- 1.43, 0.03	- 0.12	- 0.60, 0.35
Distance to Yokohama centre (km)	0.06	- 0.09, 0.21	0.17*	0.04, 0.29	0.26**	0.14, 0.37	- 0.09	- 0.21, 0.03	- 0.06	- 0.14, 0.02	- 0.02	- 0.08, 0.03
Distance to Tokyo centre (km)	0.28**	0.20, 0.36	0.21**	0.14, 0.28	0.10**	0.04, 0.17	- 0.09**	- 0.15, - 0.02	- 0.08**	- 0.13, - 0.04	- 0.01	- 0.04, 0.03
2nd Quartile of population characteristics (%) at baseline	0.28	- 1.20, 1.61	1.64*	0.40, 2.88	0.56	- 0.55, 1.67	- 2.18**	- 3.30, - 1.07	- 0.99*	- 1.82, - 0.16	- 0.09	- 0.63, 0.45
3rd Quartile of population characteristics (%) at baseline	0.50	- 1.82, 0.98	1.71**	0.48, 2.93	1.16	- 0.01, 2.32	- 3.65**	- 4.79, - 2.50	- 1.82**	- 2.65, - 1.00	- 0.58*	- 1.13, - 0.03
4th Quartile of population characteristics (%) at baseline	1.26	- 3.46, 0.41	- 0.13	- 1.45, 1.20	0.28	- 0.92, 1.49	- 6.69**	- 7.87, - 5.52	- 3.35**	- 4.24, - 2.46	- 0.70*	- 1.25, - 0.15
2nd Quartile of park area in previous year	0.20	- 1.18, 1.74	- 0.12	- 1.41, 1.18	0.27	- 0.85, 1.38	- 0.98	- 2.12, 0.16	- 0.04	- 0.90, 0.82	0.17	- 0.38, 0.71
3rd Quartile of park area in previous year	- 0.42	- 1.01, 2.01	- 0.06	- 1.32, 1.20	0.62	- 0.50, 1.73	- 0.61	- 1.79, 0.57	- 0.06	- 0.91, 0.80	0.12	- 0.42, 0.66
4th Quartile of park area in previous year	- 1.93*	- 0.16, 2.69	1.27*	0.05, 2.50	0.60	- 0.49, 1.69	- 0.02	- 1.16, 1.12	- 0.10	- 0.95, 0.74	0.37	- 0.17, 0.90
N	353		355		361		353		355		361	
Adjusted R Square	0.158		0.187		0.086		0.388		0.234		0.006	

95% CI = 95% confidential interval **: P < 0.01 *: P < 0.05

Table 5. Result of hedonic pricing models for natural log of land price and natural log of detached house price

	Land price model		Property price model	
	β	95% CI	β	95% CI
(Constant)	3.404**	3.343, 3.466	3.437**	3.415, 3.458
Ground area (m^2)	0.001**	0.001, 0.001	Excluded	
Floor space (m^2)	No Info		0.003**	0.003, 0.003
Width of front road (m)	0.011**	0.01, 0.012	0.002**	0.001, 0.002
Private road dummy	-0.027**	-0.036, -0.018	-0.022**	-0.025, -0.019
Residential zoning dummy	0.023**	0.009, 0.036	0.027**	0.022, 0.031
South-facing dummy	0.016**	0.005, 0.027	NS	
Reinforced concrete dummy	No Info		-0.036**	-0.047, -0.024
Professional and managerial workers (%)	0.007**	0.006, 0.008	0.005**	0.005, 0.005
Distance to Yokohama centre (km)	0.002*	0.0002, 0.004	0.002**	0.001, 0.003
Distance to Tokyo centre (km)	-0.007**	-0.008, -0.005	-0.004**	-0.005, -0.003
Distance to elementary school (km)	-0.021*	-0.038, -0.005	NS	
Travel time to closest rail station (min)	-0.004**	-0.005, -0.003	-0.003**	-0.003, -0.002
Cross term between bus using dummy and travel time to closest rail station	-0.002**	-0.002, -0.001	-0.001**	-0.001, -0.001
2nd quartile of park area	0.021**	0.012, 0.03	0.003	-0.001, 0.006
3rd quartile of park area	0.024**	0.014, 0.033	0.013**	0.01, 0.017
4th quartile of park area	0.026**	0.016, 0.036	0.022**	0.019, 0.025
Year 2000 dummy	-0.075**	-0.083, -0.067	-0.087**	-0.09, -0.084
Year 2005 dummy	-0.14**	-0.148, -0.131	-0.155**	-0.158, -0.152
Market reservation time (month)	NS		0.002**	0.002, 0.002
N	5828		26486	
Adjusted R square	0.651		0.612	

95% CI = 95% confidential interval
**: P < 0.01 *: P < 0.05 NS: No statistical significance
Excluded: excluded variables to avoid multi-collinearity
No Info: no information about the variable was available for land parcel data

- 17 dummy variables of wards were incorporated into the model, but the results of them are omitted from the table for brevity.

4. Discussion and conclusion

By conducting a case study of Yokohama, we used longitudinal modelling to identify the processes potentially responsible for generating environmental equity in park accessibility. First, we found that a strong association existed between inequity in park accessibility and affluence over the past 18 years in the city. We also observed that in more affluent communities and those with lower percentages of pensioners, developers tended to build more parks, although they are likely to be smaller than those built by the city authorities. Nevertheless, the long term, the cumulative effect of the disproportionate siting of parks built by developers over several decades may increase the disparity. Interestingly, the development of parks by the city council was found to be associated with a subsequent rise in the affluent population in the area, although the effect sizes were small, at least within the 15 year timespan studied. No such effect was observed in the case of parks built by developers. Whilst our hedonic pricing model indicated that park provision may increase land and property prices, which may amplify the existing inequity in park accessibility, placement of parks is thus observed to have little effect on subsequent change in population characteristics in the short to medium term.

