Quality of Life in Urban Neighborhoods in Colombia: The Cases of Bogotá and Medellín[♣]

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Abstract

We use data from Bogotá and Medellín to describe key quality of life indicators of each city and illustrate their spatial segregation at the census sector level. We present evidence that the main two Colombian cities are highly spatially segregated. Household are spatially segregated according to their education levels and access to education, coverage of public services, households headed by women and key demographic variables like their levels of adolescent pregnancy. Social phenomena like crime, measured by the homicide rates at the census sector level, present as well clusters of higher incidence in these cities. Not surprisingly, our estimated quality of life indexes resemble the mentioned segregation patterns in each city. We present estimates of spatial agglomeration that show the statistical significance of this phenomenon for each of the variables enumerated.

We estimate hedonic models of house values and life satisfaction for Bogotá and Medellín and find that the importance of the average level of education at the census sector level to determine house prices is striking. We also compare hedonic models for Bogotá and Medellín. Bogotá is better endowed than Medellín in the variables included in the analysis, in particular, it has higher education levels, and additionally, education is more equally distributed within census sectors. Bogotá has also better access to gas, and has in general houses with better conditions.

The hedonic models based on house values and life satisfaction approaches used in this article lead to similar conclusions in the aggregate when comparing their implied quality of life indexes. Although each approach allows us to determine its specific determinants, and these are not always the same, implied by their aggregated indexes suggest that these factors are just different faces of the same story.

From a policy perspective, the evidence suggests that redesigning the current socioeconomic stratification system in a way that still allows reaching the poorest while preventing segregation to deepen, might be the most important challenge to face in order to improve quality of life in main Colombian cities.

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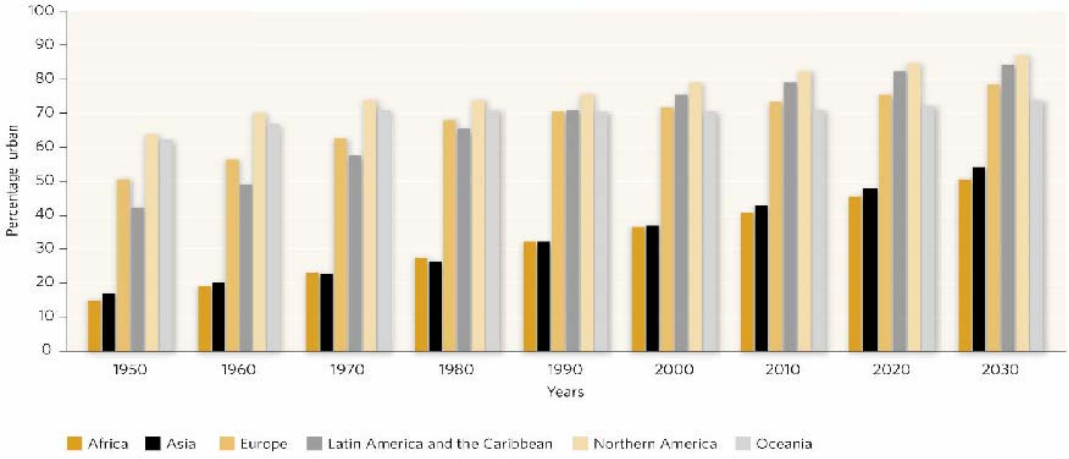
1. Introduction

During the second half of the XX century, all regions of the world went trough a deep urbanization process. A rough estimation of the aggregate urban population of the world reveals that the share of population living in urban areas changed form nearly 25% in 1950 to more than 45% in 2000. Actually, it is expected to reach 50% in 2007, thus, more than 50% of the population will live in urban areas by 2008.[1] As it is shown in figure 1, Latin American and the Caribbean, LAC, went through the 50% threshold during the 1960s, moved from 40% in 1950 to 75% in 2000, and it was expected to reach 78% in 2007.

Figure 1. Percentage of Population at Mid-year Residing in Urban Areas, by Region, 1950-2030

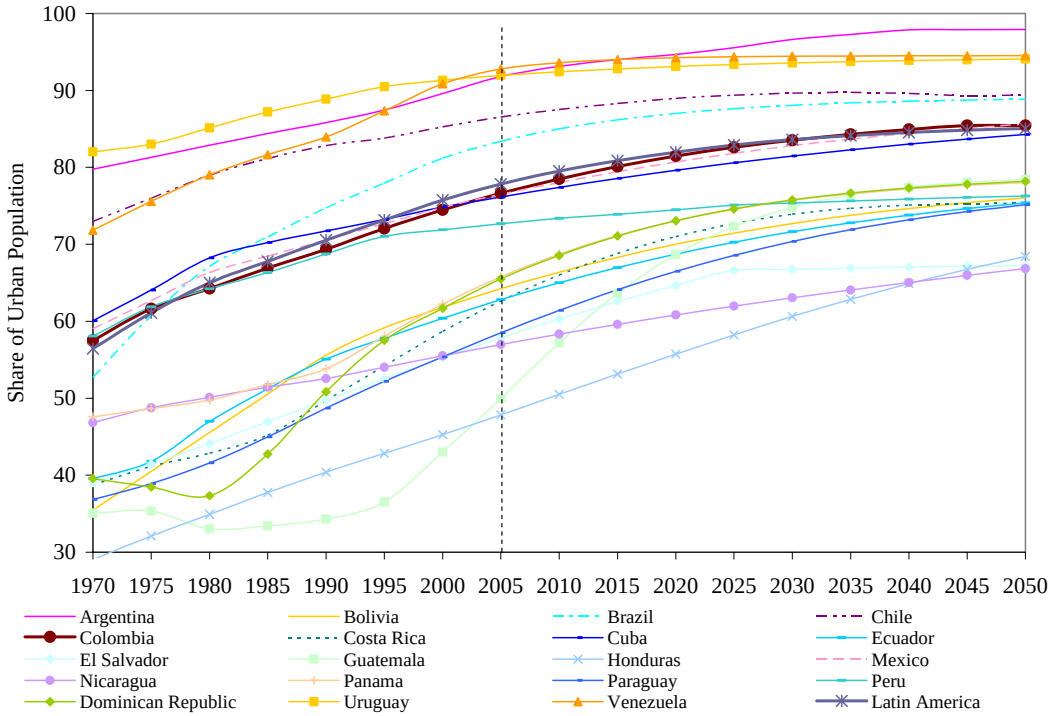


Source: UNFPA (2007)

As figure 2 shows, urbanization took place in all LAC countries with no exception. Colombia's urbanization followed closely the average pattern of the region, going from 57.5% in 1970 to 74.5% in 2000.[2] According to Colombian 2005 population census, the share of Colombians living in urban areas became 77.7% in that year. Furthermore, Colombia was in 2000 the second country in South America, besides with Venezuela, with the largest number of cities with more than one million inhabitants. According to figures published by CELADE, South America had that year 35 cities with more than one million inhabitants, although there were just five cities in 1950. Brazil was the country with the largest number of cities in that set, with 16 cities, next, there were Venezuela and Colombia, with four cities each. The four Colombian cities were Bogotá, Medellín, Cali and Barranquilla, which together account for 10.1% of the whole population of the cities with more than one million people in South America, the third largest share after Brazil, 52.7%, and Argentina, 12.6% (See table 1).

Figure 2. Urban Percentage Estimates and Projections by Sex and Quinquennial Age Groups. LAC Countries, 1970-2050.

[1] UNFPA (2007)
[2] Based on figures of population censuses reported by CELADE.



Source: CELADE/UCLAC. Updated in July/2007, based on estimations and forecasts from CELADE.

Table 1. Number of Cities with at least One Million Inhabitants, and their Population, by Country. South America, 1950-2000.

Country	Number of cities with one million and more inhabitants						Population living in cities of one million and more inhabitants (in thousands)						%
	1950	1960	1970	1980	1990	2000	1950	1960	1970	1980	1990	2000	
Argentina	1	1	1	2	3	3	4,747	6,807	8,462	10,986	13,574	14,575	12.4
Bolivia	0	0	0	0	1	2	0	0	0	0	1,119	2,534	2.2
Brazil	2	3	6	9	13	16	5,360	9,611	20,181	33,408	45,845	61,111	52.0
Chile	1	1	1	1	1	1	1,437	2,072	2,792	3,920	4,729	5,392	4.6
Colombia	0	1	3	4	4	4	0	1,683	5,371	8,576	10,502	11,685	9.9
Bogotá												**6,444**	**5.5**
Medellín												**2,088**	**1.8**
Cali												**1,997**	**1.7**
Barranquilla												**1,156**	**1.0**
Ecuador	0	0	0	1	2	2	0	0	0	1,249	2,692	3,559	3.0
Paraguay	0	0	0	0	1	1	0	0	0	0	1,177	1,613	1.4
Peru	0	1	1	1	1	1	0	1,846	3,303	4,608	6,321	7,454	6.3
Uruguay	1	1	1	1	1	1	1,140	1,310	1,402	1,511	1,591	1600*	1.4
Venezuela	0	1	1	1	3	4	0	1,372	2,184	2,640	5,155	7,962	6.8
Total	5	9	14	20	30	35	12,684	24,701	43,694	66,898	92,705	117,486	100.0

Source: DEPUALC 2004 data base, CELADE/ECLAC. UN World Urbanization Prospects: The 2003 Revision.
* Own estimation based on 1980-1990 rate of population growth.

This article aims to estimate Quality of Life, QoL, in neighborhoods within Bogotá and Medellín, the most populated cities of Colombia. These two cities, account for 7.3% of the population of all cities with more than one million people in South America. On the other hand, they account for 21% of Colombian population, and 27% of Colombian

urban population.[3] These figures make the study of QoL in these cities a relevant case not only for the country, but also for the region.

We begin in section 2 describing the source of information we used throughout the document. We use a rich battery of data from living standard measurement surveys for Bogotá and Medellín, information from the population censuses, and several administrative data provided by local authorities. We proceed in section 3 to illustrate the key empirical regularities that characterize these cities and to formally test segregation by means of spatial autocorrelation statistics. Sections 4 and 5 present hedonic models based on property values and life satisfaction for each city. Results of these sections are discussed and put in perspective in section 6. Section 7 presents the estimates of QoL based on our house values and life satisfaction models, and contrasts them with key variables like per capita income and socioeconomic stratification. Finally, section 8 offers some conclusions.

2. Data

We have information at different levels of aggregation for Bogotá and Medellín, being the census sector level the one with more detailed information. In both cases, we will use information only for the city, with no information of any of the neighbor cities included in its metropolitan area. In what follows we describe the information available for each city.

Data for Bogotá

In the case of Bogotá, we have data available at the household level with the *Encuesta de Calidad de Vida*, *ECVB*, collected by the Administrative Department of National Statistics, DANE, in 2003.[4] That LSMS survey, has detailed information about living conditions of households in Bogotá, with more than 12,770 households interviewed across 19 sub-city urban areas denominated *localidades* (See map 1).[5] Within each *localidad*, households were randomly selected in a way that would include households in each of the six different strata on which housings are assigned to in Colombia for targeting social expending (See map 2).[6]

Finally, we use census data along with official records, to collect information at the census sector level that will allow us to split Bogotá into more than 500 sectors, with an average of about 12,000 inhabitants per sector (See census sector subdivisions for Bogotá in map 3).

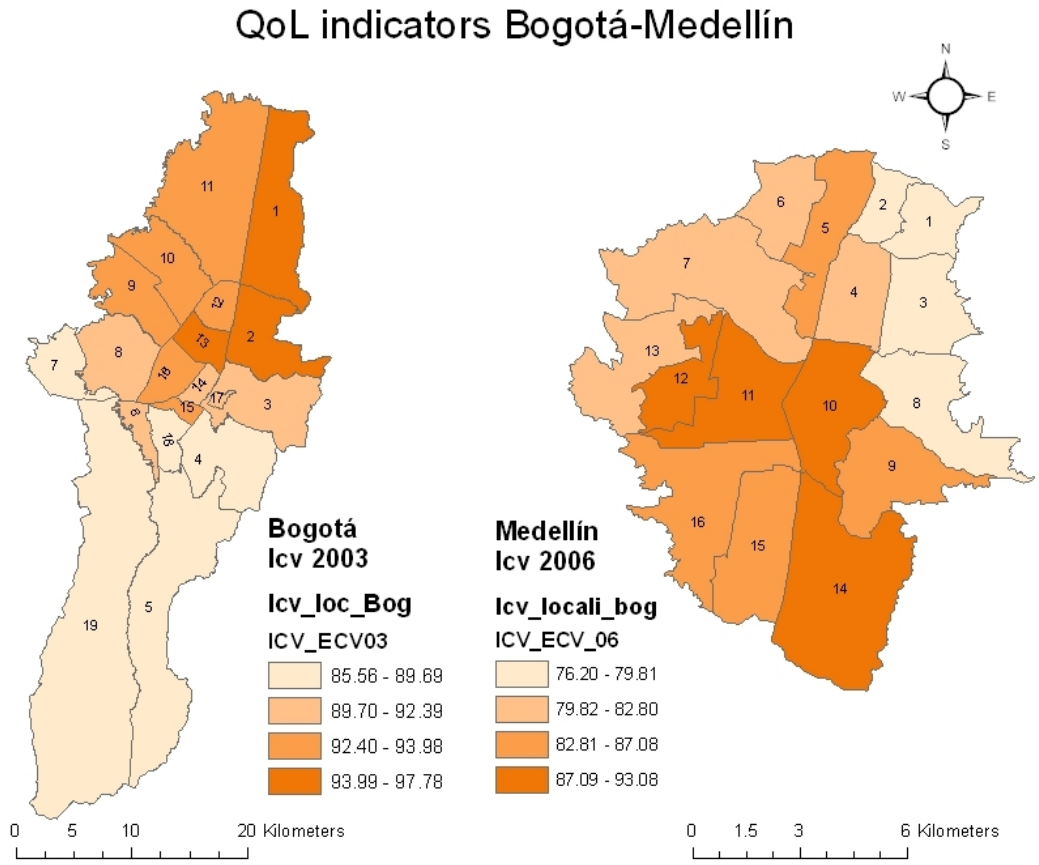
Data for Medellín

In the case of Medellín we have data available at the household level with the *Encuesta de Calidad de Vida*, *ECVM*, which was collected by *Universidad de Antioquia*, in 2003,

[3] Colombia's 2005 Population Census figures.
[4] The survey was collected between June 6 and July 23. Household members 18 and older were directly interviewed.
[5] Bogotá is split into 20 *localidades*, 19 urban and one rural.
[6] There are six socioeconomic strata in which urban areas are split in Colombia, being the first the one with the lowest QoL levels, and the sixth the one with the highest.

2004, 2005 and 2006.[7] That LSMS survey, has detailed information about living conditions of household in Medellín, with 21,787 households interviewed in 21 sub-city areas: 16 *comunas* and five *corregimientos*. Map 1 shows the *comunas* of Medellín. Within each *comuna*, households were randomly selected in a way that would include them in each of the six different socioeconomic strata, and with representation of all neighborhoods of the city. The survey is meant to allow researchers to get unemployment rates estimates within each *comuna*, with less than a 5% relative error. In addition, it is used to build key QoL indicators for each of nearly 200 polygons, a local subdivision of Medellín. We use as well census data along with official records, to collect information at the census sector level, which will allow us to split Medellín into more than 150 sectors, with an average of about 13,000 inhabitants per sector (See census sector subdivisions for Medellín in map 3).

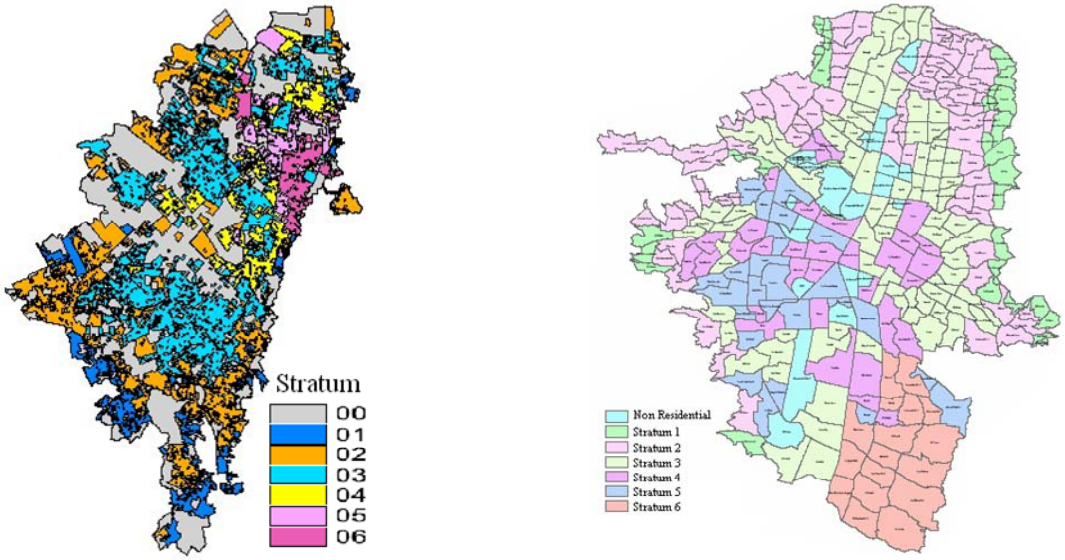
Map 1. *Localidades* and *Comunas* of Bogotá and Medellín respectively.



