Love Thy Neighbor: Income Distribution and Housing Preferences

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Abstract

Do homeowners prefer living in an area with a more equal distribution of income? We answer this question by estimating a semi-parametric hedonic pricing model for about 90,000 housing units transacted in Hong Kong between 2005 and 2006. We first identify a hedonic price function by locally regressing the rental price of the housing unit on its intrinsic and neighborhood characteristics, one of which is the Gini coefficient for household income of the constituency area. We then combine the estimates with a log utility function to obtain the heterogeneous preference parameters. Finally, we estimate the joint distribution of the preference parameters and demographics. We find that most homeowners have a strong distaste for inequality in their neighborhood, and the distaste increases with income and goes down with education level. Counterfactual experiments show that reallocating Public Rental Housing by half can increase the welfare of homeowners by about HK$8,000 on average per year, an amount which is equivalent to increasing the housing unit by 20 square feet or reducing the age of the unit by 5 years.

JEL Classification: R21, R23, R32
Keywords: hedonic pricing, housing, income inequality

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1 Introduction

"How seldom we weigh our neighbor in the same balance with ourselves"

Of the Imitation of Christ, Thomas à Kempis (1418)

Do homeowners have a preference for living among neighbors with a similar income level? Common sense suggests that homeowners prefer income equality in the neighborhood. There is the alleged snobbery of the rich towards the poor and the reciprocal jealousy of the poor towards the rich. Recent neural science research has also shown that humans have social preferences to reduce inequality in outcome distributions (see Tricomi, Rangel, Camerer, and O'Doherty (2010)). According to one sociological research (Gans (1961)), "People with higher incomes and more education may feel that they or their children are being harmed by living among less advantaged neighbors. The latter are likely to feel equally negative about the 'airs' being put on by the former...". In this paper we give a quantitative answer to the question by studying over 90,000 transactions in the Hong Kong housing market in 2005 and 2006.

There is the concern that we may be mixing up the distaste for inequality with the other unpleasant outcomes induced by inequality. For example, the poor may find it hard to find a shop that caters for his needs in a rich neighborhood; also, the rich may be concerned about the higher crime rate in a poor neighborhood. Our identifying assumption is that these unpleasant outcomes are likely to affect a *district* larger than a *local neighborhood* (the size of both will be defined later). We are then able to control for district fixed effects in order to identify the distaste for inequality in a local neighborhood.

We first present a simple model that takes the preference of a homeowner as given, and look at the equilibrium in the housing market when the homeowner prefers to live near others with a similar income level. Specifically, the model tells us how public housing affects the equilibrium distribution of the housing units and welfare. Since we are interested only in the implications of the distaste towards income inequality, our model abstracts from other important aspects of the housing market. We then describe the data, and explain why two unique features of the Hong Kong housing market are important for our purpose. First, Hong Kong is a densely populated area that magnifies the impact of neighbors (e.g. frequent face-to-face interactions in the elevator). Second, the public housing policy in Hong Kong has created substantial income inequality within local neighborhoods. Using a 3-step semi-parametric hedonic pricing technique, we obtain the willingness to pay and preference parameters for the characteristics of the housing unit and also the neighborhood characteristics. In particular, we look at the preference for income inequality and see how the preference changes with the demographics. Finally, we conduct a counterfactual experiment by reallocating half of the poorest public housing residents in all constituency areas in Hong Kong, and look at the welfare implications.

To address the concern that the neighborhood income inequality is correlated with some omitted variable that is correlated with house price, we take advantage of an exogenous policy change. On May 15, 2004, the Hong Kong SAR government made an unexpected announcement to turn a hitherto idle apartment complex to public rental housing. The expectation of an influx of relatively poor neighbors caused a drop in the housing transaction prices in that neighborhood. We compare the housing prices in this neighborhood and several control groups and find that the effect of income inequality induced by this policy change is in line with the estimates in our semi-parametric hedonic regression.

To the best of our knowledge, this is the first paper that estimates the preference of homeowners for income inequality in the local neighborhood. There are some empirical studies on the neighborhood effect or housing externalities among residents. Suppose there is an urban renewal project in one area, the land value of the nearby area may also increase due to externality. Using the American Housing Survey for 1985 and 1989, Ioannides (2002) finds that whether the neighbors (the 10 nearest housing units) of an individual have house maintenance substantially affects the individual's maintenance decision. That is, living in a dilapidated neighborhood discourages an individual to improve her housing unit, while the individual has a higher incentive to renovate when the neighbors' housing units look much better. A recent paper by Rossi-Hansberg, Sarte, and Owens (2010) looks at the concentrated residential urban revitalization programs in Richmond, VA. A few disadvantaged neighborhoods (the impact area) are supported by the federal government to renovate, but the neighborhood of the impact area also benefits from the program due to the neighborhood effects. The authors find that there is an increase in the land value of the neighborhood, and the effect decreases with the distance from the impact area. Our paper differs from the housing externalities literature that we identify the *preference* for the income inequality of the neighborhood in a hedonic pricing framework instead of the *behavior* induced by the improvement or deterioration of the neighborhood. We quantify the distaste of people for income inequality in the neighborhood, and we measure the welfare gain of reducing income inequality in the residential areas in Hong Kong. The housing externalities literature is partly based on the homeowners having the preference we identify in this paper.

This paper is also related to the literature of income sorting in residential areas, at least since Tiebout (1956). In the Tiebout's model, a local government collects taxes and provide public goods, and communities are formed endogenously. The Tiebout model predicts income stratification across communities, or, equivalently, all people in each community have the same marginal benefit from the local public goods.[1] Allowing for heterogenous preferences, Epple and Platt (1998) show that it is possible to reduce the amount of stratification, i.e. people with the same income are not necessarily in the same community. Using data from the American Housing Survey, Ioannides (2004) finds that within small neighborhoods (same as Ioannides (2002)), there is substantial income mixing. In our empirical framework each homeowner takes the income distribution in the constituency area as given, and from the data we infer how much the homeowner is willing to pay for less income inequality in the area. In addition, income distribution within constituency areas in Hong Kong is not only determined by the competitive market, but is mostly influenced by public housing policy (see Section 2). Based on the estimated preference, we look at the welfare implications of reducing income inequality in the constituency areas. Our paper calculates the welfare gain by allowing income sorting without the distortion of public housing policy.

2 Why the Hong Kong Housing Market?

Hong Kong is famous for being a densely populated city. According to the World Population Prospects [2], the estimated population density in Hong Kong is 6,433 people per squared kilome-

[1] Please refer to Hanushek and Yilmaz (2007) and Hanushek and Yilmaz (2010) for more discussion on the Tiebout model.

[2] See `http://esa.un.org/unpp/` for details.

tre for the year 2010, in contrast with 33 people in the United States, 225 people in the United Kingdom and 336 people in Japan. Of course, Hong Kong is less populated than major cities in the US like Manhattan, New York (25,850 people [3]). But since Hong Kong is characterized by high-rises and being mountainous, some of the residential areas we study are highly populated. For example, a medium-quality high-rise of 40 floors usually have more than 10 housing units on each floor, and residents are forced into having frequent interactions with neighbors (in the elevator, or even hearing a conversation from next door). As a result, Hong Kong will be a more suitable case for identifying a distaste for income inequality than other cities or regions studied in the literature.

As our interest is the preference for income inequality in the neighborhood and the potential benefit of removing inequality, we need to study residential areas with significant variations of income distribution. The public housing policy in Hong Kong has contributed to the substantial income inequality in different areas of Hong Kong.

In 1953, a fire in Shek Kip Mei destroyed thousands of shanty homes. Since then, the government of Hong Kong began to construct homes for the poor. A significant portion of people in Hong Kong are inhabiting in public housing. According to 2006 census, 3.4 million people, out of 6.9 million, lived in public housing provided by the Hong Kong government. This is the greatest government intervention in a city renowned for its free-market principle.

There are three main types of public housing in Hong Kong.[4] The first type is Public Rental Housing estates which are the most numerous type of public housing. As of 2006, 2.1 million people lived in Public Rental Housing estates. Applicants' income and total net assets value cannot exceed certain limits, which vary between families, the elderly and individual applicants. For instance, the monthly income and total net asset limit for a two-person household are HK$11,660 and HK$252,000.

The second type is the Home Ownership Scheme (HOS) estates. These are subsidized-sale public housing estates for low-income residents. As of 2006, 1.2 million people lived in these estates. The income and asset limits are higher than that of the Public Rental Housing estates. The monthly income and total net asset limit for a two-person household are HK$23,000 and

[3]See http://www.census.gov/population/www/censusdata/density.html for details.