Our original concern was that unequal political power between different social groups may cause disproportionate park provision between communities (Boone et al 2009, Talen 1998); however, it was evident that the city authority provides parks according to pre-existing levels of park provision rather than population characteristics across areas.

Other authors have noted that the principal motivation of developers is profit maximization (Maruani and Amit-Cohen 2011), and indeed we found that developers tend to build parks in socially advantaged areas, with their behavior being market driven rather than a result of the political influence of the local people as such areas are attractive for the consumers of development plans (Robison and Robinson 1986). In addition, we found that developers are likely to choose areas with a cheaper land prices to build parks, a likely consequence of the nature of their business.

Considering our results, we suggest several policy implications for remedies towards observed inequities in park accessibility. Perhaps the most important and effective remediation measure is the direct placement of parks by the city council in socially disadvantaged areas with limited parks. As we observed that park provision has little, or at least slow, effects on the reallocation of population characteristics, we suspect this would not act to drive out disadvantaged residents in the long-term. Nevertheless, it is important to remember that incorporating equity issues into the decision-making process may increase cost of that process (Talen 1998). For example, if the city council prioritize park provision in socially deprived communities with limited parks, advantaged groups who are more likely to be politically empowered may take action against them. Since private developers are motivated by profit maximization behavior, they can be responsive to economic incentives. Policies regarding taxation and subsidies therefore have the potential to facilitate and direct park provision from this source (Maruani and Amit-Cohen 2011, Alberini et al. 2005). The provision of bond funds and other legislation to encourage park siting by private developers in disadvantaged areas may also have a role to play (Wolch et al. 2005).

Our study has a number of strengths and weaknesses. Some authors have mentioned that the limited number of longitudinal studies in the equity field is a result of the limited availability of historical data (Mohai 2008, Saha and Mohai 2005, Liu 2001); historical data on both population and environmental quality is sometimes not digitised or inconsistent with contemporary information, and the boundaries of spatial units for which it is available can change. A strength of our work is thus the use of grid-based census data that circumvented the problems of boundary change. Furthermore the production of maps of park provision meant we were able to examine changes in park provision over a long period of time.

Although many previous studies have been conducted to investigate residential sorting processes (see Tiebout 1956, Epple et al. 2001, Calabrese et al. 2006), which support our migration hypothesis, the quality of data available to us compared to that used in much previous work is a significant strength of our study. In particular, we had a detailed and spatially referenced dataset on property and land prices and we made use of advanced GIS techniques in order to produce a number of novel measures of public good provision that varied over time around individual properties.

In terms of weaknesses, this research focused on just one municipal area, the city of Yokohama, and as a consequence, we could not incorporate the effect of different revenue-expenditure patterns on people’s migration because residents of Yokohama pay uniform residential tax no matter where they live within the city. Our analysis focused on just two social groups; the elderly and the poor. Children are another potentially disadvantaged group amongst whom access to parks may be particularly important (Boone et al. 2009), although we chose to focus on the elderly here as they are most likely to be living in conditions of poverty. In addition the presence of elderly populations is strongly negatively correlated with presence of children according to the Japanese census, making it difficult to separate out effects. We also examined measures of percentage population composition, rather than absolute numbers of people, although we question if an inequity affecting a greater number of individuals could ethically be deemed 'more serious'. Nevertheless, further work examining a wider range of populations would be able to identify the relative contribution of the different groups to overall inequities.

A further limitation is that, due to the availability of data, we were forced to focus on a 15 year time window for follow-up. It may be that changes in population characteristics post park provision would take longer than this, and a more dramatic change of population may happen within, for example, more than a half century (see Cutler et al. 1999). Consequently we could describe the process of population move-in as slow, albeit potentially present. Our results are based on an amalgamation of years and associations may differ over time. However, to test our findings for robustness, we ran models separately for each year (1995, 2000 and 2005) and found that associations with park accessibility remained positive and statistically significant in each time period.

Whilst we examined a wide range of explanatory variables we were not able to measure all characteristics of the environment that may cause the changes in population characteristics and in land and property prices we observed. For example other environmental improvements may have taken place that we did not measure, and the introduction of environmental disamenities such as hazardous waste sites, may have occurred. Because we have conducted a large number of statistical tests, some of the significant associations we observed may be due to chance. The fact that Japanese census data was only available for 5 year periods meant that we were not able to investigate changes in population at a finer temporal resolution and our analysis cannot detect changes that occurred very shortly after parks were provided. Nevertheless, this temporal resolution improves on many countries where only a decennial census is available. Finally, we focused solely on park provision, whilst other attributes of parks, such as the facilities they provide, may also affect their value to society.

Although very little is known about environmental equity in Japan, we found evidence inequity in park accessibility in Yokohama. This finding cannot allow us to speculate as to whether similar disparities exist in other areas, both within Japan and internationally. However our work presents methodological framework that can be applied in other contexts. Furthermore, from a policy perspective, we would suggest identifying different roles, and potential remediation measures, for both private developers and local authorities will be important whatever the context. To our knowledge, this study is one of the first attempts to test the potential causal hypotheses of amenity accessibility from an equity perspective. We hope it may assist in the development of remediation policy, as well as improving our understanding of the underlying process that generate inequity.

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