Sources: ECVB and ECVM. Bogotá *Localidades*: 1 Usaquen, 2 Chapinero, 3 Santa Fe, 4 San Cristóbal, 5 Usme, 6 Tunjuelito, 7 Bosa, 8 Kennedy, 9 Fontibon, 10 Engativa, 11 Suba, 12 Barrios Unidos, 13 Teusaquillo, 14 Los Martires, 15 Antonio Narino, 16 Puente Aranda, 17 Candelaria, 18 Rafael Uribe, 19 Ciudad Bolivar, 20 Sumapaz. Medellín *Comunas*: 1 Popular, 2 Santa Cruz, 3 Manrique, 4 Aranjuez, 5 Castilla, 6 Doce de Octubre, 7 Robledo, 8 Villa Hermosa, 9 Buenos Aires, 10 La Candelaria, 11 Laureles-Estadio, 12 La America, 13 San Javier, 14 El Poblado, 15 Guayabal, 16 Belen.

[7] The 2005 survey was collected from October 1 to December 15. Household members 18 and older were directly interviewed.

Map 2. Socioeconomic Strata. Bogotá and Medellín.



Sources: *Departamento Administrativo de Catastro Distrital* and Department of Municipal Planning of Medellín.

2. List of Variables related to Quality of Life

The list of variables related to quality of life and their grouping is shown in table 2. The table describes the available set of variables and their sources for each city.

For Bogotá and Medellín, we have both information to get a-theoretical QoL indicators, and QoL indicators based on the outcomes of hedonic regressions, since for Bogotá we have cadastral data on real state prices, and the square meters of land and built areas for each house, and for Medellín, in the 2006 survey, households who live on lease are asked the amount they pay for rent, while the owners are asked for an estimate of the value of the rent they would be paying were they living on lease. For Bogotá, houses values are as well available from the survey for households owning houses where they live. Rent prices are available for households living as tenants (how much do you pay?) and for those living in their own house (how much would you pay if it was rented?).

In addition, for each city we have a complete set of geo-referenced data with key information on amenities across the city. Table 2 describes some of the variables we are using in our estimations based on these data, which includes information on environment (contamination), equipment (social welfare, cultural places, places for recreation and sports, religious places, places for food supply, places for fairs, security -CAIS, etc.-, justice -prisons, courts, etc.-, schools, institutions of higher education, places for funeral services, hospitals, Centers for basic medical care, public entities headquarters -National, state, District, control, entities, etc.-), Public space (parks), hydrography (rivers, humid soils), massive transportation systems (*Transmilenio* for

Bogotá and *Metroplus* and the metro for Medellín), use of land, Perspectives for use of land -POT-.[8]

Table 2. List of proposed variables related to QoL. Bogotá and Medellín

Household variables		Amenities with variation within Census Sector (continuation)	
Ln of monthy rent (actually paid or reported if under lease)	(i)	Distance to nearest cultural place (km)[8]	(ii)
Monthy rent (actually paid or reported if under lease)	(i)	Distance to nearest center of basic medical attention (km)[9]	(ii)
Ln of monthy rent (actually paid)	(i)	Distance to nearest hospital (km)	(ii)
Monthy rent (actually paid)	(i)	Distance to nearest church/worship place (km)	(ii)
Ln of cadastral value	(ii)	Distance to nearest place of vigilance (km)[10]	(ii)
Cadastral value	(ii)	Distance to nearest place of defense or justice (km)[11]	(ii)
Ln of cadastral value (or house value reported)	(i),(ii)	Distance to nearest place of food provision (km)[12]	(ii)
Cadastral value (or house value reported)	(i),(ii)	Distance to nearest place of public administration (km)[13]	(ii)
Number of rooms	(i)	Distance to nearest river or stream (km)	(ii)
Number of bathrooms	(i)	Distance to nearest Transmilenio station (km)[14]	(ii),(iii)
House with piped gas service	(i)	Distance to nearest place of recreation or sports (km)[15]	(ii)
Household cocks with piped gas	(i)	Distance to nearest place of fairs (km)[16]	(ii)
Fixed phone line available	(i)	**Amenities without variation within Census Sector**	
Bad quality of energy	(i)	Number of social welfare places per 1000 inhabitants[7]	(ii)
Bad service of garbage collection	(i)	Number of schools per 1000 inhabitants	(ii)
Fixed phone line of bad quality	(i)	Number of universities per 1000 inhabitants	(ii)
House with garden	(i)	Number of cultural places per 1000 inhabitants[8]	(ii)
House with court yard	(i)	Number of centers of basic medical attention per 1000 inhabitants[9]	(ii)
House with garage	(i)	Number of beds available in hospitals per 1000 inhabitants	(ii)
House with terrace	(i)	Number of hospitals per 1000 inhabitants	(ii)
House[5]	(i)	Number of churches/worship places per 1000 inhabitants	(ii)
House with potable water service	(i)	Forest area (M^2) per 1000 inhabitants	(ii)
High quality floor material[6]	(i)	Number of places for vigilance per 1000 inhabitants[10]	(ii)
Stratum 2	(i)	Number of places of defense or justice per 1000 inhabitants[11]	(ii)
Stratum 3	(i)	Number of places of food provision per 1000 inhabitants[12]	(ii)
Stratum 4	(i)	Number of places of public administration per 1000 inhabitants[13]	(ii)
Stratum 5	(i)	Number of places of recreation or sports per 1000 inhabitants[15]	(ii)
Stratum 6	(i)	Number of places of fairs per 1000 inhabitants[16]	(ii)
Constructed area (squared meters)	(ii)	Number of humid soils/marshes per 1000 inhabitants	(ii)
Area of land (squared meters) -Land-	(ii)	Parks area (M^2) per 1000 inhabitants	(ii)
Household head takes Transmilenio	(i)	Objects theft rate	(iv)
Amenities with variation within Census Sector		Assaults rate	(iv)
Parks in neighborhood	(i)	Residential and commercial assault rate	(iv)
House has suffered for a natural disasters	(i)	Cars theft rate	(iv)
House in area vulnerable to natural disasters	(i)	Crime rate	(iv)
Factories in neighborhood	(i)	Attacks[17]	(v)
Garbage collector in neighborhood	(i)	Number of attacks against life per 10000 inhabitants	(v)
Market places in neighborhood	(i)	Number of attacks against wealth per 10000 inhabitants	(v)
Airports in neighborhood	(i)	Number of bars per 10000 inhabitants	(v)
Terminals of ground transportation in neighborhood	(i)	Number of brothels per 10000 inhabitants	(v)
House close to open sewers	(i)	Number of casinos/places for bets per 10000 inhabitants	(v)
You feel safe in your neighborhood	(i)	Number of places selling drugs/narcotics per 10000 inhabitants	(v)
Land use is productive housing	(ii)	Quality of Life Index (ICV), NBI, Misery[18]	(vi,a)
Land use is residential or commercial	(ii)	Gini coefficient of education	(vi,a)
Class of soil is conservation	(ii)	Average education	(vi,b)
Class of soil is consolidation	(ii)	Population Density	(vi,b)
Class of soil is integral improvement	(ii)	Unemployment rate	(vi,b)
Class of soil is integral renovation	(ii)	Illiteracy rate	(vi,b)
Distance to nearest social welfare place (km)[7]	(ii)	Share of female heads	(vi,b)
Distance to nearest school (km)	(ii)	Share of ethnic minority population[19]	(vi,b)
Distance to nearest university (km)	(ii)	Electricity, water, phone and piped gas coverage	(vi,b)

[1] Only includes households for which cadastral values are available. [2] Cadastral values if available, otherwise, the value reported by households surveyed. [3] Only includes households for which actual rent paid is available. [4] Actual rent paid if available, otherwise, the value households surveyed report they would pay if under lease. [5] Dummy variable equal to one if house, 0 otherwise (apartment, etc.). [6] Floor material is any of: Marble, parquet, lacquered wood, carpet, floor tile, vinyl, tablet, wood. [7] Infantile shelters, communitarian centers, *casas vecinales*. [8] Museums, theaters. [9] Health centers and units of basic medical attention. [10] Police

[8] *Transmilenio* and *Metroplus* are massive transport systems of Bogotá and Medellín respectively, which operate with buses that transit on roads of exclusive use by them. Location of *Metroplus* stations were known at the moment of the survey, although they were not yet built.

station, Center of Immediate Attention -CAIs-, Police Departments. [11] Offices of Defenders, Jails, garrisons, Family commissaryships, solicitorships. [12] Plazas, places of food supply. [13] Embassies, consulates, comptrollerships, public utilities, ministries, superintendencies, etc. [14] *Transmilenio* is the massive transport system of Bogotá, which operates with buses that transit on roads of exclusive use by them. [15] Thematic parks, pools, sport courts, clubs, etc. [16] Auditoriums, convention centers, etc. [17] Dummy variable equal to one if there have been attacks in census sector by *Fuerzas Armadas Revolucionarias de Colombia*, FARC, *Ejército de Liberación Nacional*, ELN, or other groups. [18] ICV: A-Theoretical estimator of QoL, NBI: Index of unsatisfied basic needs (see section 3.1 for definition), Misery: dummy variable equal to one if NBI>1. 19 Black/Afro, Indigenous, Gipsy.
Sources: (i) ECVB and ECVM for Bogotá and Medellín respectively. (ii) Real State Appraisal of Bogotá. (iii) Bogotá (2004). (iv) National Police-DIJIN 2000. (v) Paz Pública (2000). (vi,a) Colombian 1993 Population Census, (vi,b) Colombian 2005 Population Census.

Finally, map 12 shows adolescent (13-19) pregnancy rates by block based on New Sisben data (darker dots imply higher rates). The spatial patter is clearly consistent with previous maps: higher pregnancy rates among the poorest neighborhoods.

3. Statistical Analysis and Methods to get the Diagnosis of QoL

This section describes variables spatially and presents evidence of their spatial segregation. It illustrates segregation in the cities studied according to key variables and provides quantitative evidence when differences in location of people according to their characteristics are not random. We use this information to complement our results obtained in next section before concluding and looking for policy recommendations at the end of the document.

In this section we illustrate disparities in key variables related to the QoL of census sectors within cities. For some of these variables, we estimate statistical indicators of spatial autocorrelation: the global and local Moran indices.[1] The **global Moran index** is defined as

$$I = \frac{N}{S_0} \frac{(x-\bar{x})' W (x-\bar{x})}{(x-\bar{x})'(x-\bar{x})}$$

where x_i is the variable of interest on which we are interested to test spatial autocorrelation, W_{ij} is a matrix of weights, and $S_0 = \sum_i \sum_j W_{ij}$. Matrix W will be defined depending of the variable of interest, either using only immediate neighbors, or those neighbors and their neighbors, or a specific number of the closest neighbors based on distances, etc. An I estimate not statistically different from zero would not allow us to reject the null of no spatial autocorrelation, while a positive (negative) value would imply a positive (negative) spatial autocorrelation, suggesting that similar (different) values of the phenomenon of interest are spatially clustered. Variables spatially autocorrelated usually form clusters, in our case of census sectors, of high levels of the variable, or clusters of low levels of the variable, or both. In this sense, we will refer to a variable that is spatially autocorrelated as a variable according to which households are segregated.

On the other hand, the **local Moran index** is used to identify spatial clusters and it is defined as

$$I_i = \frac{Z_i}{\sum_i Z_i^2 / N} \sum_{j \in j_i} W_{ij} Z_i$$

Positive (negative) values of the I_i index imply the existence of a spatial cluster of census sectors with levels of the variable of interest above (below) the average around census sector *i*.

Table 3 presents estimates of the global Moran index for several variables for Bogotá and Medellín based on census sector figures of each city. Figures for enrollment rates and other variables were not available to us at the census sector level for the 2005 Population Census, we use their 1993 figures instead. All variables included are spatially correlated in a statistically significant magnitude (just weakly for the homicide rate in Bogotá). Three out of the five variables with the higher levels of spatial autocorrelation are the same for both cities: the average years of education, the college enrollment rate and the share of households with piped gas in the census sector.

[1] See Moran (1948) and Anselin (1988).

It is important to highlight the large magnitude of the estimated global Moran index in the case of the average years of education by census sector. It is the variable according to which households are more segregated in Bogotá, and the second in the case of Medellín. Since college enrollment is the fourth variable according to which household are more segregated, the evidence points to access to college as a bottle neck that prevents an important share of people to increase their educational attainment and thus reduce the existent differences across census sectors. Actually, even though both cities are as well segregated according to secondary and primary enrollment rates, the importance of the enrollment rates is increasing with the education level, being very low in the case of primary enrollment rates, a level with almost universal coverage in both cities. Although segregation on both education attainment and college enrollment is similar in importance in both cities, the higher levels found for Bogotá, along with the usual association people make between education levels and socioeconomic status, suggest that in Bogotá access to college and education attainment contributes relatively more to fragmenting the city according to class than they do in Medellín.

Another variable according to which households are highly segregated in both cities is the share of households with piped gas in the census sector. It is the most important variable for Medellín and the fifth for Bogotá. Nonetheless, there is an important difference between these cities: the cluster of census sectors with the highest shares of households with access to piped gas is the clusters of the better off in Medellín, but it is the one of the worse off in Bogotá. This fact becomes clear when one compares maps 1 and 6 (bottom row). In the case of Bogotá, *localidades* with the highest rates of access to piped gas are the poorest (*San Cristóbal*, *Usme*, *Bosa*, *Rafael Uribe* and *Ciudad Bolivar*). In the case of Medellín, they are the better off (*Laureles-Estadio*, *La America*, *El Poblado*, *Guayabal* and *Belen*). It is clear in Medellín that the *Comunas* with the lowest levels of access to piped gas are the poorest (*Popular*, *Santa Cruz*, *Manrique* and *Villa Hermosa*). In addition, it is important to complement the analysis of differences in access to piped gas by saying that the existence of clusters of neighborhoods according to access to sewerage, electricity and piped water in Bogotá relative to Medellín, is negligible. Basically it can be concluded that based on the 2005 Population Census, public utilities in Bogotá, by providing access to a very cheap service (piped gas) to the poorest neighborhoods, and providing equitable access to other public utility services, are contributing to lower differences in quality of life across the neighborhoods of the city, while in Medellín they are contributing to increase them.

Another set of variables according to which households are highly clustered are those related to reproductive and sexual health, in particular, adolescent pregnancy and the presence of children at home. Although in both cities these variables show the same pattern, they are much more clustered in Bogotá than Medellín (they are the second and third more segregated in Bogotá, and the sixth and seventh in Medellín). The adolescent fertility rate is as well very important in Bogotá.

Table 3. Global Moran indexes for key variables. Bogotá and Medellín

Variables		Bogotá			Medellín		
		Rank	I (Moran)	p-value	Rank	I (Moran)	p-value
Years of education by census sector	(i)	**1**	**0.626**	**0.0001**	**2**	**0.533**	**0.0001**
Children at home	(ii)	**2**	**0.558**	**0.0001**	6	0.353	0.0001
Age at first pregnancy	(ii)	**3**	**0.548**	**0.0001**	7	0.271	0.0001
College enrollment rate	(ii)	**4**	**0.548**	**0.0001**	**4**	**0.445**	**0.0001**
Share with piped gas	(i)	**5**	**0.471**	**0.0010**	**1**	**0.635**	**0.0010**
Share of mothers with ages between 13_19	(ii)	6	0.342	0.0001	11	0.210	0.0001
Unemployment rate	(i)	7	0.256	0.0001	**3**	**0.474**	**0.0001**
Rate of racial minority	(i)	8	0.252	0.0010	**5**	**0.363**	**0.0010**
Secondary enrollment rate	(ii)	9	0.219	0.0001	10	0.212	0.0001
Share with fixed phone lines	(i)	10	0.216	0.0010	12	0.205	0.0010
Illiteracy rate	(i)	11	0.122	0.0001	16	0.070	0.0061
Rate of household head women	(i)	12	0.102	0.0010	8	0.217	0.0010
Share with sewerage	(i)	13	0.033	0.0285	13	0.173	0.0010
Primary enrollment rate	(ii)	14	0.030	0.0396	15	0.086	0.0028
Share with electricity	(i)	15	0.025	0.0403	9	0.216	0.0010
Homicide rate	(iii)	16	0.013	0.0710	17	0.066	0.0090
Share with piped water	(i)	17	0.007	0.0030	14	0.148	0.0010

Sources: (i) Population Census 2005, (ii) Population Census 1993, (iii) National Police-DIJIN 2000 for Bogotá, and Municipal Secretary of Government (average of homicide rates between 2001 and 2006) for Medellín.