[4]The following description is based on the information from the Hong Kong Housing Authority and the Housing Department http://www.housingauthority.gov.hk/en

HK$660,000.

The third type is the Sandwich Class Housing Scheme estates. They were built for sale to the "sandwich class", which are the lower-middle and middle-income residents not eligible for other public housing but have difficulties affording private housing. The flats are sold at prices slightly below market value (usually 70%), but with quality comparable to some middle-class private housing. The supply of these estates are limited. Only 48,106 people lived in these Sandwich Class Housing Scheme estates in 2006.

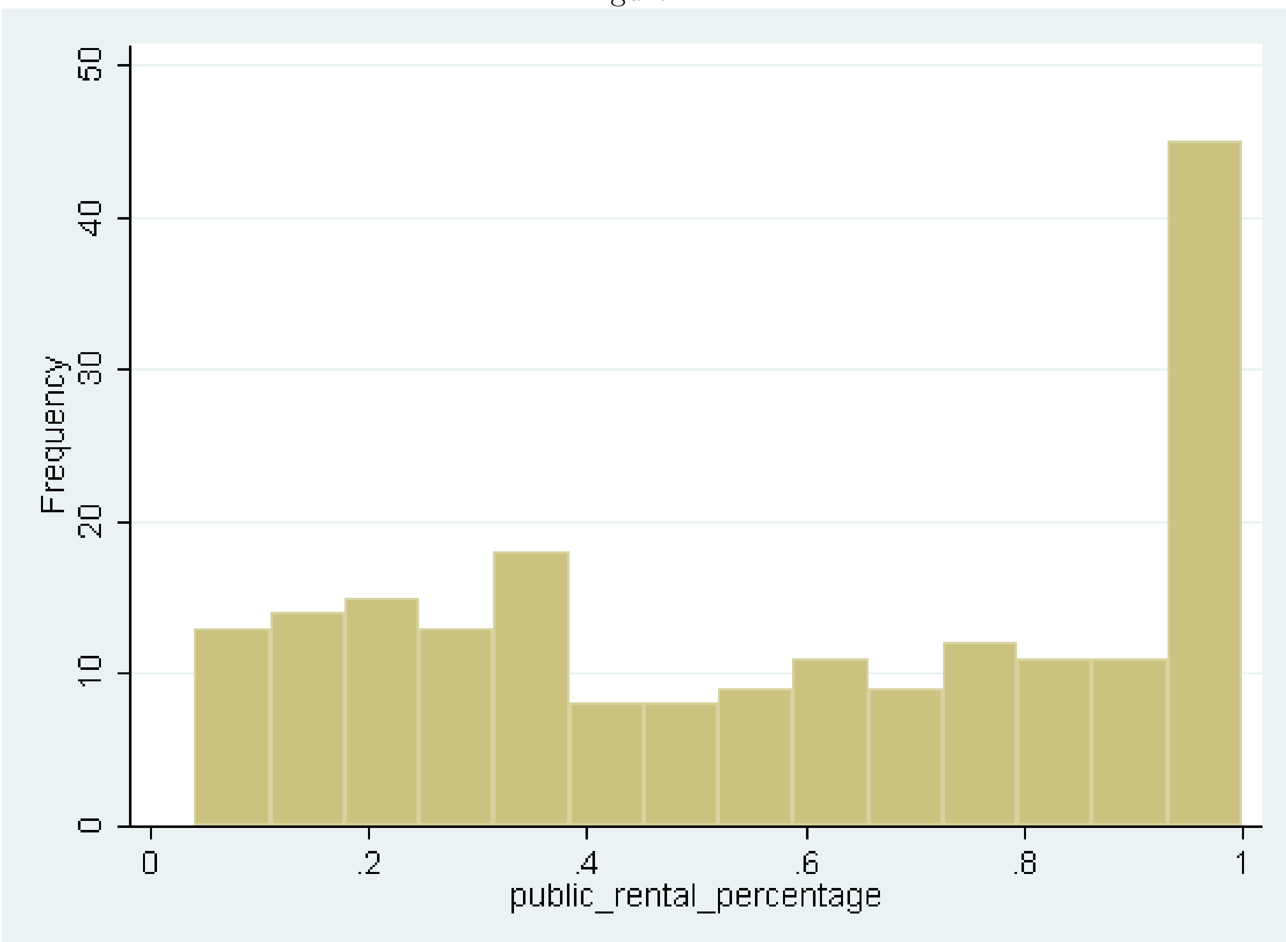
The Census data only allows us to separately identify the demographics of the Public Rental Housing estates and the rest. Also, since the housing units of both the Home Ownership Scheme estates and Sandwich Class Housing Scheme estates are transacted in private second hand market, and the income of the the residents are significantly higher than those living in Public Rental Housing estates, we count these residents as living in private housing. Thus, in the analysis below, we focus to analyze on how Public Rental Housing estates affect Gini and welfare of homeowners in different constituency area.[5]

One distinct feature in the Hong Kong housing market is that public housing inhabited by lower-income group and private housing inhabited by higher-income group can coexist in the same local neighborhood (or the same constituency area, which is to be defined later). While about half of the constituency areas (186 out of 380) do not have any Public Rental Housing estates, Figure 1 shows that the percentage of Public Rental Housing units in a constituency area varies evenly across the rest of the constituency areas.

A related literature looks at the relationship between the provision of public goods and ethnic/income fragmentation in the US (see Alesina, Baqir, and Easterly (1999) and Fernandez and Rogerson (1996)). For example, public spending may increase in an area with more serious ethnic conflicts. Under such environment it is hard to disentangle between the preference for equality and the government's reaction to inequality. In Hong Kong, given the small size and a majority of citizens of Chinese descent, provision of public goods is weakly, if at all, related to income or ethnicity. Such an environment allows a clean identification of the preference of equality.

[5]We have also calculated two other commonly used measures of income inequality, the Hoover index and the Theil index, and we find that they are highly correlated with the Gini coefficient.

Figure 1:



Percentage of Public Rental Housing Across Constituency Areas (excluding constituency areas without any Public Rental Housing)

3 Data Description

In this paper, we use housing transaction data provided by the Economic Property Research Center (EPRC) for 2005-06 as our main source of data.[6][7] We then supplement this data with the 2006 Hong Kong Census data, which is available on the internet at http://www.censtatd.gov.hk/home/index.jsp

3.1 The EPRC Data

The EPRC data contains many aspects of each household transaction, including prices, gross and net area, address, floor, age, number of bedrooms and living rooms, and so forth.[8]

Let's compare the EPRC data with the more conventional micro data from the US Census of Population and Housing. On the one hand, the US Census data provide more detailed homeowners' demographic and financial information than our data. We can only use the average demographic information of people living in private housing in various constituency areas as proxy. On the other hand, the home price data from the US Census is self-reported and is top-coded at US$875,000. In addition, home prices are partitioned into only 23 mutually exclusive categories. Also, the US Census data only provide limited information on the home's characteristics such as the number of rooms and age of the structure.

Initially, there are 357,931 observations in the EPRC data. We drop observations with missing characteristics like prices, floor, area, e.t.c. We then select the observations in major estates and building in each constituency area and merge it with the Census data which has the demographic statistics for each constituency area. This leaves us with 89090 observations. Table 1 describes the sample selection process.

Table 2 summarizes the characteristics of the transacted housing units between 2005-2006. The transaction prices and the transacted housing units are reasonably similar across the two years, which can serve as a justification for treating the two years as the same market for the

[6] We include data in 2005 to have a larger sample size, since it is reasonable to assume that the demographics did not change much between 2005 and 2006. Nevertheless, the results from using only the 2006 data are similar and available upon request. We do not have access to data beyond 2007.

[7] For studies on the Hong Kong housing market using the same dataset, see Leung, Lau, and Leong (2002) and Leung, Leong, and Wong (2006).

[8] All prices hereafter are denominated in Hong Kong dollars, in 2006 value. We account for possible inflation/deflation of house price between 2005 and 2006 by adding a year dummy in our analysis. Nevertheless, the adjustment is unimportant as the CPI inflation over the two years is less than 0.1%.