In what follows we will describe in detail the spatial distribution of key variables across census sectors of Bogotá and Medellín: indicator variables of QoL (only for Bogotá), education, public utility services, reproductive and sexual health, and crime. To do it, we present maps of each variable that describe the quintile in which the level of the variable is located in each census sector. In addition, we include maps with the respective local Moran indexes of the maps in quintiles for each variable. These maps are meant to provide statistical evidence of the existence of clusters of the analyzed variables.

3.1 Quality of Life variables

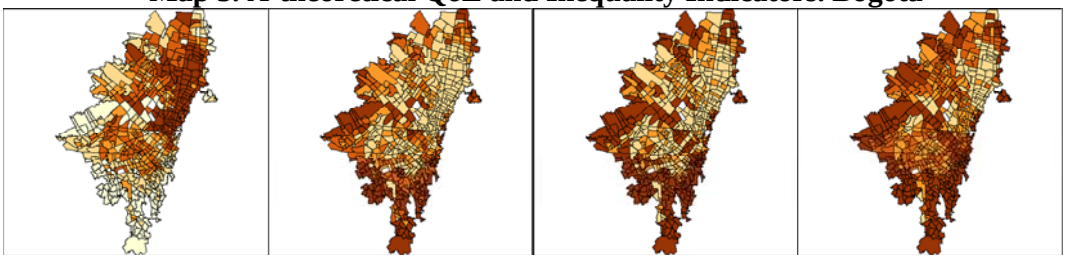
Map 3 shows quintiles of some a-theoretical QoL indicators: the denominated indexes of "Quality of Life", ICV, "Unsatisfied Basic Needs", NBI, "Misery", and the Gini of education, which measures the inequality in the distribution of the years of education in each census sector.

The ICV is estimated separately for urban and rural areas, and it is a weighted average of several components that for the case of urban areas is composed of the following components: (i) individual human capital, which includes education of household head, average education of people 12 and more in the household, and the share of youths between 12 and 18 that attend secondary education, (ii) public utility services, which includes the way the household collects garbage (thrown to a river, born or buried, collected by public service, etc.), the way households eliminate their garbage (sewerage availability, etc.), how the household gets water (car that supplies in neighborhood, water well, piped, etc.), fuel used for cooking (gasoline, firewood or coal, petroleum, gas, etc.), (iii) demographic, which includes the share of children under six in the household, school attendance of children 6 to 11, and accumulation (number of persons per room) in household, and (iv) housing, which considers the main material with which floors and walls of houses were built. The methodology performs factor analysis to identify the relevant variables to include in the estimation of the indicator, scales

qualitative into quantitative variables, and proceeds to apply standard principal components procedures.[2]

On the other hand, the NBI measures the share of households in a specific area that has at least one basic need unsatisfied, considering among the basic needs the following: (i) adequate houses, (ii) basic public utility services (water, sewerage and electricity), (iii) accumulation in household (if the ratio of household members to number of rooms, including living room and dining room –excludes kitchen, bathrooms and garages-, is equal or higher than three), (iv) economic dependency (if there are more than three dependents per person employed in a household with head with up to two years of education), and (v) dropouts (at least one children between seven and 11 not attending school). Based on the NBI, the Misery Index is estimated, which counts the share of households with at least two unsatisfied basic needs.

Map 3. A-theoretical QoL and Inequality Indicators. Bogotá



The darkest tones correspond to the highest quintiles. See sources in table 2. From left to right: (1) ICV, (2) NBI, (3) Misery, (4) Gini coefficient of the years of education.

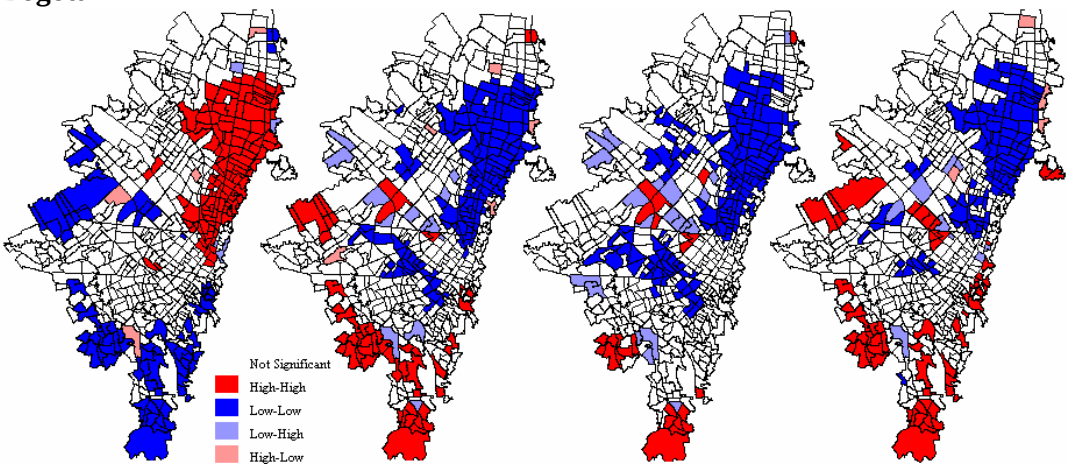
The map illustrates a very consistent pattern among the ICV, NBI and Misery indicators in which the poorest are consistently located over the southern and western census sectors of the city, and those better off are located in the sectors that match the highest socioeconomic strata in map 2. In addition, the gini coefficient of the years of education suggests that while census sectors in which the better off live are highly homogeneous with highly educated people (see in map 5 quintiles of average education by census sector), those in which the worse off live are highly unequal in that dimension.

Map 4 presents a similar exercise for the case of the QoL and inequality indicators previously analyzed with map 3. In the case of the ICV there emerges a clear cluster of high ICV all over the highest socioeconomic strata of the city, and a couple of clusters, one on the south and another in the west, of low ICV. NBI and Misery maps are very consistent with the ICV map, nonetheless, in the case of the Misery index, it becomes clear that the south of Bogotá is much poorer than the western part of it. Finally, areas of the city with high ICV are very equal in the distribution of education, while those worse off, mostly matched by ICV and NBI maps (south and west), are very unequal.

This evidence suggest that stratification in Bogotá has been, at least at some point in time (or might still continue being), one of the driving forces segregating households into clusters of high and low QoL across the city. The way the city has grown with respect to the location of key places such as buildings of public administration, the available equipment of the city (schools, hospitals, parks, rivers, etc.) might have as well contributed to segregation.

[2] See DNP (1997)

Map 4. Local Moran Indexes of A-theoretical QoL and Inequality Indicators. Bogotá



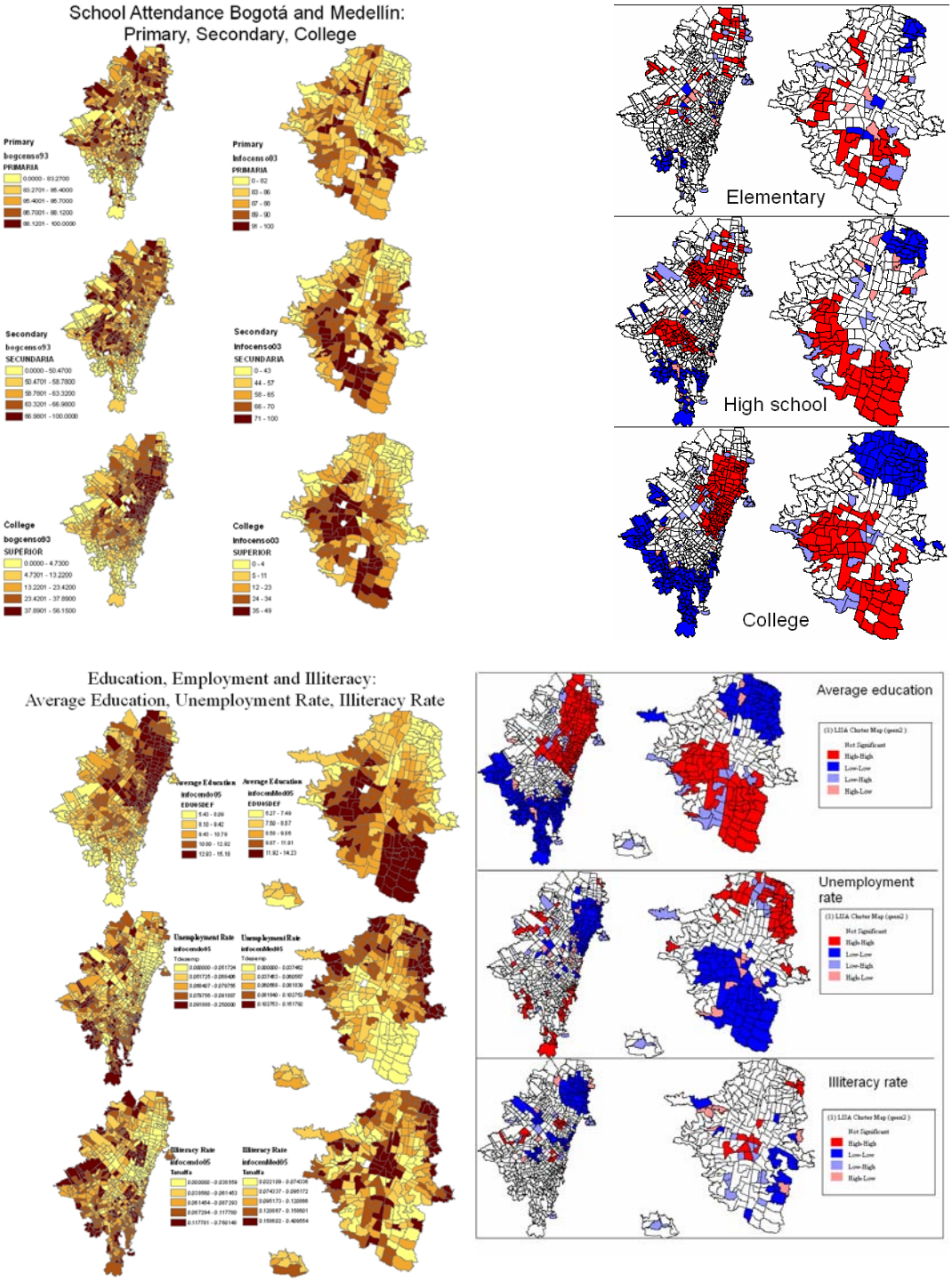
See sources in table 2. ICV, (2) NBI, (3) Misery, (4) Gini coefficient of the years of education

To illustrate the relation between some of our QoL indicators and income, we estimate simple correlation coefficients between income and these QoL variables. The estimates are 0.20, 0.16, and -0.13 for socioeconomic stratum, the ICV index and the NBI index respectively. The highest correlation estimated is with the socioeconomic stratum, although it is not of a very high magnitude. The results is explained, at least in part, by the fact that the QoL indicators considered, namely, stratum, ICV and NBI, have a much smaller variation than income does (for example, there are just six socioeconomic strata).

3.2 Education variables

The spatial analysis of variables related to education shows that human capital is an additional variable that characterizes the spatial sorting of households among census sectors in Bogotá and Medellín. Map 5 shows quintiles and clusters of enrollment rates, average education, and the illiteracy rate. In all of these variables we find evidence of spatial sorting (weaker for the illiteracy rate). In addition, when this evidence is coupled with results presented above regarding inequality of education, it becomes clear that the better off census sectors have lower inequality of education because most of their households have a much better access to education and thus attain higher levels. On the contrary, among the worse off census sectors there is much more heterogeneity in access to education that makes them ending up with a much more unequal distribution.

Map 5. Enrollment rates, average education, unemployment and illiteracy rates. Bogotá and Medellín.

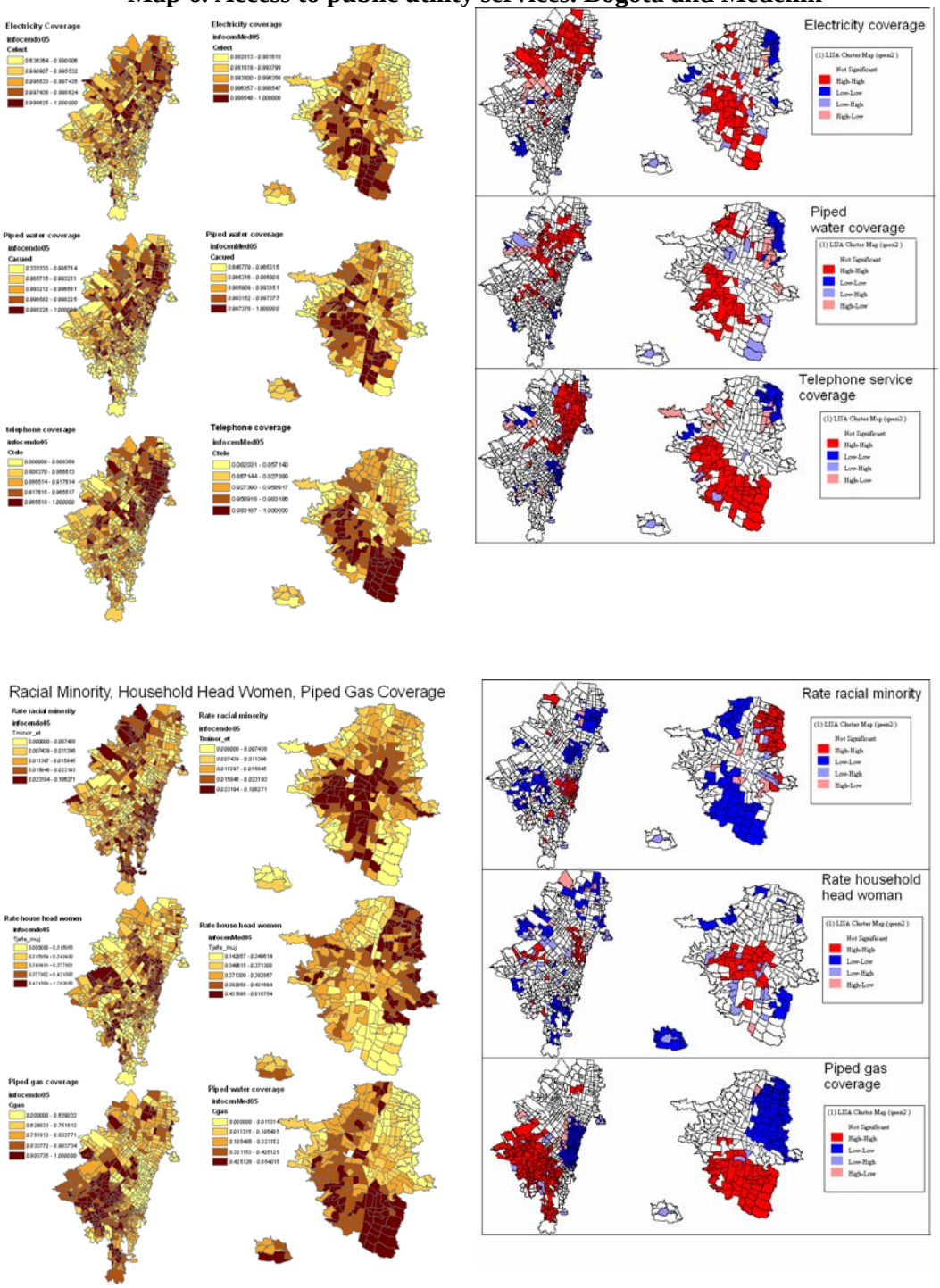


3.3 Public utility services

Despite the high rates of coverage of public utility services in Bogotá and Medellín, map 6 presents evidence that for all public utility services in both cities there are clusters, mostly of households with very high coverage rates. As mentioned previously, these households are the better off in both cities in the cases of water, electricity and fixed phone lines, and in the case of piped gas for Medellín (while they are in that case the worse off in Bogotá). In the case of Medellín, *Comunas* 1, 2 and 3 (*Popular, Santa*

Cruz, and *Manrique*) are characterized for a presence of a cluster with the lowest quintiles in coverage rates of water, electricity, fixed phone lines and piped gas.