Table 1: Sample Selection in the Homes Transaction Data

Reasons for exclusion	Year 2005 # dropped	Year 2005 # remain	Year 2006 # dropped	Year 2006 # remain
Initial Sample	N.A.	173445	N.A.	184486
Missing Floor	4097	169348	3613	180873
Missing Gross Area	45072	124276	53017	127856
Missing Net Area	14249	110027	15429	112427
Missing Bedroom	26587	83440	27691	84736
Missing Living Room	31	83409	24	84712
Price = 0	1731	81678	2021	82691
Price Outliers	1621	80057	1652	81039
Non-major Estates/Buildings	33790	46267	38216	42823

Table 2: Summary Statistics for Hong Kong Homes Transacted in 2005-06

	Year 2005	Year 2006
Price ($HK Million)	2.46 (1.81)	2.51 (2.02)
Floor	18.63 (12.77)	18.31 (12.29)
Gross Area (sq ft)	713.61 (248.34)	722.07 (263.45)
Net Area (sq ft)	561.94 (207.10)	572.86 (224.54)
Bedrooms	2.38 (0.55)	2.40 (0.56)
Living Rooms	1.87 (0.33)	1.86 (0.34)
Age of Structure	12.42 (7.85)	14.07 (7.76)
Swimming Pool	0.80 (0.40)	0.78 (0.41)
Club House	0.54 (0.50)	0.52 (0.50)
std. dev. in parenthesis.	N = 46267	N = 42823

following analysis.

3.2 Census Data

In the EPRC dataset housing units are grouped into 49 *districts*. But the Census data, collected every five years, are available at a more refined level of 380 *constituency areas*. To combine the two datasets, we match each housing unit in the EPRC dataset to a constituency area .

For purpose of elections in the District Council, the government divides Hong Kong into 380 constituency area [9] The 2006 Census data includes various demographic, social, educational, economic and household information of each of the 380 constituency areas. Table 3 summarizes the demographic information of the constituency areas. The average population in

[9] The District Council is responsible for advising the government on issues like public facilities and community activities in the district. Qualified voters can vote in their own constituency area, and the candidate with the largest number of votes in each area wins and enters the District Council. As a result there are 380 elected members in the Council, along with some other appointed members. For more details, see http://www.elections.gov.hk/elections/dc2003/english/.

Table 3: Summary Statistics of Constituency Areas

	Mean	Std. Dev.	Min.	Max.
Population	17148.22	4465.66	5158	46447
Median Age	39.72	3.23	26	50
Median Household (Monthly)Income	10769.88	2959.966	7000	25000
Average Household Size	3.00	0.32	2.3	4
% Post Secondary Education	22.25	12.69	5	64.9
Gini	0.45	0.06	0.22	0.60
% Public Rental Housing	0.30	0.37	0	1

N=380

a constituency area is 17,148. All of the variables reported in Table 3 have reasonable variation across constituency areas. As shown in Table 3, the Gini coefficient across constituency areas vary a lot from 0.22 to 0.6, average at 0.45.

4 Implications of the Distaste for Inequality

Given that people have a distaste for income inequality in the neighborhood, what can we say about the location choice of the people? How does the introduction of public housing affect the location choice, and composition and income inequality within and across communities? Does public housing reduce the welfare of some people? To illustrate the main points of this paper, in this section we present a stylized model that takes the preference of residents as given, and abstracts from many other aspects of the housing market.[10]

In the model, there is a unit measure of agents, $i \in [0, 1]$. Each agent is endowed with income $w(i)$, with $w'(i) \geq 0$, so agent 0 is the poorest and agent 1 is the wealthiest. Given $w(i)$ and $w(-i)$, agent i chooses to stay in neighborhood n, where $n = 1, \ldots, N$. Denote the policy function of agent i, which will be discussed further below, as $P(i| - i)$.

In this model, an agent has a distaste to stay in a neighborhood in which neighbors' incomes are very different from that of the agent. The utility of agent i living in neighborhood n is the average squared income difference between i and his neighbors:

[10]This model only illustrates some qualitative results. For quantitative results, reader can refer to Sarpca, Leung, and Yilmaz (2010) which uses a quantitative spatial equilibrium model to compare the welfare and equilibrium outcomes under no government, public housing as well as housing voucher.

$$u(i,n) = -\int_0^1 \frac{P(j|-j)[w(i)-w(j)]^2}{S_n}\,dj$$

where $S_n = \int_0^1 P(j|-j)\,dj$, which is the size of neighborhood n.

Agent i's problem is to choose a neighborhood that maximizes his utility. Thus the policy function solves the fixed point problem below:

$$P(i|-i) = \arg\max_k u(i,k) \tag{1}$$

We have not been able to prove the existence and uniqueness of the fixed point. Thus, no analytical solution can be provided at the moment. Instead, we solve the fixed point numerically and find that the result is fairly robust.

The set up of the numerical exercise is as follows. We have 200 home buyers and 5 locations.[11] Income of each home buyer is drawn from a log-normal distribution. Income is then sorted from low to high, so that $w(1) \leq w(2) \leq \ldots \leq w(200)$. Each home buyer chooses to locate in one of the 5 neighborhoods as modeled above. The solution of the problem is a 200-by-1 vector policy function for the 200 agents. That is, each policy function solves equation (1). To see if the result is robust to different income draws, we repeat the above steps 100 times. The average location and welfare can be interpreted as the expected location and welfare of the home buyer.

We solve two equilibria. First, it is the free market equilibrium in which every agent is free to choose his neighborhood. Second, it is the public housing equilibrium in which the poorest 50 agents are assigned to two neighborhoods.

Figure 2 shows the income distribution in each of the five neighborhoods in the two equilibria. The first column is the free market equilibrium, and the second column is the public housing equilibrium. There are two things to note. First, the income of agents living in private housing is lower in the two neighborhoods with public housing, which is empirically testable.

To test this implication, we use the Census data to show that the percentage of households living in public housing in a constituency area is negatively correlated with mean household income among households living in private housing. We regress mean household income on the percentage of public housing. Since there are unobserved district-level characteristics (e.g. crime

[11] Our results are robust to the number of homeowners and number of locations.

rate or schooling quality) that are correlated with the percentage of public housing, we control for district fixed effects in the regression. For each percentage point increase in the proportion of households living in public housing, there is a drop (roughly $400) in monthly mean household income among households living in private housing, which is consistent with the implication of the model.

The second implication of the model is that, aside from the richest neighborhood, the incomes in all other neighborhoods are more spread in the public housing equilibrium. This means all but the richest agents would be worse off when there is public housing, which is implied in Figure 2. To quantify the size of the welfare loss of public housing, in Section 9 we conduct a counterfactual experiment by removing half of the public housing in each constituency area.

5 A Hedonic Price Model

In this section, we build a model of housing demand for households in Hong Kong between 2005-2006. A home $j = 1, \ldots, J$ is a bundle of three types of characteristics: physical attributes, neighborhood attributes and attributes observed by consumer but not by econometricians. The physical characteristics include floor, net gross ratio, gross area, bay window, age of structure, the presence of a swimming pool. The neighborhood characteristics are 1) the percentage of households living in public housing and 2) the Gini coefficient in the constituency area. These two groups of attributes are grouped as $\mathbf{x}_j$. The unobserved attribute is modeled as a scalar ξ_j.

Prices of houses are determined by the interaction of buyers and sellers in the equilibrium. The price function $\mathbf{p}$ maps housing characteristics $(\mathbf{x}, \xi)$ into their equilibrium prices:

$$p_j = \mathbf{p}(\mathbf{x}_j, \xi_j) \tag{2}$$

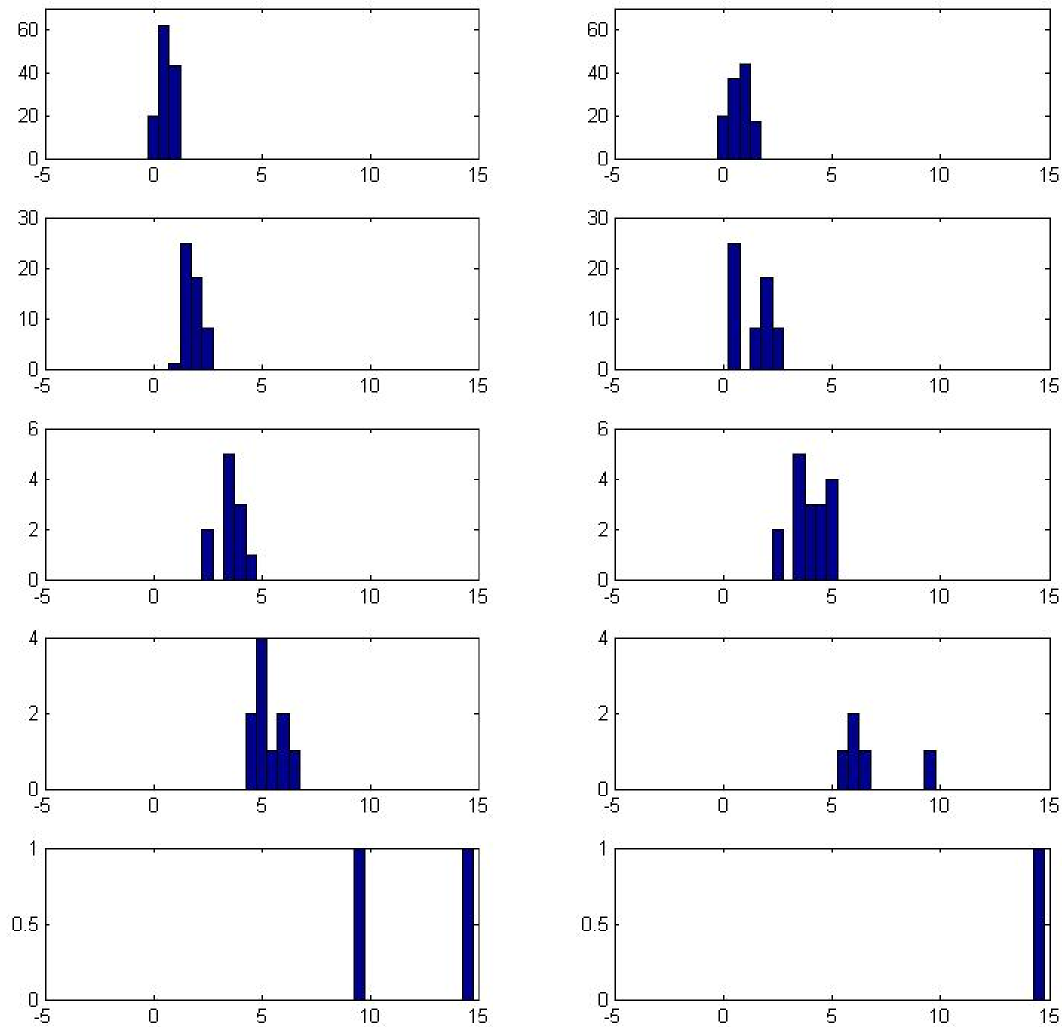
Households take prices as given and solve the following static utility maximization problem:

$$u_{ij} = \max_j u_i(\mathbf{x}_j, \xi_j, c) \text{ Subject to: } p_j + c \leq y_i \tag{3}$$

where c is a composite commodity, with a price normalized to $1 (pre-tax).

Suppose the characteristic k is continuous and that j^* is household i's optimal choice. The

Figure 2:



Income Distribution in Different Neighborhood (Column 1: free market equilibrium; Column 2: public housing equilibrium) first-order condition of equation (3) says that the marginal rate of substitution between product characteristics k and the composite commodity must equal to the implicit price:

$$\frac{\frac{\partial u_i(\mathbf{x}_{j^*},\xi_{j^*},y_i-p_{j^*})}{\partial x_{j,k}}}{\frac{\partial u_i(\mathbf{x}_{j^*},\xi_{j^*},y_i-p_{j^*})}{\partial c}} = \frac{\partial \mathbf{p}(\mathbf{x}_{j^*},\xi_{j^*})}{\partial x_{j,k}} \tag{4}$$

As noted by Bajari and Benkard (2005b) and Bajari and Kahn (2008), a single cross section observed in this data is not enough to recover a household's utility function globally. We follow the literature on random coefficient discrete choice models to specify household's utility to be:

$$u_{ij} = \beta_i'[\log(\mathbf{x}_j); \log(\xi_j)] \tag{5}$$

We allow for a rich specification of heterogeneity in tastes as we allow the marginal valuation of the characteristics to be household specific, since β_i are household specific. Also, utility in equation (5) is a log-linear function of the product characteristics. The log specification allows product characteristics to have diminishing marginal utility.

Most of the previous studies on differentiated product assume β_i to have a parametric distribution. In particular, they are independently and normally distributed.[12] We do not impose any parametric distribution on β_i and will estimate the distribution of new homeowners' tastes semi-parametrically.

In this paper, we are interested to see how distaste against income inequalities of households with different demographic characteristics differ. We thus model the joint distribution of the random utility coefficients, β_i, and demographics.[13] As discussed in Bajari and Kahn (2008), the lack of micro level data on household level characteristics requires an assumption of linearity between tastes and demographics.

6 Estimation

Our estimation approach involves three steps. The first two steps are similar to those used in Bajari and Benkard (2005a); the last step is similar to Bajari and Kahn (2008). In the first step,

[12]See Berry, Levinsohn, and Pakes (1995), Petrin (2002), Nevo (2000), and Rossi, Allenby, and McCulloch (2005).

[13]Section 7 provides more discussion on the set up.

we estimate the hedonic price function $\mathbf{p}$ using a flexible local linear regression method described in Fan and Gijbels (1996) and applied in Bajari and Kahn (2005) and Bajari and Kahn (2008). Second, we "back out" the random utility coefficients for each household by applying first order conditions for optimality. Finally, we recover the joint distribution of random utility coefficients and household demographics. Since we only have access to demographics aggregated at the level of constituency areas, we follow Bajari and Kahn (2008) to estimate household-level preferences with this aggregated data.

6.1 First Step: Estimating the Hedonic Price Function

We follow Fan and Gijbels (1996) and use local linear methods to estimate the hedonic flexibly. For a particular home j^*, we assume the hedonic price function $\mathbf{p}$ is locally linear and satisfies:

$$p_j = \alpha_{0,j^*} + \sum_k \alpha_{k,j^*}(x_{j,k} - x_{j^*,k}) + \xi_j \tag{6}$$

We only assume the hedonic in equation (6) is locally linear, not globally linear as in a linear regression model. The coefficients $\alpha_{\cdot,j^*}$ have a subscript j^* to emphasize that they are specific to (x_{j^*}, ξ_{j^*}).

For any $j^*, 1 \leq j^* \leq J$, we follow Fan and Gijbels (1996) to use weighted least squares to estimate α_{j^*}

$$\begin{aligned} \alpha_{j^*} &= \arg\min_{\alpha}(\overrightarrow{\mathbf{p}} - \mathbf{X}\alpha)'\mathbf{W}(\overrightarrow{\mathbf{p}} - \mathbf{X}\alpha) && (7) \\ \mathbf{p} &= [\text{RPRICE}_j], \mathbf{X} = [\mathbf{x}_j], \mathbf{W} = diag\{K_h(\mathbf{x}_j - \mathbf{x}_{j^*})\} && (8) \end{aligned}$$

In equations (7) and (8), $\overrightarrow{\mathbf{p}}$ is the vector of the owner's equivalent rent for all homes $j = 1, \ldots, J$, $\mathbf{X}$ is a vector of regressors which correspond to the observed product characteristics and $\mathbf{W}$ is a matrix of kernel weights.

The kernel weights in $\mathbf{W}$ are a function of the distance between home j^* and j. The local linear regression assigns more weights to observation near j^*. As discussed in Fan and Gijbels (1996), local linear methods have the same asymptotic variance and a lower asymptotic bias than the Nadaraya-Watson estimator, whereas the Gasser-Mueller estimator has the same asymptotic bias and a higher asymptotic variance than local linear methods. We chose the following normal kernel function with a bandwidth of 3:

$$K(z) = \prod_k N(z_k/\hat{\sigma}^2) \tag{9}$$

$$K_h(z) = = K(z/h)/h \tag{10}$$

In equation (9), K is a product of standard normal density and $\hat{\sigma}^2$ is the standard sample deviation of characteristic k.

We interpret the residual the hedonic regression from equations (7) and (8) as the unobserved home characteristic.

$$\xi_{j^*} = p_{j^*} - \mathbf{x}_{j^*}\alpha_{j^*} \tag{11}$$

In the first step, we run a linear regression on the characteristics of the housing unit. The physical characteristics include floor, net gross ratio, gross area, bay window, age of structure, the presence of a swimming pool. The neighborhood characteristics are the percentage of households living in public housing and the Gini coefficient in the constituency area.[14] To control for unobserved attributes that may be correlated with the characteristics, we also include district fixed effect in the regression.[15] The district fixed effects absorb important attributes such as distance from work, air quality, crime rate and local school quality that can be correlated with the percentage of public housing or income inequality. We then subtract the district fixed effects from the owner's equivalent rent and estimate the local linear regressions described above.