Map 6. Access to public utility services. Bogotá and Medellín

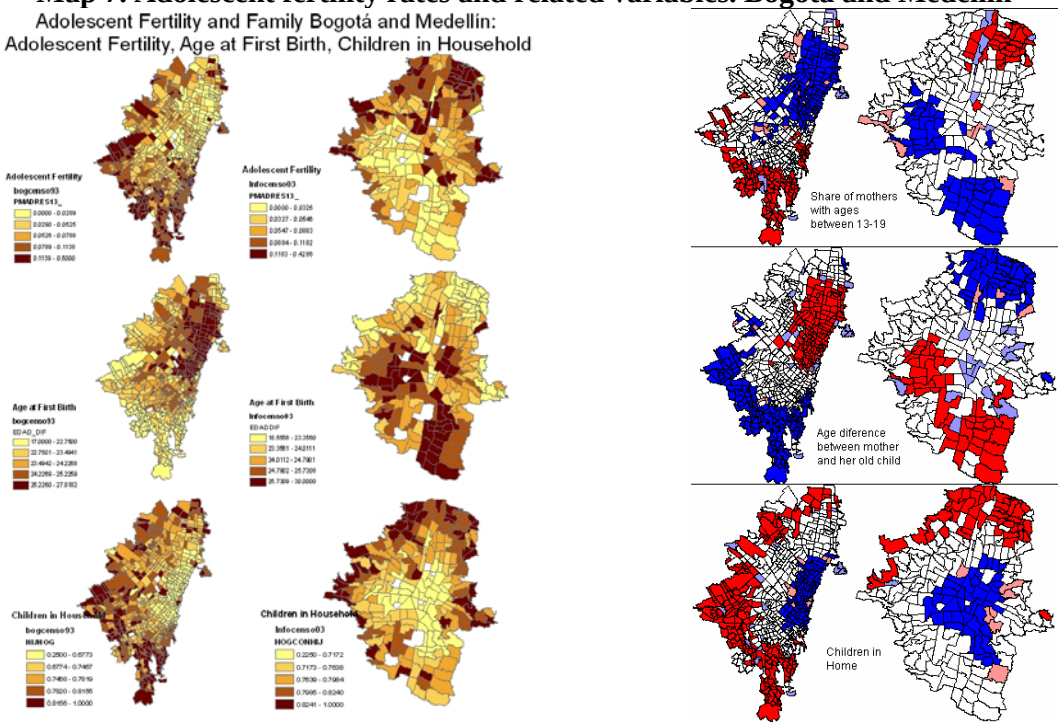


3.4 Reproductive and sexual health

Spatial segregation of households according to variables related to reproductive and sexual health had been previously documented for Bogotá by Gaviria et. al. (2008).

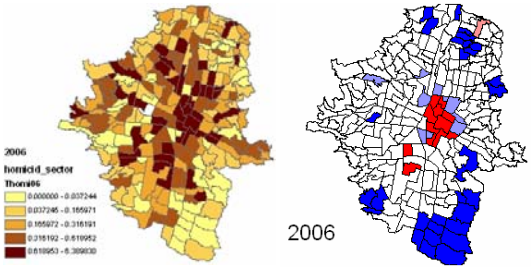
Here we complement their results with the ones for Medellín. Map 7 presents evidence of spatial segregation according to all of the variables considered: adolescent fertility, age of mother when she first gave birth, and the presence of children in the household. Clearly, women living in better off census sectors were significantly older when they first gave birth and have lower adolescent fertility rates.

Map 7. Adolescent fertility rates and related variables. Bogotá and Medellín



3.5 Crime variables

Map 8. Quintiles and clusters of the homicide rates in Medellín, 2006.



High crime rates are as well clustered in specific neighborhoods of Bogotá and Medellín. Gaviria et. al. (2008) presents evidence for the case in Bogotá, showing that the highest assault, car and objects theft rates, take place in the census sectors with the highest socioeconomic strata. On the contrary, FARC attacks, and attacks against life, are more likely in the periphery of the city, which is poorer. In addition, downtown Bogotá has as well a high rate of attacks against life. The case of Medellín is illustrated in map 8, where it becomes clear the existence of a cluster with high homicide rates in downtown Medellín, *Comuna* 10 (*La Candelaria*), is characterized by a cluster of high homicide rates, while *Comuna* 17 (*El Poblado*) by a cluster of low homicide rates. Homicides rates in Medellín have been very dynamic in recent years, with significant reduction in homicide rates in Comunas 7, 12 and 13 (*Robledo, La America* and *San Javier*) that were in the top quintile in years 2001, 2002 and 2003.

4. Quantitative analysis to construct the QoL index by sub-city area

4. Hedonic prices approach to infer prices of characteristics

In this section we estimate standard hedonic models to infer the prices of household characteristics and amenities, which will be used in chapter 6 to construct indexes of quality of life.[1] Relationships found in this section are not meant to be causal. Rigorous identification of causal relationships would require specific strategies, often different for different explanatory variables. We still consider we are getting reasonable estimates for most of our variables, since our rich battery of data allow us to minimize the omitted variable bias problem, the most common in these cases.

4.1 Bogotá

Our data for Bogotá allows us to estimate hedonic equations using cadastral values of houses (which we can complement with self reported prices by household owner of the survey), and rent values (either of households who report the amount they actually pay, or those who estimate how much would they pay were not they owners). Table 4A presents the results of the hedonic regressions of the logarithm of each of these dependent variables, on a battery of household and amenities variables. The equation estimated is

$$\ln(P_{ij}) = \alpha_0 + \alpha_1 H_i + \alpha_2 A_j + u_{ij} \quad (1)$$

Where P_{ij} is either the value of the house or that of its rent, H_i is a vector of household i variables, and A_j is a vector of amenities in census sector j. Table 4A presents the results of estimating this equation using the cadastral value of houses in panel one. Panel two increases the number of observations by including those households that could not be matched to cadastral data, but reported the value of their houses. Panel three uses rent values for households actually living on lease as the dependent variable, and panel four increases the number of observations by including the amount households report they would pay were the house be rented. For all OLS regressions we get robust standard errors correcting for clustering at the census sector level. Although we include in the regressions a large set of control variables, we drop all variables with coefficients with statistical significance under 90%.[2] Each panel has three columns that contain the estimated coefficients, their t statistic, and the standardized beta coefficients which tell us how many standard deviations change our dependent variable for each standard deviation of increase in our control variable.

Overall, the estimates found present intuitive signs. As it is shown, in the regressions on house values, the value of houses increases with better characteristics such as their number of rooms, if the house has garden, court yard, garage, potable water service, better floor materials, and if the house is located in a better socioeconomic stratum. Clearly, house value increases with its constructed area. Constructed area and area of land, are available only for households that could be matched to cadastral data, and as it can be seen in the table, these variables substantially improve the fit of the regression.

Among the amenities included in the regression, we find that house values increase with variables at the census sector level like the average education, distance to places of food

[1] Rosen (1974).

[2] We begin with a model that includes all variables in table 2 related to housing or neighborhood characteristics.

supply, schools per capita, and surprisingly, to average illiteracy rate.[3] House values are also higher if there is no terminal of ground transportation in the neighborhood, with lower homicide rates, attacks against life, lower inequality of education, proximity to universities, lower unemployment rates, and lower shares of female heads of household among others.[4]

We include the distance to the nearest *Transmilenium* Station and do not find it related to house values. This result reveals the difficulties in identifying the relationship between some of these variables and the value of the house or its rent. Complementary exercises not included here, show that the relationship between house values and their distance to their nearest *Transmilenio* station is non linear, with prices of houses within 200 meters from their nearest station being 5% to 7% lower, and houses between 350 and 650 meters from the station being 1% to 4% higher, than houses 1 kilometer or more from their nearest station.[5] The former result suggests a cost of being close to an important street or highway, the usual corridors of Transmilenio, while the later quantifies the benefits of having access to transportation while still benefiting from residencial (less commercial) more quiet neighborhoods. Finally, since the relative importance of this variable according to our beta coefficients and *Shorrocks* decomposition was low in several exploratory exercises (see also the section comparing Bogotá and Medellín results below) we do not consider this a key factor at the margin for Bogotá. The fact that according to the 2003 quality of life survey less than 8% of people take *Transmilenio* to go to work, while about 50% use the traditional system, and lack of integration between the traditional transit system and *Transmilenio* might be at the core of this result.[6]

Relative importance of the explanatory variables

To quantify the importance of each of our control variables we present the results of two exercises. First, we present the standardized beta coefficients of table 4A and then we present a decomposition that quantifies the share of the variance of the dependent variable explained by our model that is explained by each of our controls.

Table 4A presents the standardized beta coefficients. These coefficients allow us to compare the importance of the different control variables, since by quantifying how many standard deviations change the house value when each control is increased a one standard deviation; it requires similar relative difficulty in terms of the magnitude of the change in the control variable, to get the same effect on the dependent variable.

According to the table, changes in the constructed area are the ones that would imply the largest changes in the house value, since a one standard deviation increase in the

[3] Complementary exercises (not reported) show that the illiteracy result is driven by household in the lowest two socioeconomic strata.

[4] The finding of a positive relation between the number of schools in the census sector and house values, and distance to schools negatively related to house values, suggests households like to have schools in their proximity, although not too close to bear costs like those arising from traffic congestion. Some exploratory exercises (not reported) show that there are nonlinearities in the relationship between distance to school and house value.

[5] Mendieta and Perdomo (2007) also find a positive effect of being closer to a *Transmilenio* station, although of much higher magnitude.

[6] Echeverry et al. (2005) point to lack of integration of the Traditional and *Transmilenio* transit systems as one of the most important at the moment of quantifying negative spillovers of *Transmilenio*.

constructed area would imply nearly 0.6 standard deviations increase in the house value. The socioeconomic strata are as well very important at the moment of determining house values. For example, increasing the share of strata 4 houses in a specific census sector a one standard deviation from its current level, would imply an increase of a quarter of a standard deviation in the average value of its houses. Similar magnitudes are found for socioeconomic strata 3, 5 and 6. On the other hand, increasing the average education of the census sector where the house is located would imply an increase of one fifth of a standard deviation in the house value. The most important variable according to this criteria would be the constructed area, a house value, followed by the socioeconomic stratum (which is estimated as a function of house and neighborhood variables), and then by the average education of the census sector, an amenity.[7]

The next variable in terms of its importance is the inequality in the distribution of education in the population of the census sector, as measured by the Gini coefficient of education of the census sector, another amenity. An increase of one standard deviation in the Gini of education of the census sector would decrease the value of the house ten percent of its standard deviation.

A similar analysis shows that when we use the augmented sample that includes all households for which we know either the cadastral value of their houses of their reported value, tells us that the most important variables in that case are the socioeconomic strata, followed by the average education of the census sector, the distance to a center of higher education, whether the household lives in a house (as opposed to an apartment), the number of rooms, and having a garden. Note that in this case, the constructed area is not included in the model since it is not available for houses that report the value of their houses but did not match cadastral data.

For rents, the most important variable is the number of rooms, followed by the socioeconomic stratum, the average education of the census sector, and whether the household has gas available for cooking.

Our second approximation to quantify the importance of the different determinants of house value is by decomposing the variance of the house value that is explained by the model.[8]

Table 4B presents the results of the decomposition. We include in the first column the estimated coefficient, in the second the mean of the variable, in the third the contribution to the R^2, and finally, in the last column there is the share of the R^2 explained by the term. Again, consistent with our analysis above, the most important variable is the constructed area of the house: it alone explains nearly 43% or the R^2. It follows in importance the average and the inequality in the distribution of education in the census sector, which together explain about 22% of the R^2. The socioeconomic strata explain together 19% of the R^2, and finally, the distance to a center of higher education explains close to 5% of the R^2. Excluding the constructed area, all of these variables are either wholly or at least partly (in the case of the socioeconomic strata) amenities.

[7] An opulent house would rarely be stratified poorly, even if located in a poor neighborhood. Similarly would happen for a modest house located in an opulent neighborhood.

[8] We follow Shorrocks (1982), who defines a model $Y = X\beta + e$, from which it follows that the contribution of the control variable k, is $s_k(\sigma^2) = \text{cov}(X_k\beta_k, Y) / \sigma^2_Y$, and $\sum_k s_k(\sigma^2) = 1$.

Since socioeconomic strata by definition include both information of housing and amenities, we estimate the share of the explanatory power of the model explained by housing variables and by amenities, excluding what is explained by socioeconomic strata. Given the huge importance of the constructed area, housing variables as a whole account for 51% of the explanatory power of the model, while amenities account for 30%. Even if we estimated the decomposition with the model that uses as dependent variable the amount paid for rent, which does not include the constructed area variable, housing variables still explain 45% of the model, while amenities explain 35% and socioeconomic strata explain 20%.[9]

Controlling for amenities at the census sector level is important as it is implied by the variance of our dependent variable explained by our model: when we include fixed effects by census sector, the R^2 becomes 0.885. Our model with both amenities at the census sector and those that vary within census sectors has a R^2 of 0.796. Once we drop the census sector amenities, the R^2 falls to 0.773, and if additionally we drop the remaining amenities, it falls to 0.770. Thus, our amenities explain only about 22.5% of what is explained by the census sectors fixed effects.

Table 4A. Hedonic regression for Bogotá

Variable	Log of cadastral values			Log of cadastral values + value reported by households			Rent paid + Value households would pay under lease			Rent paid		
	N: 8868		R2: 0.7963	N: 10832		R2: 0.5657	N: 12660		R: 0.6648	N: 5356		R: 0.6826
	Coeff	*t*	beta	Coeff	*t*	beta	Coeff	*t*	beta	Coeff	*t*	beta
Number of rooms	0.0351	9.90	0.0722	0.0533	10.82	0.1053	0.1796	28.35	0.3449	0.1830	18.86	0.3505
Number of bathrooms							0.0180	2.16	0.0217	0.0576	3.86	0.0674
House with piped gas service				0.0974	2.98	0.0571	-0.1115	-3.81	-0.0650	-0.0932	-3.29	-0.0643
Household cocks with piped gas				-0.0725	-2.32	-0.0441	0.2019	7.18	0.1218	0.1733	6.35	0.1225
Bad service of garbage collection				-0.0943	-2.23	-0.0204	-0.0555	-1.83	-0.0119			
Fixed phone line of bad quality				-0.0768	-3.14	-0.0221						
House with garden	0.0907	8.35	0.0598	0.1633	12.40	0.1052				-0.0304	-2.19	-0.0212
House with court yard	0.1133	3.69	0.0312	0.1524	4.10	0.0410						
House with garage	0.0856	7.48	0.0514	0.0939	6.45	0.0565	0.1256	9.33	0.0734	0.1062	4.68	0.0616
House with terrace				0.1686	11.62	0.0931	0.0507	3.91	0.0270			
House	-0.0905	-6.45	-0.0594	-0.1834	-13.08	-0.1181	0.0731	6.29	0.0457			
House with potable water service	0.2954	3.35	0.0314									
High quality floor material	0.0332	2.40	0.0171	0.0971	5.20	0.0483	0.1190	7.53	0.0582	0.1474	7.82	0.0792
High quality wall material							0.3730	6.14	0.0481	0.2602	3.19	0.0354
Stratum 2	0.2379	9.06	0.1507	0.2585	7.99	0.1586	0.0567	2.41	0.0341			
Stratum 3	0.4119	12.61	0.2691	0.4398	11.04	0.2821	0.1441	4.80	0.0907			
Stratum 4	0.6547	15.22	0.2523	0.5974	11.30	0.2346	0.3603	8.83	0.1367	0.1424	3.96	0.0538
Stratum 5	0.8780	16.19	0.2330	0.8538	12.70	0.2239	0.6387	12.63	0.1640	0.3178	5.43	0.0821
Stratum 6	1.0818	16.51	0.2320	1.1259	13.99	0.2541	1.0119	15.78	0.2193	0.6752	9.96	0.1314
Constructed area (squared meters)	0.0036	10.39	0.5951									
Area of land (squared meters) -Land-	-0.0002	-1.82	-0.1293									
Parks in neighborhood				-0.1428	-7.59	-0.0648	0.0547	3.67	0.0250			
House has suffered for a natural disasters				-0.0889	-3.78	-0.0302						
House in area vulnerable to natural disasters	-0.0504	-2.73	-0.0171				0.0658	2.42	0.0130			
Factories in neighborhood				0.0638	3.20	0.0252				-0.0422	-2.10	-0.0190
Garbage collector in neighborhood										0.0668	1.71	0.0138
Airports in neighborhood							0.0592	2.15	0.0140			
Terminals of ground transportation in neighborhood	-0.0563	-2.88	-0.0128	-0.0867	-3.57	-0.0216						
Land use is productive housing				0.0891	6.29	0.0570						
Class of soil is integral improvement							-0.0582	-3.82	-0.0332	-0.0757	-4.22	-0.0496
Class of soil is integral renovation				0.0915	3.37	0.0185						
Distance to nearest school (km)	-0.0002	-3.37	-0.0280	-0.0003	-5.15	-0.0530				-0.0001	-2.41	-0.0295
Distance to nearest university (km)	0.0000	-7.14	-0.0669	-0.0001	-9.91	-0.1169	0.0000	-3.59	-0.0290	0.0000	-3.14	-0.0364
Distance to nearest place of public administration	-0.0001	-5.47	-0.0479	-0.0001	-5.95	-0.0731	-0.0001	-5.89	-0.0498	-0.0001	-4.85	-0.0644
Distance to nearest cultural place (km)8										0.0001	4.12	0.0375
Distance to nearest place of defense or justice				0.0000	5.50	0.0629						
Distance to nearest place of food provision	0.0000	4.90	0.0388									
Distance to nearest place of fairs (km)16							0.0000	-2.83	-0.0317			
Number of social welfare places per 1000 inhabitants				0.1343	5.26	0.0412						
Number of cultural places per 1000 inhabitants	-0.0882	-4.92	-0.0417	-0.1020	-6.11	-0.0460						

[9] In that case, the variable number of bedrooms seems to capture most of what is captured in the model that includes the constructed area.