The treatment for binary variables (e.g. the presence of a swimming pool) is different. Suppose the household i chooses a house j^*. Define $\hat{\mathbf{x}}_j$ as the observed characteristics of house j^* except one of the binary variable x is set to 1, and $\bar{\mathbf{x}}_j$ as the same characteristics

[14] We do not include the constituency-level average income as one of the neighborhood characteristics since that will be included in our third step estimation. Also, since average income is positively correlated with Gini coefficient, and homeowners may have preference for living in a rich neighborhood, omitting the constituency-level average income only leads to a bias of the coefficient on Gini coefficient towards zero.

[15] To control for macro-economic fluctuations, we also add month-year fixed effects. Since the results are very similar, we only report the results without these month-year fixed effects.

with the binary variable set to 0. The implicit price for the binary characteristic x is then $\mathbf{p}(\hat{\mathbf{x}}_j, \xi_j) - \mathbf{p}(\bar{\mathbf{x}}_j, \xi_j)$, and if household i chooses $x = 1$ then $\beta_{i,x} > \mathbf{p}(\hat{\mathbf{x}}_j, \xi_j) - \mathbf{p}(\bar{\mathbf{x}}_j, \xi_j)$ and $\beta_{i,x} < \mathbf{p}(\hat{\mathbf{x}}_j, \xi_j) - \mathbf{p}(\bar{\mathbf{x}}_j, \xi_j)$ otherwise. That is, $\beta_{i,x}$ is not identified.

6.2 Second Step: "Backing Out" the Random Utility Coefficients

Due to the log utility function (5), we can calculate the random utility coefficients easily. Let $\hat{\alpha}_{j^*,k}$ be the estimated coefficients from the local linear regression for variable x_{j^*}. The coefficients are the implicit prices faced by household i, who chooses x_{j^*}, in the market, and hence $\hat{\alpha}_{j^*,k}$ is the estimated implicit price $\frac{\partial \mathbf{p}(\mathbf{x}_{j^*}, \xi_{j^*})}{\partial x_{j,k}}$. The random coefficients for this household i is calculated as:

$$\hat{\beta}_{i,k} = \hat{\alpha}_{j^*,k} x_{j^*,k} \tag{12}$$

That is, we obtain a random coefficient for every characteristic k and for every household i.

6.3 Third Step: Finding the Joint Distribution of Preferences and Demographics

We model the relationship between preferences and demographics using a linear model. Denoting $d_{i,s}$ as the demographic characteristic $s = 1, ..., S$ of household i, we can estimate:

$$\hat{\beta}_{i,k} = \theta_{0,k} + \theta_{k,1} d_{i,1} + \cdots + \theta_{k,S} d_{i,S} + \eta_{i,k} \tag{13}$$

Unfortunately, we do not have observations on the household's characteristics $d_{i,s}$. Instead, we observe the average characteristics of households in each constituency area $d_{t,s}$ for $t = 1, ..., T$. We follow Bajari and Kahn (2008) and estimate (13) with the group-mean method. We divide the $i = 1, ..., I$ households into G groups each of size $n = I/G$, and write (13) as:

$$\bar{\beta}_{g,k} = \theta_{0,k} + \theta_{k,1} \bar{d}_{g,1} + \cdots + \theta_{k,S} \bar{d}_{g,S} + \bar{\eta}_{g,k} \tag{14}$$

That is, we regress the mean preference parameter in each group on the mean demographic characteristics of each group. We do not observe these group means either, but we can approximate

Table 4: Summary of Implicit Hedonic Prices

Variable	Mean	Std. Dev.	25%	50%	75%
Constant	1385.5	95885.4	-59069.1	-14094.1	37535.9
Floor	675.1	62.6	642.2	661.7	691.4
Net Gross Ratio (%)	1274.3	219.4	1167.4	1253.6	1365.7
Gross Area (sq. ft.)	382.1	12.0	375.3	380.5	386.2
Bay Window (sq. ft.)	-290.2	95.7	-317.8	-294.9	-265.6
Age of Structure	-1603.6	146.3	-1682.7	-1639.2	-1570.6
Swimming Pool	36727.7	4095.9	34880.2	35960.6	37460.1
Const. Area Gini	-73166.5	32404.9	-84151.0	-69586.5	-57862.5
Const. Area % Public Housing	-45505.7	6781.4	-48533.5	-46541.0	-44296.8

it by:

$$\bar{d}_{g,s} \simeq \frac{1}{n} \sum_{i \in g} \sum_{t} d_{t,s} \times 1 \{t(i) = t\} \tag{15}$$

The approximation would be close if T and n are large. First, we draw without replacement and group the households into G groups each with n members. Next, we calculate the group average preference $\bar{\beta}_{g,k}$ and average demographics $\bar{d}_{g,s}$ by (15). Third, with the G observations on $\bar{\beta}_{g,k}$ and the G observations on each $\bar{d}_{g,s}$, we can can estimate $\theta_{0,k}, ..., \theta_{k,S}$ for each preference parameter k by OLS.

In Bajari and Kahn (2008) only one draw is made and the OLS standard errors are used for inference. To account for the uncertainty induced by using group means instead of household-level demographic characteristics, we draw with replacement and estimate (14) for 1000 times. Instead of using the OLS standard errors, we take the standard deviation of the 1000 sets of $\theta_{0,k}, ..., \theta_{k,S}$ estimates to build our confidence intervals.

7 Results and Discussion

7.1 Hedonic Pricing Estimates

In Table 4, we show the hedonic prices for various housing attributes from the first step estimation. Since we use a semi-parametric regression technique, we display the distribution of the hedonic prices. Most of the average hedonic prices have signs and magnitudes consistent with economic intuition. One floor higher is priced at HK$675.1 per year. Homeowners would pay, on average, HK$382.1 per year for each extra square foot in gross area and HK$1274.3 per year for each percent increase in the net gross ratio.[16] That is, holding the gross area constant, the homeowner would prefer increasing the net area (for which the homeowner cares more than, say, a bigger swimming pool). Of the community characteristics, homeowners prefer a homogenous neighborhood. Home price drops, on average, by HK$7,317 when the Gini coefficient increases by 0.1. In other words, homeowners, on average, are willing to exchange 19 square feet of gross area (about half the size of a typical bathroom in Hong Kong) for a decrease in the Gini coefficient in the local neighborhood by 0.1. Local income inequality is a statistically and economically important factor to an average homeowner. In addition, the price of each 1% decrease in the people living in public housing is HK$455. Home price can drop with more public housing in the constituency area for many reasons: more crime, more traffic or higher population density.[17] Whatever the reason, the presence of this characteristic in the hedonic price function makes sure that the Gini coefficient variable is not measuring any unpleasant effects of public housing, but purely reflecting local income distribution.

7.2 Preferences Estimates

In the second step, we use the hedonic price estimates, and homeowners' optimal consumption of various housing attributes, to recover homeowners' marginal valuation for various housing attributes. In Table 5, we present the distribution of estimates of willingness to pay for a 10% increase in consumption of various attributes. In particular, suppose household i's current consumption of attribute k is x_k, the willingness to pay for an extra 10% for attribute k is:

$$WTP_{i,k} = \beta_{i,k}(\log(1.1x_k) - \log(x_k)) = \beta_{i,k} \log(1.1) \tag{16}$$

Again, most of the estimates have signs and magnitudes consistent with economic intuition. The average homeowner is willing to pay HK$1,197 per year for home that is 10% higher in floor, HK$26,348 per year for for a 10% increase in gross area and HK$9,524 per year for a 10% increase in the net gross ratio. Homeowners are very sensitive to the age of housing units.

[16] The net area is defined as the area that a resident actually occupies, whereas the gross area is the sum of the net area and "public area" like lobby, corridor and other recreational facilities.

[17] But this price drop is not due to the external effects at the district level as they are captured by district fixed effects.

Table 5: Consumer Willingness to Pay for Housing Attributes

Variable	Mean	25%	50%	75%
Floor	1197.1	542.5	1049.2	1670.6
Net Gross Ratio (%)	9524.0	8644.6	9337.4	10302.2
Gross Area (sq. ft.)	26347.8	19685.8	24120.0	29959.6
Bay Window (sq. ft.)	-599.3	-903.3	-658.4	-225.2
Age of Structure	-2075.4	-2994.7	-2049.2	-1023.0
Swimming Pool	2784.6	3214.6.0	3387.9	3542.2
Const. Area Gini	-3203.6	-3704.7	-3015.0	-2500.5
Const. Area % Public Housing	-205.1	0.0	0.0	0.0

Units are in HK dollars per year.

They are, on average, willing to pay almost HK\$2,075 less per year if housing units are 10% older. The average homeowner is willing to pay HK\$3,204 to avoid the Gini coefficient in the constituency area to increase by 10%. Again, the Gini coefficient is an important consideration for a homeowner: each 1% increase in the Gini coefficient is equivalent to a 1.25% decrease in the size of the housing unit. For example, the homeowner is indifferent between the Gini coefficient going down from 0.50 to 0.45 and the size going up from 1000 square feet to 1012.5 square feet.

Figure 3 plots the first stage coefficients of Gini on the rental price. If we take the rental price of the housing unit as a proxy of the buyer's wealth, Figure 3 shows that richer household dislikes income inequality more than less rich household. The third stage estimation described above can enable us to quantify this.

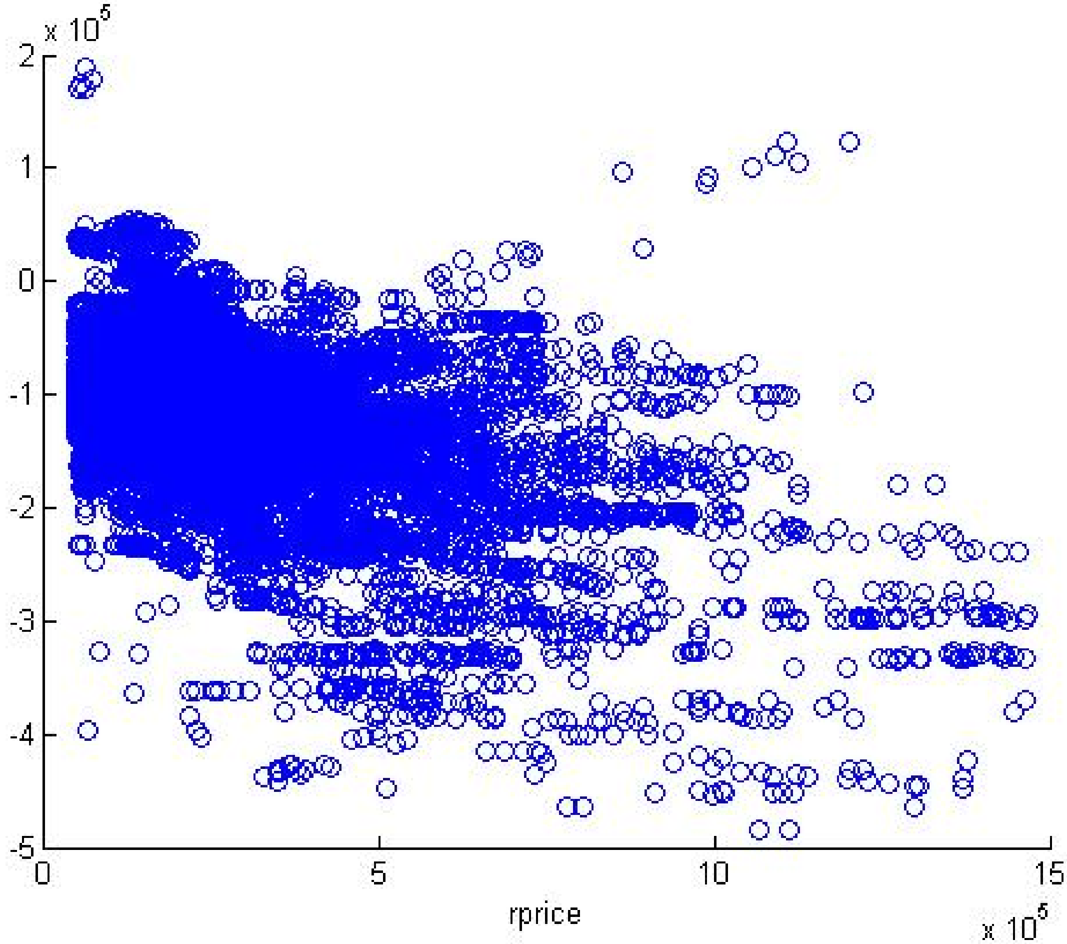
In the third stage estimation, we include four demographic variables in the regression (13):

- age;
- monthly household income ('000);
- marital status (dummies for married, widowed, and separated, and single is the omitted group); and
- education (dummies for less than high secondary, more than high secondary but less than college, and college or above, and high secondary is the omitted group).[18]

For these variables, we exclude the data of people living in public rental housing who we assume not to be homeowners. We then calculate the mean of these variables to be the control

[18]High secondary means completing Form 5, the level at which a student is about 17 years old. This is roughly equivalent to finishing high school in the US.

Figure 3:



Scatter Plot of Coefficients of Gini and RPrice

Table 6: Willingness to Pay for Income Inequality as a Function of Household Demographics

Age	62.8 (38.4)
Household Income (in $1,000s)	-39.2 (7.0)
% Less than High Secondary Education	-90.6 (23.9)
% Above High Secondary Education	-54.6 (35.2)
% College or Above	-42.2 (19.8)
% Married	35.5 (23.8)
% Widowed	20.2 (67.9)
% Divorced	23.5 (73.3)
% Separated	-192.1 (185.1)
Constant	-1039.5 (2500.2)
Mean R^2– 0.1268	

variables. In the calculation of mean age for each constituency area, we exclude certain age groups which are not likely to purchase a housing unit. In particular, we exclude people under age of 25. Results are in Table 6. First, homeowners with higher income dislikes income inequality more. For each HK$1,000 increase of monthly income the the willingness to pay for a 10% increases in Gini goes down by HK$40 per year. Second, older homeowners have a higher tolerance for income inequality. One year increase in age increases the willingness to pay for a 10% higher Gini by HK$62.8 per year. While the distribution of the willingness to pay is weakly related to marital status, it is strongly related to education level. Comparing to the omitted high secondary education group, the lowest education group is much more willing to pay for reducing inequality, For each 1% increase in the probability that the average adult household member receive less than high secondary education, the willingness to pay for a 10% higher Gini increases by HK$90.6 per year. The same holds for the two higher education groups, but by a less significant and much smaller amount.

8 A Small Natural Experiment

If the Gini coefficient and the percentage of public housing are correlated with some omitted variable that affects house price, we cannot establish a causal relationship between house price and local income inequality. To address the potential endogeneity problem, we take advantage of an exogenous policy change.

Under the recommendation of the Hong Kong SAR government, the Housing Authority of Hong Kong stopped the production or sale of housing units under the Home Ownership Scheme

(HOS) from 2003 onwards. For HOS projects that were either completed and ongoing when the policy change announcement was made, they were kept unoccupied, sold to private developers or changed to public rental housing.[19]

Since it is reasonable to assume that the government's choice of which HOS project to be changed into rental housing is uncorrelated with the house price in the affected neighborhood [20], we can use the policy change as an exogenous shock to 1) the Gini coefficient and 2) the percentage of public housing in that neighborhood.