Number of schools per 1000 inhabitants	0.1302	4.18	0.0524	0.1787	7.60	0.0680						
Lakes area (M2) per 1000 inhabitants	0.0000	7.02	0.0367	0.0000	4.42	0.0379						
Number of places of fairs per 1000 inhabitants										0.3080	1.82	0.0158
Parks area (M2) per 1000 inhabitants							0.0000	6.08	0.0293	0.0000	7.11	0.0534
Forest area (M2) per 1000 inhabitants										0.0000	-2.54	-0.0151
Cars theft rate							0.0050	2.31	0.0176			
Homicide rate	-0.0342	-4.87	-0.0286	-0.0566	-5.96	-0.0446	-0.0136	-1.81	-0.0106			
Attacks17				-0.1095	-6.82	-0.0665	-0.0271	-2.10	-0.0161			
Gini coefficient of education	-5.7485	-5.77	-0.0940	-7.4861	-7.08	-0.1232	-2.7689	-2.86	-0.0447			
Number of attacks against life per 10000 inhabitants	-0.0355	-4.90	-0.0337				-0.0319	-4.62	-0.0321	-0.0488	-3.77	-0.0596
Number of attacks against wealth per 10000 inhabitants										0.0253	2.45	0.0343
Number of bars per 10000 inhabitants							0.0163	3.14	0.0222	0.0303	2.68	0.0323
Number of casinos/places for bets per 10000 inh.												
Number of places selling drugs/narcotics per 10000 inh.							0.0223	2.65	0.0241			
Population Density				0.0004	4.37	0.0357	-0.0003	-3.24	-0.0290	-0.0006	-3.21	-0.0688
Unemployment rate	-1.6936	-4.92	-0.0457	-3.2778	-8.13	-0.0890	-1.3047	-3.82	-0.0347	-1.9631	-3.96	-0.0556
Average of education years by census track	0.0692	9.27	0.1995	0.0596	6.54	0.1720	0.0420	6.22	0.1191	0.0877	14.65	0.2645
Share of female heads	-2.2659	-6.32	-0.0731	-3.8437	-9.66	-0.1200						
Illiteracy rate	0.4705	3.30	0.0281	0.7852	6.00	0.0462						
Piped gas coverage	-0.3515	-7.03	-0.0640	-0.5070	-7.97	-0.0905	-0.3141	-6.36	-0.0566	-0.3912	-7.81	-0.0845
Constant	16.3259	80.90	.	17.5977	107.98	.	11.1935	83.22	.	10.7803	90.23	.

[1] Only includes households for which cadastral values are available. [2] Cadastral values if available, otherwise, the value reported by households surveyed. [3] Only includes households for which actual rent paid is available. [4] Actual rent paid if available, otherwise, the value households surveyed report they would pay if under lease. *t* statistics computed based on robust standard errors corrected by clustering at the census sector level. Definitions and description of variables are available in table 2.

Table 4B. Shorrocks decomposition. Bogotá

Variable	Coef	Mean	Contribution	Share
Constructed area (squared meters)	0.0036	173	0.3254	0.427
Average of education years by census track	0.0692	10.19	0.0901	0.118
Gini coefficient of education	-5.7485	0.0506	0.0743	0.097
Stratum 6	1.0818	0.0276	0.0524	0.069
Stratum 4	0.6547	0.1096	0.0520	0.068
Stratum 3	0.4119	0.4337	0.0418	0.055
Distance to nearest university (km)	-0.000047	1,319	0.0370	0.049
Stratum 5	0.8780	0.0316	0.0308	0.040
Unemployment rate	-1.6936	0.0745	0.0228	0.030
House with garage	0.0856	0.2811	0.0218	0.029
Number of rooms	0.0351	3.35	0.0218	0.029
Distance to nearest place of public administration	-0.000053	871	0.0173	0.023
Number of schools per 1000 inhabitants	0.1302	0.3433	0.0108	0.014
House	-0.0905	0.3998	0.0105	0.014
Piped gas coverage	-0.3515	0.7615	0.0076	0.010
High quality floor material	0.0332	0.8058	0.0061	0.008
House with garden	0.0907	0.4450	0.0043	0.006
House has suffered for a natural disasters	-0.0504	0.0684	0.0037	0.005
Number of attacks against life per 10000 inhabitants	-0.0355	0.5471	0.0033	0.004
Homicide rate	-0.0342	0.5326	0.0025	0.003
House with potable water service	0.2954	0.9904	0.0014	0.002
Lakes area (M2) per 1000 inhabitants	0.0000	233	0.0009	0.001
Terminals of ground transportation in neighborhood	-0.0563	0.0264	0.0007	0.001
House with court yard	0.1133	0.0444	-0.0001	0.000
Distance to nearest school (km)	-0.000151	199	-0.0011	-0.001
Area of land (squared meters) -Land-	-0.0002	118	-0.0032	-0.004
Number of cultural places per 1000 inhabitants	-0.0882	0.2693	-0.0036	-0.005
Illiteracy rate	0.4705	0.0835	-0.0044	-0.006
Distance to nearest place of food provision	0.000022	1,758	-0.0050	-0.007
Share of female heads	-2.2659	0.1009	-0.0253	-0.033
Stratum 2	0.2379	0.3358	-0.0341	-0.045

R2	0.7624	
Share Housing variables (not including strata)		50.9%
Socioeconomic strata		18.7%
Share Amenities (not including strata)		30.4%

4.2 Medellín

Results of estimating the hedonic regression for Medellín are reported in table 5A. There are two panels, each with a different set of observation determined by the dependent variable used. The first panel includes the rent paid by households living under lease and the amount owner households (who already fully paid their houses) report they would pay if they were living under lease. The second panel includes only households living under lease. As we do for Bogotá, each panel of the table has three columns that contain the estimated coefficients, their *t* statistic, and the standardized beta coefficients which tell us how many standard deviations change our dependent variable for each standard deviation of increase in our control variable.

The table shows that house rents increase with the number of rooms and bathrooms of the house, if the house has access to fixed phone lines, piped gas, piped water, internet or satellite television, if it is an apartment rather than a house, if it has garage, and good materials of floors and walls. Finally, rent values increase with socioeconomic stratum.

Among the amenities included in the regression, we find that house rents increase with variables at the census sector level like the average education and the per capita number of places of food supply. Rent values decrease if the house is located in a place subject to environmental risks (flooding, landslides, etc.). Distance to the metro or Medellín's *Transmilenio* stations, are negatively related to house price, meaning that proximity implies a premium to house values.[10] House rents also increase with the distance to inter-municipal roads, the distance to public utilities and to places of cultural value. It decreases with distance to universities.

Relative importance of the explanatory variables

We estimate for Medellín the same models we did in the case of Bogotá to quantify the importance of each of our control variables. Table 5A presents the standardized beta coefficients. According to the table, changes in the socioeconomic strata are the ones that would affect the most house rents. Increasing the share of strata 5, 6 and 3 houses in a specific census sector a one standard deviation from its current level, would imply an increase of a 0.3, 0.25 and 0.2 standard deviations in the average rent of its houses respectively. On the other hand, increasing the average education of the census sector where the house is located, the number of rooms, and the number of bathrooms one standard deviation, would imply an increase of 0.145, 0.14 and 0.10 standard deviations in the house rent respectively. Finally, decreasing the distance to a metro or *Metroplus* station a one standard deviation, would increase house rents in 0.064 standard deviations (that is, decreasing distance to the nearest station 1 kilometer would increase house value about 7% approximately).

[10] Medellín's *Transmilenio* is called *Metro-Plus*. It was still under construction at the moment of the survey, nonetheless, by then households already new where its stations were going to be located.

Again, for Medellín as it was for Bogotá, most of the key determinants of house rents are amenities.

A similar analysis shows that most of the variables found to be key determinants of rent values when we used either rent paid or the rent reported that would be paid in the case the household owned it, are as well the most important when we use the actual rent paid by the subset of households who live on lease.

Let us now analyze the results of variance decomposition presented in table 5B. Here again we consider the fact that socioeconomic strata include both information of housing and amenities and estimate the share of the explanatory power of the model explained by housing variables and by amenities, excluding what is explained by socioeconomic strata. In the case of Medellín, the importance of socioeconomic strata is striking relative to Bogotá: they explain 38% of the R^2, versus just 20% in the case of Bogotá (also in the regression on houses rent). Again, consistent with our analysis above, the most important amenity is the average education, which alone explains 15% of the R^2. House characteristics like the number of rooms, number of bathrooms, the material of the floors and having a garage, explain 10%, 9%, 5.4% and 4.5% of the R^2 respectively. Together, amenities (not including socioeconomic strata) explain 25% of the R^2 while house characteristics (not including socioeconomic strata) explain 37%.

When we include fixed effects by census sector, the R^2 becomes 0.774, our model with both amenities at the census sector and those that vary within census sectors has a R^2 of 0.762. Once we drop the census sector amenities, the R^2 falls to 0.755, and if additionally we drop the remaining amenities, it falls to 0.743. Thus, our amenities explain about 60% of what is explained by the census sector fixed effects, much more than it was the case for Bogotá.

Table 5A. Hedonic regression for Medellín

Variables	Rent paid + Value			Rent paid		
	N: 16323		R2: 0.7636	N: 6275		R2: 0.7246
	Coefficient	t	Beta	Coefficient	t	Beta
Number of rooms	0.0674	22.46	0.142	0.0717	14.74	0.162
Number of bathrooms	0.0944	12.62	0.102	0.1133	11.48	0.113
House with fixed telephone line	0.1238	7.34	0.032	0.1072	4.37	0.034
House with piped gas service	0.0789	7.73	0.049	0.0535	3.91	0.033
Household cocks with piped gas	-0.0276	-3.49	-0.018			
House with GPL service	0.0315	3.35	0.021	0.0234	2.13	0.018
House with interenet service	0.0719	7.24	0.039	0.0634	4.22	0.034
House with Satellite television service	0.0447	5.94	0.030	0.0383	3.32	0.029
House	-0.0189	-2.51	-0.013	-0.0287	-2.73	-0.022
House with garage	0.1082	7.93	0.057	0.1408	7.59	0.072
High quality floor material	0.1469	16.43	0.083	0.1677	13.30	0.106
High quality wall material	0.1022	2.67	0.015			
House with potable water service	0.3633	1.90	0.007			
Kitchen is an aditional room	0.1564	5.51	0.028	0.1657	3.83	0.036
Stratum 2	0.1046	5.93	0.068	0.0751	3.47	0.055
Stratum 3	0.3340	13.67	0.212	0.2821	9.48	0.206
Stratum 4	0.5760	19.28	0.245	0.4847	13.21	0.231
Stratum 5	0.7762	20.65	0.301	0.6529	14.03	0.258
Stratum 6	1.0358	19.63	0.254	0.9056	12.80	0.172
House in area vulnerable to natural disasters	-0.0613	-3.09	-0.019	-0.0973	-2.38	-0.030

Class of soil is urban				0.5543	5.82	0.041
Class of soil is rural				0.4971	4.65	0.031
Class of soil is residential	-0.0223	-2.06	-0.012	-0.0269	-1.94	-0.017
Distance to nearest cultural place	0.000032	2.55	0.021			
Distance to nearest place of public administration (km)	-0.000020	-1.45	-0.016	-0.000050	-3.64	-0.043
Distance to nearest metro or metroplus station	-0.000055	-6.46	-0.064	-0.000050	-4.86	-0.063
Distance to nearest place of refugee for children and old people	-0.000049	-5.23	-0.058	-0.000073	-6.21	-0.095
Distance to nearest market place	0.000025	4.17	0.046	0.000018	2.13	0.035
Distance to nearest place of recreation or sports (km)				-0.000027	-1.87	-0.020
Distance to nearest church/worship place (km)				-0.000054	-1.60	-0.013
Distance to nearest place of vigilance (km)	-0.000031	-2.14	-0.020			
Distance to nearest place related with utility services	0.000052	3.61	0.026	0.000034	2.51	0.019
Distance to nearest place of help in case of disasters (km)	0.000023	2.69	0.040			
Distance to nearest river or stream (km)	-0.000021	-1.97	-0.034	-0.000017	-1.89	-0.031
Distance to nearest hill (km)				0.000020	2.72	0.030
Distance to nearest place identified as cultural Heritage (km)				0.000050	2.43	0.047
Distance to nearest inter-municipal road (km)	0.000007	2.03	0.018	0.000008	1.97	0.023
Distance to nearest university (km)	-0.000032	-4.49	-0.036	-0.000037	-4.88	-0.046
Number of social welfare places per 100 inhabitants				-0.1619	-2.11	-0.021
Number of cultural places per 1000 inhabitants	0.0987	1.64	0.012	0.1795	2.97	0.028
Number of places of public administration	-0.0016	-0.18	-0.001	0.0132	1.31	0.010
Number of metro or metroplus stations per 1000 inhabitants				-0.0559	-1.15	-0.012
Number of market places per 1000 inhabitans	0.3535	2.33	0.012	0.2948	2.16	0.014
Number of places related with utility services per 1000 inhabitans				-0.0760	-1.66	-0.010
Population Density				0.0000	1.29	0.006
Average of education years by census track	0.0529	9.61	0.145	0.0546	8.69	0.156
Homicide rate	-0.0039	-6.20	-0.044	-0.0028	-3.41	-0.035
constant	10.4345	49.20	.	10.3699	77.14	.

Table 5B. Shorrocks decomposition. Medellín

Variable	Coef	Mean	Contribution	Share
Stratum 5	0.7762	0.087	0.1279	0.167
Average of education years by census track	0.0529	9.20	0.1155	0.151
Stratum 6	1.0358	0.03	0.1018	0.133
Number of rooms	0.0674	4.21	0.0761	0.099
Stratum 4	0.5760	0.11	0.0758	0.099
Number of bathrooms	0.0944	1.44	0.0673	0.088
High quality floor material	0.146934	0.77	0.0416	0.054
House with garage	0.1082	0.18	0.0344	0.045
Distance to nearest place of refugee for children and ol	0.0000	1166	0.0217	0.028
House with internet service	0.0719	0.19	0.0194	0.025
House with piped gas service	0.0789	0.30	0.0192	0.025
Stratum 3	0.334047	0.31	0.0170	0.022
Homicide rate	-0.0039	10.73	0.0154	0.020
House with Satellite television service	0.0447	0.57	0.0131	0.017
Distance to nearest university (km)	0.0000	1,522	0.0091	0.012
Distance to nearest metro or metroplus station	-0.0001	1,195	0.0086	0.011
House with fixed telephone line	0.1238	0.96	0.0064	0.008
Distance to nearest river or stream (km)	0.0000	2,077	0.0054	0.007
House in area vulnerable to natural disasters	-0.0613	0.06	0.0045	0.006

Kitchen is an aditional room	0.1564	0.98	0.0042	0.005
Distance to nearest place of help in case of disasters (k	0.0000	1,965	0.0036	0.005
Distance to nearest place related with utility services	0.0001	678	0.0027	0.004
Household cocks with piped gas	-0.0276	0.4041	0.0023	0.003
Distance to nearest place of public administration (km)	0.0000	1,155	0.0020	0.003
Distance to nearest church/worship place (km)	0.000032	707	0.0018	0.002
House	-0.0189	0.502	0.0018	0.002
High quality wall material	0.1022	0.9881	0.0017	0.002
Distance to nearest market place	0.0000	2,416	0.0015	0.002
Number of cultural places per 1000 inhabitants	0.098693	0.032	0.0009	0.001
Class of soil is residential	-0.0223	0.8187	0.0009	0.001
Distance to nearest inter-municipal road (km)	0.0000	4,409	0.0007	0.001
Number of market places per 1000 inhabitans	0.3535	0.0022	0.0005	0.001
House with potable water service	0.3633	0.9994	0.0002	0.000
Number of places of public administration	-0.0016	0.0134	0.0000	0.000
Distance to nearest place of vigilance (km)	0.0000	741	-0.0026	-0.003
House with GPL service	0.0315	0.3977	-0.0037	-0.005
Stratum 2	0.1046	0.3532	-0.0319	-0.042
R^2			0.7667	
Share Housing variables (not including strata)				37.0%
Socioeconomic strata				37.9%
Share Amenities (not including strata)				25.1%

4.3 Comparing Bogotá and Medellín results

Comparing the results found in Bogotá and Medellín is not an easy task. First, even though these cities are the first and second larger cities in the country, there still are differences in several dimensions that limit comparisons. There are cultural differences, there are more immigrants in Bogotá, more multinational firms, there are the Central Government headquarters in Bogotá, etc. Furthermore, we do not have information available to control for some of these differences. In addition, we do not have the same information for both cities, and the one we do have for both cities comes from surveys implemented by different agencies with clearly different methodology in some cases. Despite the mention caveats, it is still worth to make an effort to compare the findings in these cities. To do it, we first determine the subset of variables available for both cities. Then, we estimate the hedonic models for each city with all the set of common variables and keep only those which estimates are significant at least at the 90% significance. Finally, we keep the union of variables that remained in either of the estimations to run what we call the *intersection* model, a model that contains exactly the same variables in both cities. Regressions are estimated for rents values, since we do not have house values for Medellín.

Results of this exercise are reported in table 6. The table is divided in three panels, the top panel with the house variables, the middle the socioeconomic strata, and finally, the bottom one with the amenities. The table contains for each city, the number of observations of each variable, its mean, and contains the estimated coefficients and their *t* statistics. Finally, it contains *t* test of significance in the difference of the means and the coefficients of the variables.

Let's begin with the socioeconomic strata, which we found to be among the most important variables in our hedonic models. There is a very large difference in the share of households in stratum 3, with Bogotá with 43% of households in that stratum while

Medellín with only 31%. Bogotá in turn, has smaller shares of households in every other socioeconomic stratum but stratum 4. This stratification structure favors the poor of Medellín relative to the poorest of Bogotá, at the cost of diminishing the size of the middle class that lives in strata 3 and 4, and classifying them as either stratum 5 or 6. Actually, in strata 5 and 6, the higher socioeconomic strata, there are just 6% of households in Bogotá while 12% in Medellín. On the other hand, the price set by the market to the different socioeconomic strata relative to stratum 1, is similar in both cities except for the price of strata 3 and 4, which is lower for Bogotá. This means that all characteristics related to these two socioeconomic strata are being relatively much more valued with respect to stratum 1 in Medellín that in Bogotá. This fact reveals the existence of sharper differences among the socioeconomic strata in Medellín, what is undesirable if we wanted a more equal city.

The average education at the census sector level is much larger in Bogotá, with 10.3 years of education on average compare to Medellín with just 9.2 years. Its market price on the other hand, is similar in both cities. Overall, Bogotá is better endowed in amenities than Medellín: it has lower homicide rates, lower inequality in the distribution of education, universities and cultural places are closer to people, there are more per capita cultural places, there are higher levels of average education, lower unemployment rates and higher rates of piped gas coverage. On the other hand, there are more areas vulnerable to natural disasters and public transit stations are farther from people.[11]

Bogotá has as well better endowed houses: they have better floor and walls materials, and are more likely to have garage, although less people cooks in an independent room. The number of rooms is smaller in Bogotá, and it is larger its number of bathrooms, both characteristics that might be related to household sizes relatively smaller, and better living conditions in Bogotá.

Piped gas coverage represents one of the most striking differences of these cities. For Bogotá, piped gas has been installed mostly in the poorest neighborhoods, while for Medellín it has been installed mostly in the richest neighborhoods, thus being related negatively and positively respectively to rent values in each of these cities. Thus, beyond differences in mean coverage, which strongly favor Bogotá, there is the issue of the much more progressive targeting of this public service in Bogotá. Actually, at the moment of our surveys, public utilities in Medellín might have been doing a good business with piped gas, since they were basically supplying it only to stratum 6, but utilities in Bogotá were making social policy supplying it to the very poorest.

Table 6. Comparing Bogotá and Medellín

[11] Nonetheless, *Metroplus* stations, which are included in the regression, were not yet working at the moment of the survey.

Variable	Bogotá			Medellín			Differences Bog-Med			
	Mean	Coeff	*t*	Mean	Coeff	*t*	ΔMean	*t*	Δcoeff	*t*
Number of bedrooms	3.37	0.1796	21.28	4.22	0.0729	23.37	**-0.85**	**-46.77**	**0.107**	**11.85**
Number of bathrooms	2.07	0.0154	1.73	1.45	0.1001	12.90	**0.63**	**59.27**	**-0.085**	**-7.16**
House with piped gas service	0.66	-0.0931	-2.94	0.30	0.0667	7.34	**0.36**	**65.14**	**-0.160**	**-4.85**
Household cocks with piped gas	0.62	0.1857	5.61	0.40	-0.0152	-2.30	**0.21**	**37.02**	**0.201**	**5.95**
House with garage	0.28	0.1333	7.74	0.18	0.1223	8.88	**0.10**	**20.41**	0.011	0.50
House	0.38	0.0677	4.52	0.50	-0.0224	-2.79	**-0.12**	**-21.36**	**0.090**	**5.30**
House with potable water service	0.988	0.1514	1.37	0.999	0.3719	1.88	**-0.011**	**-11.53**	-0.221	-0.97
High quality floor material	0.81	0.1294	7.80	0.77	0.1631	17.64	**0.04**	**7.90**	-0.034	-1.78
High quality wall material	0.99	0.3315	4.26	0.99	0.1243	3.19	0.00	-1.79	**0.207**	**2.38**
Kitchen as an additional room	0.96	0.1888	5.95	0.98	0.1738	6.07	**-0.02**	**-10.26**	0.015	0.35
Stratum 2	0.33	0.0694	2.32	0.36	0.0934	5.02	**-0.03**	**-5.32**	-0.024	-0.68
Stratum 3	0.43	0.1841	4.81	0.31	0.3380	13.23	**0.12**	**20.72**	**-0.154**	**-3.34**
Stratum 4	0.12	0.3865	7.32	0.11	0.5810	18.46	0.01	1.79	**-0.195**	**-3.16**
Stratum 5	0.03	0.6425	10.58	0.09	0.7572	19.27	**-0.06**	**-21.71**	-0.115	-1.59
Stratum 6	0.03	1.0366	8.73	0.04	1.0714	22.36	**-0.004**	**-1.92**	-0.035	-0.27
House in area vulnerable to natural disasters	0.07	-0.0245	-1.07	0.05	-0.0729	-3.27	**0.02**	**5.48**	0.048	1.51
Homicide rate	0.54	-0.0132	-1.58	10.74	-0.0033	-4.15	**-10.20**	**-155.22**	-0.010	-1.18
Gini coefficient of education	0.05	-2.7256	-1.72	0.40	-0.1847	-1.24	**-0.35**	**-369.64**	-2.541	-1.60
Distance to nearest university (km)	1,318	-0.0000225	-3.13	1,523	-0.0000257	-3.38	**-205.4**	**-17.23**	0.000003	0.31
Distance to nearest cultural place (km)8	366	0.0000172	0.89	708	0.0000318	2.83	**-341.2**	**-73.89**	-0.000015	-0.65
Distance to nearest medical center	532	-0.0000008	-0.03	510	-0.0000215	-1.30	**21.89**	**5.72**	0.000021	0.65
Distance to nearest place of public administration	861	-0.0000623	-5.64	1,147	-0.0000089	-0.70	**-285.6**	**-38.02**	**-0.0001**	**-3.17**
Distance to the neaters public transit station	1,727	-0.0000012	-0.22	1,194	-0.0000304	-3.94	**532.5**	**40.56**	**0.00003**	**3.07**
No of public admin. places per 1000 inhabitants	0.27	0.0079	0.72	0.01	-0.1358	-4.39	**0.26**	**27.11**	**0.144**	**4.38**
Number of cultural places per 1000 inhabitants	0.28	0.0065	0.34	0.03	0.2134	3.06	**0.25**	**31.27**	**-0.207**	**-2.86**
Average of education years by census track	10.28	0.0571	5.99	9.22	0.0462	4.33	**1.05**	**41.36**	0.011	0.77
Unemployment rate	0.07	-1.1079	-2.27	0.08	-0.6352	-1.75	**-0.004**	**-12.09**	-0.473	-0.78
Piped gas coverage	0.76	-0.4112	-6.45	0.22	0.1626	3.21	**0.53**	**226.89**	**-0.574**	**-7.05**
Constant		10.7437	46.58		10.6419	42.34			0.102	0.30
Number of observations		12,660			16,196					

When we repeat the *Shorrocks* decomposition with the exercise that compares Bogotá and Medellín controlling for the same variables, there again the number of room is the most important variable for Bogotá (Medellín), explaining 31.5% (12.4%) of the R^2, followed by the average education of the census sector, which explains 18.5% (12.4%) of the R^2. All amenities in Bogotá (Medellín) explain 32% (28%) of the R^2, while house variables explain 47% (38%). Socioeconomic strata explain 21% of the R^2 for Bogotá and 34% for Medellín. These corroborate our previous results according to which there seem to be more characteristics, beyond the ones controlled for here and associated to socioeconomic strata that are being arbitraged with price differences, mostly through higher prices for strata 3 and 4 in Medellín relative to Bogotá.

5. Life-Satisfaction approach to construct the QoL index by sub-city area

Looking at perceptions of people about their living conditions is becoming an accepted practice among previously skeptic economists on these approaches. As several authors have stated it, relevance of studying happiness should be straightforward, since it is considered for most one of the key goals of life.[12]

One of the issues that made most researchers become skeptical about the life-satisfaction approach was the lack of evidence regarding the reliability of people reported perception about their well being. On this matter, recent objective evidence previously reported by Layard (2003) among others, has contributed to accept individuals' perception as reliable measures of life-satisfaction. In fact, Layard documents evidence from the neuro-science documented in research like that in

[12] For a survey on this Topic see Frey and Stutzer (2002) or van Praag (2007). We will use the terms life-satisfaction and happiness indistinctively, since previous work by Blanchflower and Oswald (2000), and by Di Tella, MacCulloch and Oswald (2001), have found their implications to be similar.

Davidson (2000) and Davidson et. al. (2000), according to which brain activity is closely related to feelings reported by people, longitudinally for each individual, and across people. These facts have been put forward by researchers to support quantitative life-satisfaction analysis based on the cardinality and interpersonal comparability assumptions implicit in the approach.

In what follows we present the results of estimating regression with similar specification to the hedonic one, but that use self reported life satisfaction as dependent variable. We include in these regressions additional controls previously found to be related to life satisfaction like the age and health of household head, household income, number of children in household, etc.

5.1 Bogotá

In order to describe how self reported data on life satisfaction behaves for the case of Bogotá, figure 3 illustrates the relation of this variable to three variables related to welfare: Old and New Sisben, and income decile.[13] As it becomes clear from the figure, self reported life satisfaction is positively related to all three indicators of welfare in Bogotá, consistent with results reported elsewhere.[14] It is worth to highlight that the dispersion of life satisfaction seems to have increased between 1997 and 2003, so that worse off people became relatively less happy than the better off.

Figure 3. Life Cond. and Welfare, Bog.

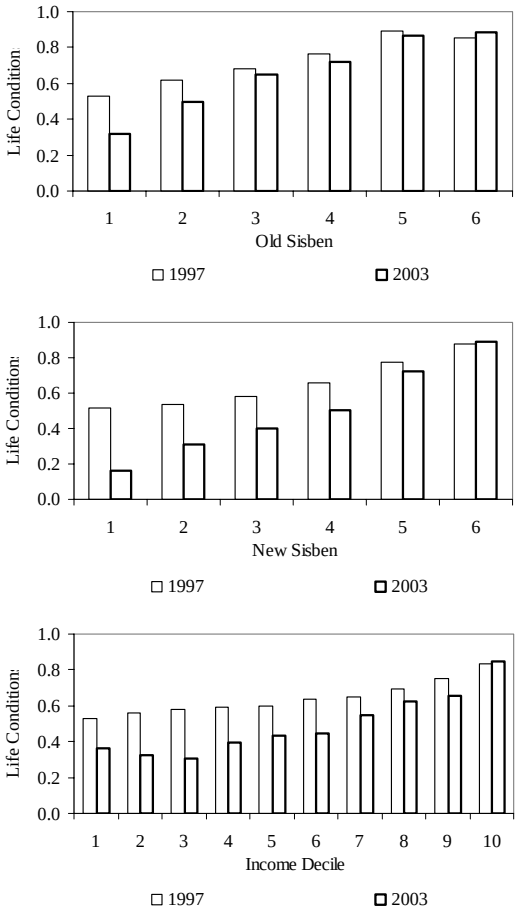
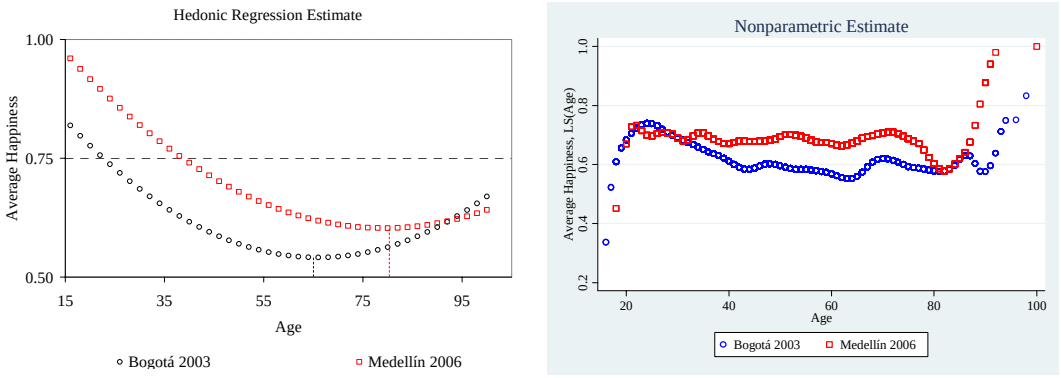


Table 7 presents our regression results. There are four panels in the table. The first presents the results of estimating an ordered probit model using the four answer options to the question "currently living conditions in your household are:": (i) very good, (ii) good, (iii) fair, and (iv) bad; the second and third panels present the coefficients and marginal effects of estimating a probit model using answers (i) and (ii) as the "positive" ones.[15] Finally, the last panel presents the standardized coefficients defined in the previous section, obtained from a linear regression, that uses as dependent variable the one used in the probit model. The Results are very much in line with the cross section models reported by Ferrer-i-Carbonell and Frijters (2004). For example, for all models, the linear term of the age of the household

[13] Old and New Sisben are Proxy-means tests used to target social public expenditure in Colombia.
[14] See for example Fray and Stutzer (2002), Layard (2003), and the references therein.
[15] Similar results are found if we estimated an ordered probit model using as dependent variable the actual four answers of households.

head variable is negatively while its quadratic part is positively related to happiness, implying a U-shaped relationship between age and happiness. The implied relationship is illustrated in figure 4, where the graph on the left shows the curve implied by our hedonic model, and the one on the right shows a nonparametric estimate, which still slightly resembles the U-shaped patern of the hedonic model in the case of Bogotá, but is much flater in the case of Medellín, suggesting levels of happiness much more neutral to age its the hedonic model.

Figure 4. Life Satisfaction over the Life Cycle. Bogotá and Medellín.



Household per capita income is positive while the number of children in the household 2-5 negative and significant. In addition, divorced heads of household are less happy. We also find a positive relation between objective health and happiness. We use as measures of objective health whether the household head suffers of any chronic disease, had been ill during the last 30 days, or had been hospitalized during the last 12 months, all of which are negatively related to happiness in a significant magnitude. Once controlling for all of our covariates, the socioeconomic stratum does not explain in a significant magnitude household head happiness.

A relation that has generated high controversy in the literature is the one between the number of children in the household and life satisfaction. As Frijters et. al. (2004a) mention, "There is no consistent finding for the effect of children on life satisfaction". Although in their paper they find a positive effect of children on life satisfaction in East Germany, their (2004b) article confirms it, but also finds a negative effect in West Germany. The authors do not provide any intuition for this result. On the other hand, Ferrer-i-Carbonell and Frijters (2004) show that to obtain the positive effect result it is key to have longitudinal data.