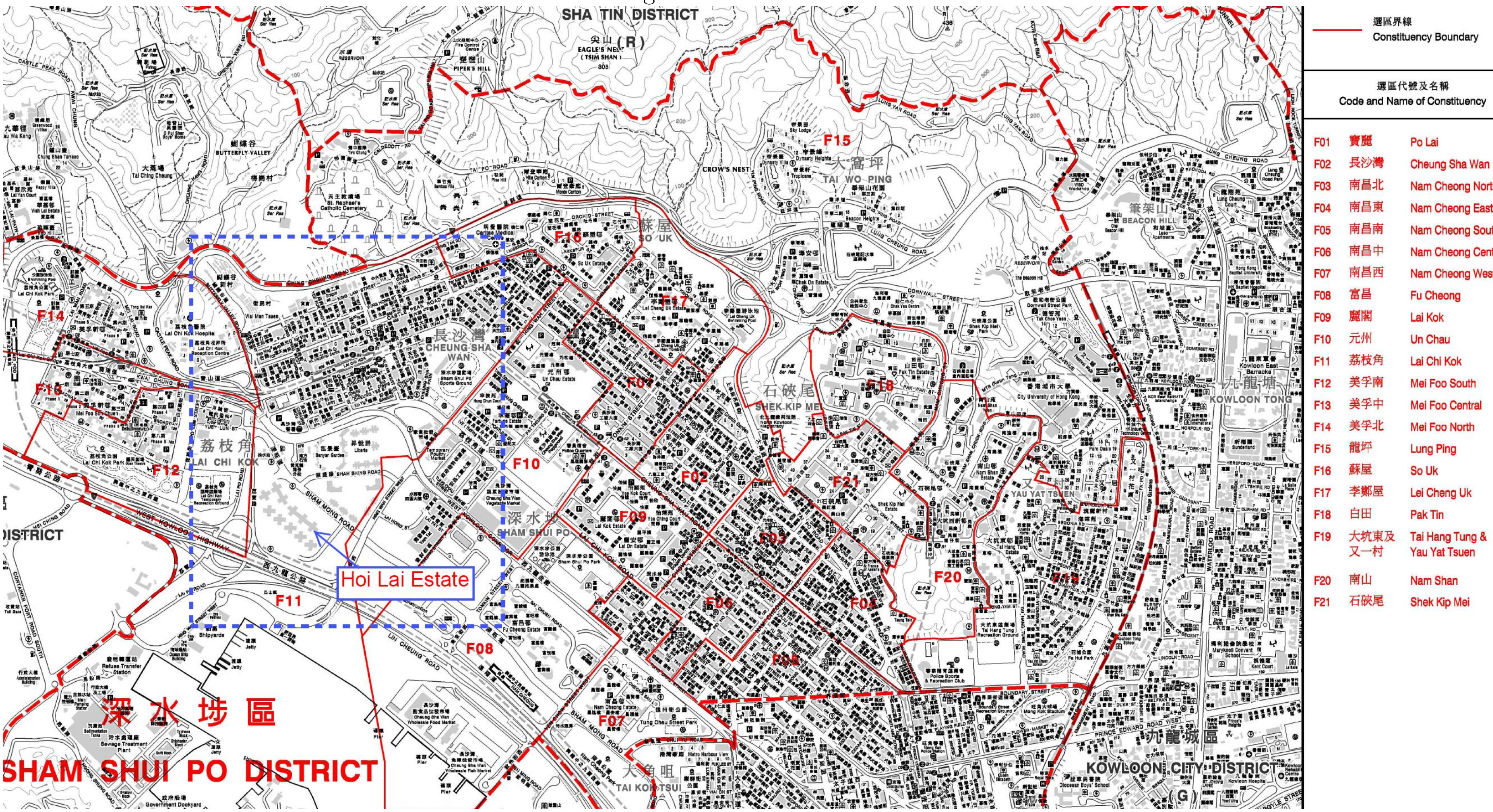
The case of Hoi Lai Estate in Cheung Sha Wan, Kowloon, which was an HOS project changed into rental housing, can serve as a natural experiment. Hoi Lai Estate is located in the constituency area Lai Chi Kok, which itself is within the Sham Shui Po district. Before Hoi Lai Estate, there was no public rental housing but only middle-to-upper private housing estates and schools in that constituency area. The policy change increases the proportion of public housing in that constituency area from 0 % to 31% and Gini coefficient from 0.494 to 0.496 from 2004 to 2005, the year in which residents moved in the estate.[21] To estimate the impact of the policy change, we look at the house prices of Lai Chi Kok and the 20 nearby constituency areas in the Sham Shui Po district (see Figures 4 and 5) and see if house price in Lai Chi Kok drops relative to that in nearby constituency areas.

[19]For more background on the ceasing of the HOS, see a paper by the Legislative Council Panel on Housing that can be accessed at `http://www.legco.gov.hk/yr02-03/english/panels/hg/papers/hg0318cb1-1129-4-e.pdf`.

[20]Our identification strategy fails if a) the government knows that price in some areas are going to drop, and b) the government is more likely to change the HOS units in those areas into public housing. Neither statement seems realistic to us.

[21]We use the 2006 Census to back out these numbers. Ideally, we would prefer to have a natural experiment that occurred between 2005 and 2006. But there was no such policy change in that period. Using the Hoi Lai Estate case may underestimate the effect of the policy since some rich people might opt to move out.

Figure 4:



Constituency Areas in the Sham Shui Po District

Table 7: Summary of Housing Units Transacted in May 2004

	Lai Chi Kok	Other C.A.s in Sham Shui Po	C.A.s in Group A	C.A.s in Group B
RPrice	224920 (55726)	125350 (70194)	142685 (115008)	128744 (37326)
Age of Structure	0.05 (2.76)	26.86 (8.34)	15.66 (6.56)	1.49 (2.68)
Floor	33.77 (16.35)	9.78 (5.90)	16.27 (10.64)	33.17 (12.03)
Gross Area (sq ft)	702.06 (101.21)	711.68 (249.73)	605.74 (251.99)	553.22 (96.51)
Net Gross Ratio	74.37% (2.06%)	81.64% (6.76%)	75.37% (6.71%)	70.84% (2.47%)
Bay Window (sq ft)	34.53 (12.72)	1.62 (5.85)	23.74 (15.86)	26.49 (7.17)
Swimming Pool	93.63% (24.46%)	0.34% (5.84%)	80% (40.14%)	96.72% (17.88%)
	N=408	N=293	N=140	N=122

The *announcement* of the change of Hoi Lai Estate into public rental housing was made in May 15, 2004.[22] Since there is no evidence of major shocks in the housing market two weeks before and two weeks after the announcement, we extract the housing transactions in the Sham Shui Po district occurred between May 1, 2004 and May 31, 2004.[23] Table 7 summarizes the characteristics of the housing units transacted in May 2004.

Since there were three new private housing complex in Lai Chi Kok being sold on the market in that period,[24] the number of transaction is higher, the ages of the housing unit are smaller, and the buildings are taller in Lai Chi Kok compared to those in other constituency areas in Sham Shui Po. While the net gross ratio is slightly lower, the gross area is about the same between the units transacted in Lai Chi Kok and the rest of Sham Shui Po.

To evaluate the impact of this announcement on the housing market in Lai Chi Kok, we run the following regression:

$$\begin{aligned} RPrice_j &= \beta_0 + \beta_1 Floor + \beta_2 Netgross + \beta_3 Grossarea + \beta_4 Baywindow \\ &\quad + \beta_5 Swimmingpool + \beta_6 Age + \beta_7 Announcement + \beta_8 LaiChiKok \\ &\quad + \beta_9 (Announcement \times LaiChiKok) + u_j \end{aligned}$$

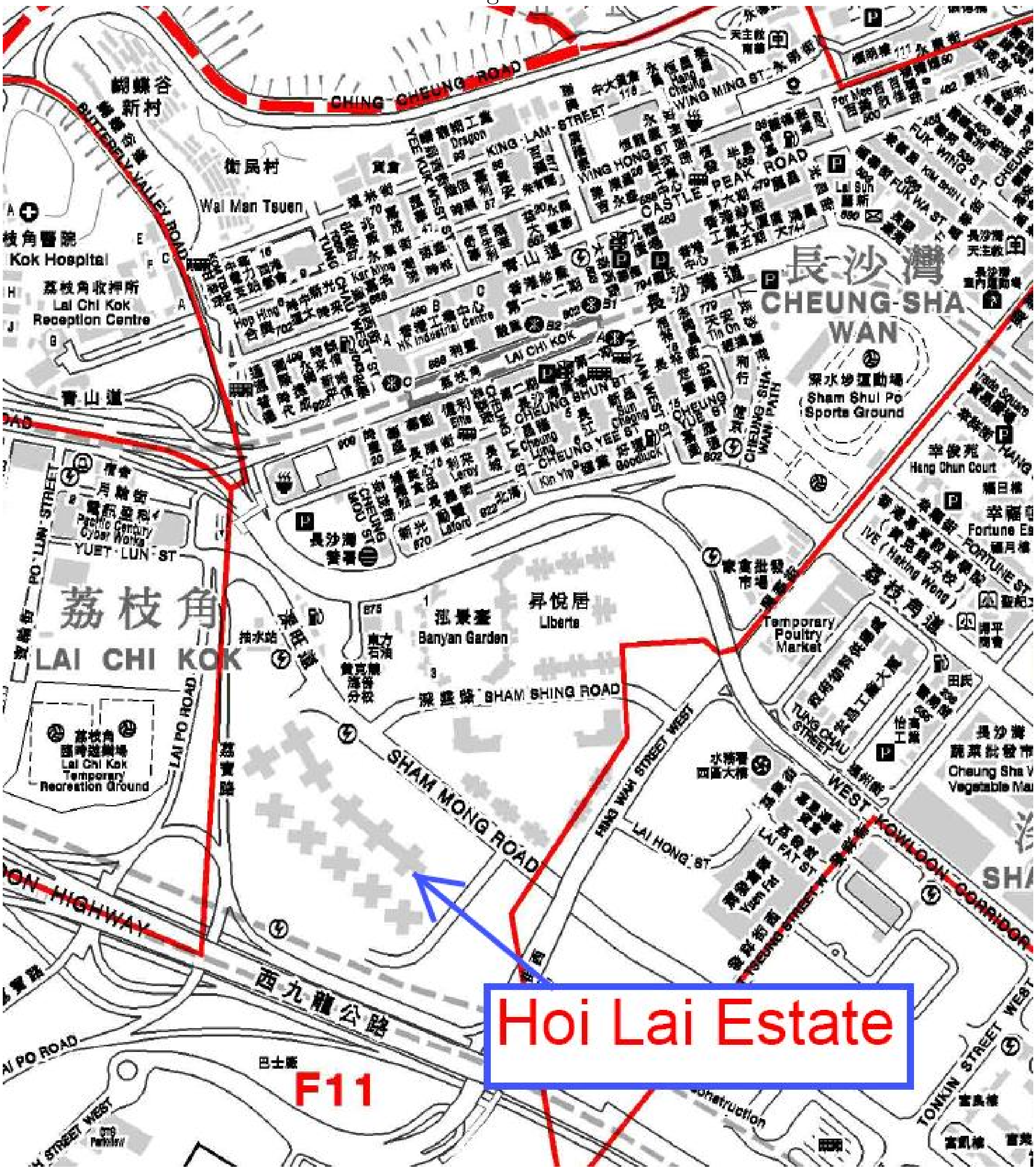
where *Announcement* is an indicator function which equals one if the date of transaction is

[22]The day on which we find the earliest news report: "Three Thousand HOS Units To Become Rental Public Housing" in the newspaper *Sun*.