Previous studies that find a negative relation between children and life satisfaction link this result to higher levels of anxiety, stress, and depression, mostly among unmarried parents, and find this negative relationship to be stronger for men than women.[16]

A more recent article by Kohler et. al. (2005) presents a comprehensive analysis that uses information of identical twins to control for unobservable endowments, which are supposed to explain a large part of variation in happiness according to the "setpoint theory" of happiness, which argues that happiness is mostly explained by individual

[16] See As Kohler et al. (2005) who review work done by McLanahan and Adams (1987), Nomaguchi and Milkie (2003), Hakim (2003b), and Ferrer-i-Carbonell and Frijters (2004) who quotes the arguments posed by Argyle (1999).

characteristics and genetic factors.[17] In contrast to this view, the authors find that even after differencing out those endowments, both marital status and children have persistent significant effects on happiness. In particular, being currently in partnership is associated with higher levels of happiness, the first-born (additional) children is associated with more (less) happiness (males prefer a first-born sons over a first-born daughter), and early motherhood (first birth at or before 21) is associated with less happiness (only for women).

Here we explore whether children affect different types of households differently, by analyzing how they are associated to happiness of households with different income levels, with heads of different marital status or education levels, and finally, we explore one of the issues tackled by Kohler et al. (2005), namely, the importance of early pregnancy on happiness. Our approach is very simple and consists of including interacting terms of the presence of children 2-5, and under 18, with income, marital status and education level of the household head, and including a proxy variable for early pregnancy.

Table 7 shows that even controlling for these additional variables, the coefficients of the presence of children 2-5 are negative and significant in both ordered and probit models. Nonetheless, the additional variables allow us to infer more deeply what that coefficient means. Our interaction variables show that richer households with children less than 18 are happier, and so are heads married or who live with a partner having children under 18. More educated (complete secondary or more) heads of household with children less than 18 are less happy than their less educated counterparts, although the most educated heads (college or more) with children 4 or less are happier. Were not this result biased by the presence of uncontrolled for unobservables, it might signal a higher opportunity cost of more educated parents to deal with their adolescent children. On the other hand, younger household heads with children under 18 are happier than the older ones.

Finally, we include a variable defined as the difference between the age of the spouse of the household head (if household head male), or the household head (if household head female), and her oldest children, as a proxy of households with children coming from women's early pregnancy. Its relation to happiness is found to be insignificant. We have to bear in mind though that we are including too many control variables, and the total effect of this variable might be to a large extent being captured by some of these additional covariates through which early pregnancy would be transmitting its effect.

In order to determine the relative importance of the variables included in the model, we estimate an OLS model with standardized coefficients as we did it for the hedonic regression models. Results are presented in the last panel of table 7. In this case, the linear and quadratic terms of age are the most important variables of the model in the sense explained for the hedonic models. For example, a one standard deviation increase in the age (age squared) would imply 0.45 (0.35) standard deviations decrease (increase) in happiness. Income is the second most important variable, with a one standard deviation increase in the log of per capita income implying 0.21 standard deviations increase in happiness. Other interesting result is that a one standard deviation increase in the interaction variable that implies a household composed by a married couple, or a couple living in partnership, living with children, makes happiness to increase 0.11

[17] Easterlin (2003, 2005).

standard deviations. Although the average education of the census tract is still an important variable, it has a much more modest importance than it did in the hedonic model based on property values, with an effect similar to the one of the education of the household head that has a beta coefficient of 0.06.

Table 6. Life-Satisfaction regression for Bogotá

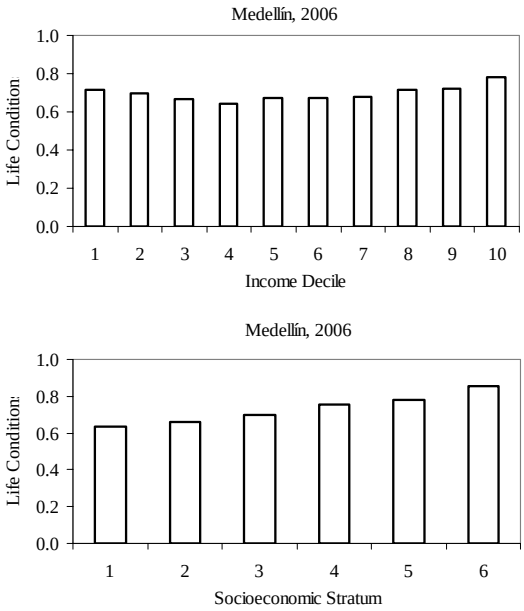
Variable	Ordered Probit N=12621 R2=1543		Probit N=12621 R2=0.1853		Marginal Effects N=12622 R2=0.1854		Linear Regression N=12623 R2=0.21
	Coeff.	z	Coeff.	z	Coeff.	z	Beta
Number of bedrooms	0.0903	6.46	0.0814	6.18	0.0302	6.18	0.081
Number of bathrooms	-0.0331	-1.68					
House with piped gas service	0.1811	5.46	0.1483	3.99	0.0556	3.99	0.041
Bad quality of the electricity service	-0.2158	-2.67	-0.2657	-2.43	-0.1024	-2.43	-0.027
Bad quality of the garbage collection service	-0.2202	-2.54	-0.2503	-2.73	-0.0963	-2.73	-0.027
Bad quality of the service of fixed phone lines	-0.1179	-2.07	-0.2153	-3.52	-0.0824	-3.52	-0.031
Parks in neighborhood	0.1332	3.12	0.1019	1.83	0.0373	1.83	0.018
Floor material is any of: Marble, parquet, lacquered wood	0.0965	2.60	0.1338	3.19	0.0504	3.19	0.041
Stratum 2	0.0067	0.12	-0.0096	-0.14	-0.0035	-0.14	-0.0003
Stratum 3	-0.0860	-1.23	-0.1039	-1.27	-0.0387	-1.27	-0.028
Stratum 4	-0.1104	-1.25	-0.2054	-1.82	-0.0783	-1.82	-0.041
Stratum 5	-0.0256	-0.24	-0.2013	-1.47	-0.0770	-1.47	-0.033
Stratum 6	0.0169	0.14	0.0092	0.07	0.0034	0.07	-0.027
Sewerage canal in neighborhood	-0.0796	-2.02					
You feel safe in your neighborhood	0.3431	10.75	0.4045	11.32	0.1532	11.32	0.125
Gini coefficient of education	-4.5672	-2.55					
Number of attacks against wealth per 10000 inhabitants	-0.0366	-2.26	-0.0395	-2.31	-0.0147	-2.31	-0.025
Number of bars per 10000 inhabitants	0.0697	3.50	0.0420	2.90	0.0156	2.90	0.027
Number of burdels per 10000 inhabitants	-0.0460	-2.35					
Number of places selling drugs/narcotics per 10000 inhabitants	0.0228	1.92	0.0621	3.46	0.0230	3.46	0.033
Distance to nearest social welfare place (km)			-0.0002	-2.18	-0.0001	-2.18	-0.027
Distance to nearest church (km)	0.0001	2.88					
Distance to places for recreation or sports per 1000 inhabitants	0.0000	1.68	0.0000	2.31	0.0000	2.31	0.021
Number of places of fairs per 1000 inhabitants	0.0000	-1.66					
Number of places of food provision per 1000 inhabitants			0.5994	1.74	0.2225	1.74	0.011
Forest area (km2)	0.0000	2.64					
Number of churches/worship places per 1000 inhabitants			-0.2207	-2.23	-0.0819	-2.23	-0.020
Number of places of defense or justice per 1000 inhabitants			-0.1585	-2.08	-0.0588	-2.08	-0.013
Number of places for vigilance per 1000 inhabitants			-0.3801	-2.87	-0.1411	-2.87	-0.018
Land use is productive housing	-0.0594	-1.69	-0.0846	-2.12	-0.0315	-2.12	-0.031
Average education by census tract			0.0422	2.72	0.0157	2.72	0.063
Piped gas coverage	-0.4117	-3.38	-0.5701	-3.96	-0.2116	-3.96	-0.049
Population density			-0.0005	-1.91	-0.0002	-1.91	-0.019
Log of household's per capita income	0.3054	14.74	0.2723	11.79	0.1011	11.79	0.211
Score of Sisben	0.0181	2.87					
Household head with complete high school	0.1966	3.68	0.2009	3.29	0.0724	3.29	0.057
Household head with incomplete college	0.2544	4.76	0.2761	4.69	0.0980	4.69	0.060
Household head with complete college	0.2821	4.99	0.3103	4.32	0.1100	4.32	0.066
Age	-0.0474	-9.24	-0.0477	-7.60	-0.0177	-7.60	-0.450
Age squared	0.0004	7.58	0.0004	6.22	0.0001	6.22	0.350
Number of children 2-5 in household	-0.0987	-2.81	-0.0886	-1.99	-0.0329	-1.99	-0.023
Widowed household head			0.1160	2.06	0.0422	2.06	0.022
Unemployed household head	-0.3286	-5.23	-0.3809	-5.25	-0.1477	-5.25	-0.061
Household head has any kind of health insurance	0.1956	4.39	0.2637	6.08	0.1004	6.08	0.076
Household head has any chronic disease	-0.1450	-3.92	-0.1671	-4.05	-0.0631	-4.05	-0.044
Household head was sick any time during the last 30 days	-0.1459	-3.07	-0.1879	-3.88	-0.0714	-3.88	-0.038
Hhold head was hospitalized any time during the last 12 months			-0.1224	-2.03	-0.0463	-2.03	-0.021
Mean difference between age and education (only under 25)			-0.0065	-1.64	-0.0024	-1.64	-0.009
% of people under 25 attending a public school or college	-0.0684	-1.96	-0.0922	-2.28	-0.0342	-2.28	-0.034
Household head's mother with complete elementary school	0.0508	1.83	0.0927	2.68	0.0341	2.68	0.031
Log of household's per capita income *(No. of children under 18)	0.0000	2.04	0.0000	4.49	0.0000	4.49	0.019
Married*(Number of children under 18)	0.1485	6.60	0.1493	5.19	0.0554	5.19	0.109
Hhold head with complete high school *(No. children under 18)	-0.0572	-1.76	-0.0742	-1.97	-0.0275	-1.97	-0.022
Household head with college*(Number of children under 18)	-0.1228	-3.26	-0.1446	-3.32	-0.0537	-3.32	-0.029
Household head with college*(Number of children under 4)	0.1569	2.78	0.1880	2.40	0.0698	2.40	0.027
Household head age*(Number of children under 18)	-0.0021	-3.56	-0.0033	-4.33	-0.0012	-4.33	-0.076
Constant			-2.5633	-6.99	0.0000	0.00	.
cut 1	0.765	2.28					
cut 2	2.559	7.59					
cut 3	4.732	13.74					

5.2 Medellín

Figure 5. Life Cond. and Welfare, Med.

Data on life satisfaction for Medellín comes from a survey collected during the fourth quarter of 2007 by the *Centro Nacional de Consultoría*, to a sub sample of nearly 1900 of the same households of the Medellín 2006 LSMS. The complete questionnaire and the methodology employed to collect it can be found in Annex 1. The question we used is the number 9 of that questionnaire, which is identical to the one in Bogotá 2003 LSMS.

Figure 5 illustrates the relationship between happiness and income, and between happiness and socioeconomic stratum. The former is U-shaped, while the later is increasing, resembling more the pattern found between income and happiness for Bogotá.



We estimate a similar hedonic model to the one estimated for Bogotá. In this case most of our estimates imply as well reasonable relationships between covariates and happiness. As it can be observed in table 7, the linear and quadratic terms of the age of the household head variables are negative and positively related to happiness respectively. The log of the household per capita income is also positively related, and the number of children in the household (0-18) is negatively related. In this case though, the effect does not vary by education level of the household head or his age. We do not find either any relation between objective good health (household head ill during the last 30 days, or hospitalized during the last 12 months) and happiness (in this case, we do not know whether the household head suffers of any chronic disease).

In contrast to what was found for Bogotá, even after controlling for all of our covariates, in the case of Medellín the socioeconomic stratum still contributes to explain household head happiness, with households in strata 3, 4, 5 or 6 being happier.

In the case of Medellín, age is again the most important variable in determining happiness: a one standard deviation increase in age (age squared) implies a decrease (increase) of 0.47 (0.35) standard deviations in happiness. This relationship is consistent with the U-shaped pattern illustrated in figure 4.

The demographic composition of the household is very important in Medellín, being household heads 16% of one standard deviation less happy when they have an increase of one standard deviation in the number of children under 18, but very importantly, they have an increase in happiness of 11% of a standard deviation if the probability of having at least one child living in the household would move one standard deviation beyond the average. This figures are consistent with a family structure that has difficulties in bearing the costs of raising children under 18 while simultaneously benefiting from the support of those older than 18. The socioeconomic strata, the education of the household head and its marital status are as well among the most important variables. Household per capita income has a lower importance for Medellín relative to what it did for Bogotá.

Table 7. Life-Satisfaction regression for Medellín

Variable	Ordered Probit		Probit		Marginal Effects		Beta
	N=1873	Ps R^2=0.1215	N=1890	Ps R^2=0.1223	N=1890	Ps R^2=0.1203	N=1890;R^2= 0.1377
	Coeff.	***z***	**Coeff.**	***z***	**Coeff.**	***z***	**Coeff.**
Number of bedrooms	0.0387	1.85	0.0365	1.35	0.0125	1.35	0.0415
Satelital TV service	0.1966	2.94	0.1904	2.31	0.0655	2.31	0.0664
House	-0.1023	-1.82					
Floor material is any of: Marble, parquet, lacquered wood	0.1447	1.78	0.1756	1.77	0.0614	1.77	0.0576
Stratum 3	0.1473	1.83	0.2342	2.54	0.0779	2.54	0.0796
Stratum 4	0.3627	3.18	0.6448	4.19	0.1835	4.19	0.1216
Stratum 5	0.4785	3.51	0.6167	3.13	0.1752	3.13	0.1034
Stratum 6	0.8238	3.91	0.8775	3.25	0.2193	3.25	0.0783
Distance to nearest cultural place	0.0001	1.69	0.0001	1.77	0.0000	1.77	0.0481
Distance to nearest place of public administration			0.0002	2.74	0.0001	2.74	0.0613
Distance to nearest intermunicipal road			0.0000	-1.91	0.0000	-1.91	-0.0602
Number of prisons per 1000 inhabitants	1.3181	1.93	2.7019	3.56	0.9208	3.56	0.0384
Number of cultural places per 1000 inhabitants			0.5402	1.40	0.1841	1.40	0.0337
Number of hospitals or medical care centers per 1000 inhabitants			-0.6895	-3.05	-0.2350	-3.05	-0.0752
Number of places related to utility services per 1000 inhabitans			0.3633	0.76	0.1238	0.76	0.0189
No. of places for help in case of disasters per 1000 inhabitants			3.2814	2.85	1.1183	2.85	0.0368
Classification of soil: rural			-1.1154	-5.00	-0.4230	-5.00	-0.0301
Classification of soil: residential			-0.2080	-2.18	-0.0682	-2.18	-0.0573
Unemployment rate	-1.9948	-1.80	-1.6462	-1.15	-0.5610	-1.15	-0.0338
Population density	0.0000	0.04	0.0001	0.67	0.0000	0.67	0.0079
Age	-0.0480	-3.45	-0.0444	-3.13	-0.0151	-3.13	-0.4706
Age squared	0.0004	3.13	0.0003	2.44	0.0001	2.44	0.3461
Log of per capita Income	0.0131	2.59	0.0133	2.17	0.0045	2.17	0.0441
Household head with complete elementary school	0.1607	1.92	0.1425	1.43	0.0479	1.43	0.0596
Household head with incomplete high school	-0.0566	-0.34	0.1317	0.67	0.0436	0.67	0.0259
Household head with complete high school	0.3649	3.59	0.2298	1.76	0.0752	1.76	0.0775
Household head with incomplete college	0.3264	1.90	0.0841	0.37	0.0282	0.37	0.0422
Household head with complete college	0.4344	3.35	0.2871	1.49	0.0911	1.49	0.0605
Number of children under 18	-0.5637	-1.80	-0.2165	-2.57	-0.0738	-2.57	-0.1591
Married household head	0.1984	2.85	0.2171	2.63	0.0738	2.63	0.0769
Widowed household head	0.1918	2.21	0.2525	2.32	0.0815	2.32	0.0645
Household head has any kind of health insurance	0.3819	3.10	0.3811	2.35	0.1405	2.35	0.0524
Mother or father unemployed or inactive * No. Children under 5			-0.1834	-2.27	-0.0625	-2.27	-0.0593
% of people under 25 that attend a public school or college			-0.1445	-1.98	-0.0492	-1.98	-0.0463
Hhold head with complete primary *(No. children under 18)			0.1459	1.35	0.0497	1.35	0.0741
Hhold head with complete high school *(No. children under 18)			0.0756	0.70	0.0258	0.70	0.0373
Household head with college*(No. children under 18)			0.1409	1.22	0.0480	1.22	0.0592
Hhold head with complete high school *(No. children under 4)	-0.2432	-1.63					
At least one child living in the household	0.2509	3.32	0.3733	4.06	0.1331	4.06	0.1071
Age *(No. children under 18)	0.0202	1.67					
Age squared *(No. children under 18)	-0.0002	-1.78					
Constant			0.6533	1.45			
cut 1	-2.63	-6.03					
cut 2	-0.53	-1.26					
cut 3	1.32	3.16					

6. Reconciling results of models based on house prices and life satisfaction

The results presented in the previous sections, although intuitive, are not always leading to the same conclusions at the moment of determining which are the key variables that determine QoL in Bogotá and Medellín. First of all, even though we included all the variables available for the hedonic model in the life satisfaction model, there are some variables that are only included in the later, like the age, education, marital status, health and health insurance of the household head, and the per capita income and number of children in the household. As it was expected, variable like the age of the household head and household per capita income were key determinants of life satisfaction. The inclusion of household per capita income for example, might be at least in part, the reason why socioeconomic strata were not relevant in the life satisfaction model for Bogotá. Average education, which was important in the life satisfaction model for Bogotá and not in the one for Medellín, might as well have captured part of the socioeconomic strata fixed effects. In the case of Medellín, socioeconomic strata was still highly important, and definitely well beyond the importance of household per capita income or average education, which is consistent with the evidence gathered so far according to which socioeconomic strata are much more associated to QoL in Medellín relative to Bogotá.