[23]We also use transactions occurred four and six weeks before and after May 15, 2004. Results are similar and thus omitted here.

[24]The three complexes are Banyan Garden, Liberte and Pacifica. See Figure 4 and Figure 5 for their exact locations.

Figure 5:



Constituency Area: Lai Chi Kok

Table 8: Demographics of Lai Chi Kok and the 5 Comparison Constituency Areas

	Lai Chi Kok	Fo Tan	Hung Hom Bay	Kornhill Garden	Shau Kei Wan	Wong Uk
Median Income	HK$12,000	HK$13,750	HK$11,500	HK$15,000	HK$10,000	HK$13,000
Gini	0.494	0.495	0.518	0.492	0.493	0.500
% Less than	40	39	43	37	51	37
High Secondary Edu.						
% Above	38	44	37	40	38	43
% College or Above	22	17	20	23	12	21

after May 15, 2005, and $LaiChiKok$ is an indicator function which equals one if the housing unit is located in Lai Chi Kok. The treatment effect, is β_9, captures the drop in rental prices of housing units in Lai Chi Kok right after the announcement.

With a control group, our result is not biased even if there is some city-wide negative price shock that affects all private housing units equally. But if there is some unobserved negative price shock that affects more or only affects private housing units with similar characteristics as those in Lai Chi Kok, our result is biased. To address this problem, we replace the observations in the rest of Sham Shui Po with two other groups A and B of constituency areas as the control group. In Group A we handpick five other constituency areas which have similar demographics with Lai Chi Kok. The five constituency areas are Fo Tan, Hung Hom Bay, Kornhill Garden, Shau Kei Wan and Wong Uk. Two of them (Fo Tan and Wong Uk) are located in New Territories, one (Hung Hom Bay) is located in Kowloon and the remaining two (Kornhill Garden and Shau Kei Wan) are located in Hong Kong Island. Just like in Lai Chi Kok before the announcement, there is no public housing in any of these constituency areas. And as shown in Table 8, the demographics among the five constituency areas are very similar. In Group B we have Sycamore, located in Kowloon. Similar to Lai Chi Kok, the transactions in Sycamore are mainly from a new private housing complex, Metro Harbour View. From the third column in Table 7, we can see that the characteristics of the housing units are very similar between Lai Chi Kok and Sycamore.

The first column of Table 9 reports the results when we use Sham Shui Po as the control group. Most of the coefficients are consistent with the hedonic regression in Table 4, except for bay window. The parameter of interest, β_9, has an estimate of -12,628., and is statistically significant at 5% level. Since the policy change increases the proportion of public housing in that Lai Chi Kok from 0 % to 31% and Gini coefficient from 0.494 to 0.496, the results in Table

Table 9: Implicit Hedonic Prices From Natural Experiment (std. err.)

	Sham Shui Po as Control Group	Group A as Control Group	Group B as Control Group
Constant	-115573.1 (20661.0)	-97322.8 (54273.2)	-84755.8 (79306.2)
Floor	552.4 (88.9)	722.9 (88.3)	662.3 (74.5)
Net Gross Ratio (%)	861.4 (306.1)	440.3 (614.1)	303.7 (1113.1)
Gross Area (sq. ft.)	265.8 (13.4)	307.1 (15.7)	302.9 (14.0)
Bay Window (sq. ft.)	1099.7 (167.8)	1210.7 (161.6)	1006.5 (240.8)
Age of Structure	-984.1 (283.9)	-2641.2 (741.7)	-3609.1 (807.1)
Swimming Pool	38982.2 (7590.4)	-350.0 (7026.4)	662.0 (8854.2)
Announcement	1101.4 (3662.9)	1352.2 (6042.3)	1681.3 (3383.2)
LaiChiKok	-813.2 (7160.9)	10133.5 (13812.7)	19230.4 (5992.5)
Announcement × LaiChiKok	-12627.9 (4962.9)	-11586.8 (7029.3)	-12553.9 (4837.5)
District Fixed Effect for Treatment Group	No	Yes	Yes
	N=701	N=548	N=530

4 implies that the RPrice would drop by $73166.5 \times 0.02 + 45505.7 \times 0.31 \approx 15570$, which is reasonably close to 12628.

The second and third column of Table 9 report the results when Group A and Group B are used as the control group. The estimates of β_9, is still around -12,000 and statistically significant at 10% level. Some coefficients estimates like age and swimming pool are a bit off in those two columns since there is not much variation in the age of structure and swimming pool for the two groups.

Since the estimates from this small natural experiment are consistent with our main results, we now proceed to our counterfactuals based on the estimates in Table 4.

9 Counterfactuals

In the previous sections, we show that homeowners have a large and statistically significant distaste for income inequality in their neighborhood. At the same time, local income inequality is induced by the presence of Public Rental Housing. In our data, out of the 89,090 homes transacted between 2005-06, 27,738 of them are located in constituency areas in which there is public rental housing. One natural question to ask is thus: If the Hong Kong government separates private and public housing completely, so that private homeowners do not have Public Rental Housing in their neighborhood, what would be the welfare gain for homeowners?

To answer this question, we do the following counterfactual experiment. Suppose Hong Kong government is to reallocate the poorest 50% Public Rental Housing units to constituency areas exclusive to Public Rental Housing. At the same time, we leave the location of homeowners unchanged. This can improve welfare of homeowners through two channels. First, Gini coefficients in some constituency areas decrease. In particular, out of the 199 constituency areas in which we have property transaction data, income inequality in 79 constituency areas changes under this policy. Second, the percentage of public housing units in those 79 constituency area would drop by 50%.

Since most transactions (61,456) took place in constituency areas in which this policy has no effect, the welfare of these homeowners are not affected by this policy. For the rest of the homeowners (27,738), the average welfare gain improves HK$8,126 per year, in which HK$2,150 is due to lower Gini in those constituency areas and HK$5,976 is due to 50% of public housing units in those constituency areas.[25]

Is HK$8,126 per year a large amount? We can get an idea of the magnitude by using our results in Table 5. The amount of welfare gain is roughly equivalent to increasing the housing unit by 20 square feet or reducing the age of the housing unit by 5 years, both of which is quantitatively important.

10 Conclusion

People dislike living near others who have a lower or higher income level, and the dislike is substantial: on average, a homeowner is willing to pay about HK$3,200 for a 10% drop of the local Gini coefficient, and it is same as the amount the home buyer is willing to pay for a 1.25% increase in the size of the housing unit. We also find that the dislike of income inequality varies with demographics: it goes up with income and goes down with age. To avoid the potential endogeneity problem, we make use of a policy change in 2004 and conduct a natural experiment using a small part of the sample, and the results are similar. To gauge the relevance of our results, we show through a counterfactual experiment that relocating part of the Public Rental Housing improves homeowners' welfare by an economically significant amount. Of course, the experiment ignores the potential problems of grouping all low-income individuals in one area.

[25] We have done the experiment for reducing public housing by 75%, and the welfare change is about HK$12000.

Our results are local, and we also ignore how income distribution is endogenously formed in each constituency area. The main purpose of this paper is to identify the preference against local income inequality among homeowners, though our results point to further questions: Why do homeowners dislike income inequality, even after controlling for the presence of public housing and district fixed effects? Should public housing policymaking take into account such a preference? How does this preference effect local income distribution over time? We leave these questions for future research.

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