It is worth to analyze in more detail the differences in the importance of socioeconomic strata at the moment of explaining life satisfaction in Bogotá versus Medellín. First of all, we have to understand well what stratification means in Colombian cities. To determine the socioeconomic strata a house belongs to, an agency of the central government design a methodology that is applied by each municipality. The methodology considers both information of the house (constructed squared meters, number of rooms, number of bathrooms, material of floors, walls, etc.) and its neighborhood (quality of streets, public parks, access to transportation, etc.). Thus, to some extent, stratification is endogenous since households decide whether to make improvements to their houses or not, based on which the local authority will determine the socioeconomic strata of their houses. Nonetheless, given the difficulties in bringing about collective action among the household members of a neighborhood (for example by promoting or requiring improvements to their local authorities), amenities are to a large extent exogenous to them. Thus, there are important externalities that limit the scope of households' interventions in the quality of their houses.

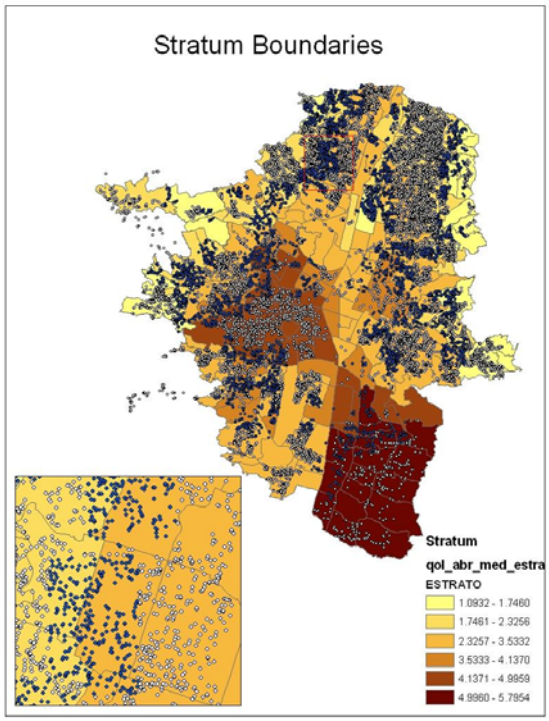
On the other hand, at the moment of determining whether houses on a specific street belong to one stratum or the other, the local authority uses to limit each socioeconomic stratum from its neighbor strata with natural barriers like streams, parks, etc., or existent infrastructure like highways, airports, terminals, etc., provided they can classify neighbors on both sides of the specific barrier in different socioeconomic strata. Nonetheless, as it was established by Medina and Morales (2007) in the case of Bogotá, in most of the cases houses on both sides of a boundary between two socioeconomic strata become more similar the closer they are to their common boundary.[1]

[1] See Black (1999) for a similar application in neighbors of the United States.

To determine whether the existence evidence for Bogotá follows for the case of Medellín, we should estimate mean differences of key houses and amenities variables for houses on both sides of their common boundary, and at different distances to it, and find that those variables become more similar the closer houses get to the boundary. Since we do not have the required distances in the case of Medellín we do not provide such evidence, nonetheless, there are no apparent reason to expect that the finding in the case of Bogotá does not follow for Medellín. Houses might become similar at a lower pace in Medellín than Bogotá, but they still should become more similar the closer they are to their common boundary. Amenities on their part, at exactly the same in the limit, that is, at the common boundary between socioeconomic strata.

Given the clear converge in amenities on the boundaries between socioeconomic strata and the expected convergence in houses characteristics; we would expect life satisfaction based on objective information to become much more similar as well among households close to those boundaries than far away from them. Lack of convergence in life satisfaction across boundaries would suggest the existence of non observables, possibly subjective information, that are of great value to households at the moment of determining their happiness. Those differences might signal the presence of stigma associated to belonging to a specific socioeconomic strata, or to a specific network linked to it.

Map 9. Selected households according to proximity to their stratum boundary



To provide a preliminary test of the existence of socioeconomic strata specific fixed effects, even at their boundaries, we estimate the life satisfaction model only for households that live close to the boundary between his socioeconomic stratum and his closer socioeconomic stratum. The selection of the set of households is shown in map 9. The points on the map represent households surveyed in Medellín, and the white points represent the households among we select the sample of households near the boundaries of their socioeconomic strata (the blue points).

The estimated coefficients of the socioeconomic strata are shown in table 8. The panel on the left includes the estimates of table 7 while those on the right panel presents the estimates obtained with the sub sample of households that are closer to the boundaries of their respective stratum. All socioeconomic strata coefficients are larger for the second sample but only two of them are statistically significant, presumably due to the smaller number of observations. The stability in the magnitude and significance of

the estimates suggest, as we mentioned previously, the existence of non observables, possibly cultural or subjective information linked to the socioeconomic strata, that determine, beyond our objective controls, happiness in households of Medellín.

Table 8. Life satisfaction models with different sets of households according to their distance to the boundaries of their socioeconomic strata. Medellín, 2006.

Variable	All sample (N = 1890)			Near to a boundary (N = 689)		
	Coeff.	Std. Err.	*z*	Coeff.	Std. Err.	*z*
Stratum 3	0.147	0.081	1.83	0.065	0.109	0.59
Stratum 4	0.363	0.114	3.18	0.547	0.160	3.41
Stratum 5	0.478	0.136	3.51	0.302	0.206	1.46
Stratum 6	0.824	0.211	3.91	1.251	0.360	3.48

Both models control for all the covariates include in table 7.

7. Indexes of Quality of Life based on the hedonic and Life Satisfaction Models

In this section we present the results of estimating QoL indexes at the census sector level, for Bogotá and Medellín, based on our hedonic and life satisfaction estimates. Since several of the variables included in these models come from the LSMS surveys of these cities, which as we mentioned previously, do not allow us, by design, to make inferences at the census sector level, we estimate the value of these variables, and our predicted indexes, at the census sector level non-parametrically. To do it, we estimate kernel regressions of predicted values of the hedonic and life satisfaction models, and of each control variable, at the center of each census sector, with the distance to its nearest neighbors.[2] Finally, we use the non-parametric estimates of the estimated variables at the census sector level to get their first principal component as an additional A-theoretical estimate of QoL at the census sector level.[3]

In this section we refer to our estimated QoL index based on the hedonic regression of house values (rents) for Bogotá (Medellín) as the hedonic quality of life index, QoL, and to that based on the happiness equation as the life satisfaction index.

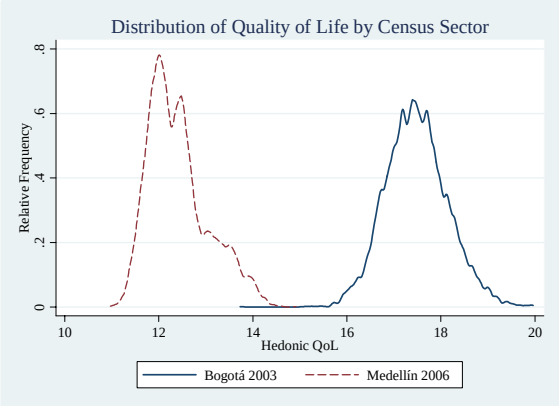
Figure 6 shows the distribution of our hedonic and life satisfaction indexes for Bogotá and Medellín. The distribution of Bogotá in the hedonic index contains more extreme values, but once we trim the figure the shape becomes similar although more disperse than that of Medellín. There is a difference in the levels between the two curves because the index is estimated using the log of house values for Bogotá and the log of rent values

[2] To estimate indexes by census sector, we use the nearest 200 neighbors to the centroid of each census sector, based on which we define a bandwidth for each census sector, with which we construct biweight kernels. We found similar results when using the nearest 400 neighbors.

[3] For a-theoretical QoL indicators, there already exist sophisticated indexes for Bogotá (presented in the previous sections) and Medellín, like the ones estimated by González et. al. (2004), and Castaño (2006) respectively. Both studies follow methodologies similar to the one developed in DNP (1997), namely, scaling of qualitative into quantitative variables, factor analysis for determining the relevant variables to include in the indicator, and the standard principal components procedure.

for Medellín. Both reported and estimated life satisfaction show that household heads from Medellín are happier on average and less disperse.

Figure 6. Distribution of QoL indexes of households for Bogotá and Medellín.



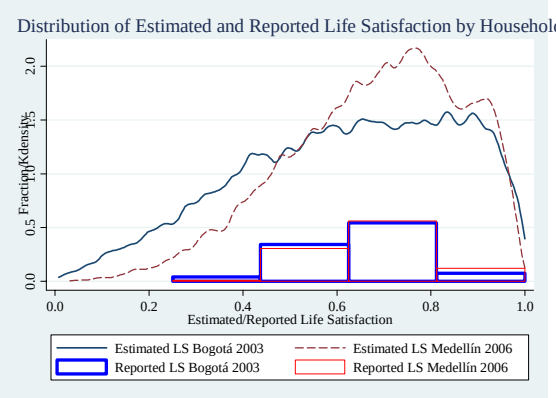
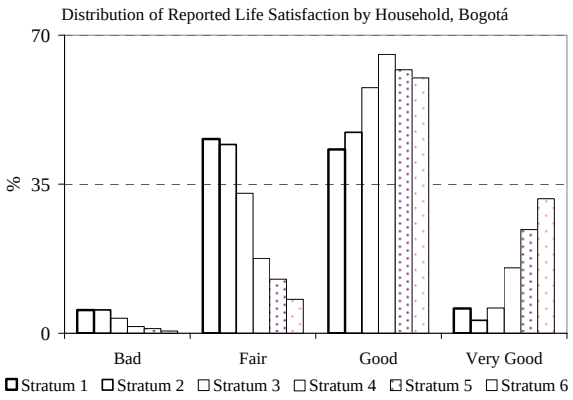
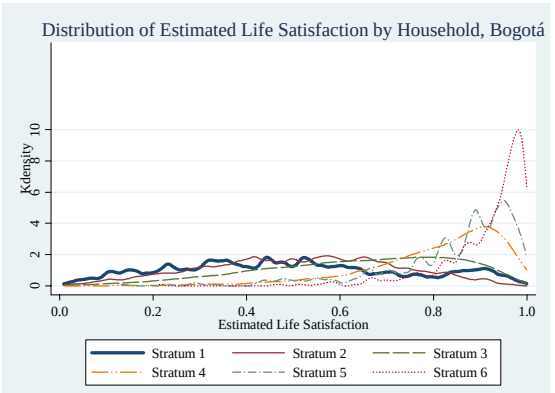
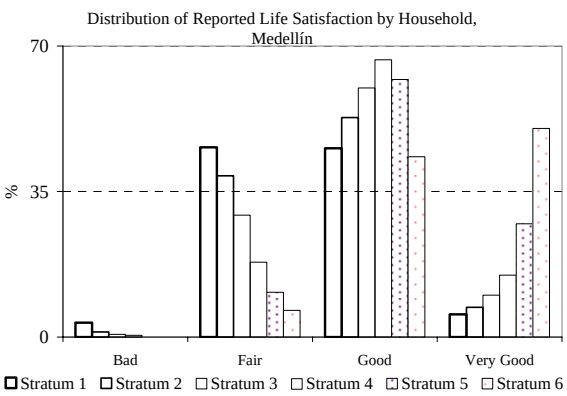


Figure 7 illustrates the distribution of reported and estimated life satisfaction by city and socioeconomic stratum. In both cities the levels of life satisfaction increase with socioeconomic stratum from averages of 2.5 at stratum 1 to 3.4 at stratum 6. The figure shows that the overall higher level of life satisfaction in Medellín is observed in each of the socioeconomic strata. Although mean differences in life satisfaction by stratum are small, they are still statistically significant for strata 2, 3 and 6, with higher life satisfaction in Medellín in these socioeconomic strata.

Figure 7. Distribution of Reported Life Satisfaction by Socioeconomic Stratum







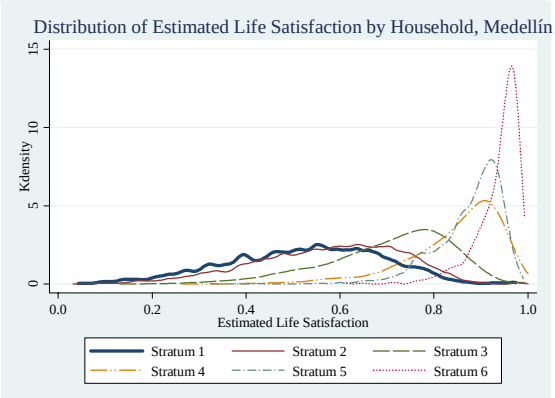
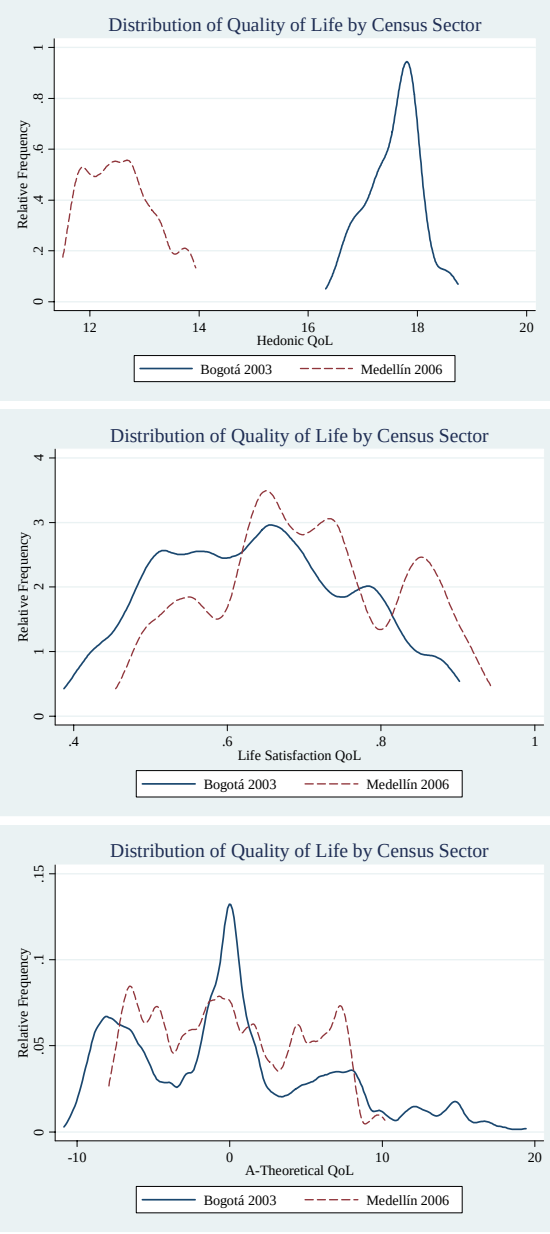


Figure 8. Distribution of QoL indexes of census sectors. Bogotá and Medellín



For both the hedonic and life satisfaction indexes, predicted values resemble the reported ones (actual house values/rents not shown). Once we aggregate these indexes into census sectors, we obtain distributions at the census sector level, which are shown in figure 8.

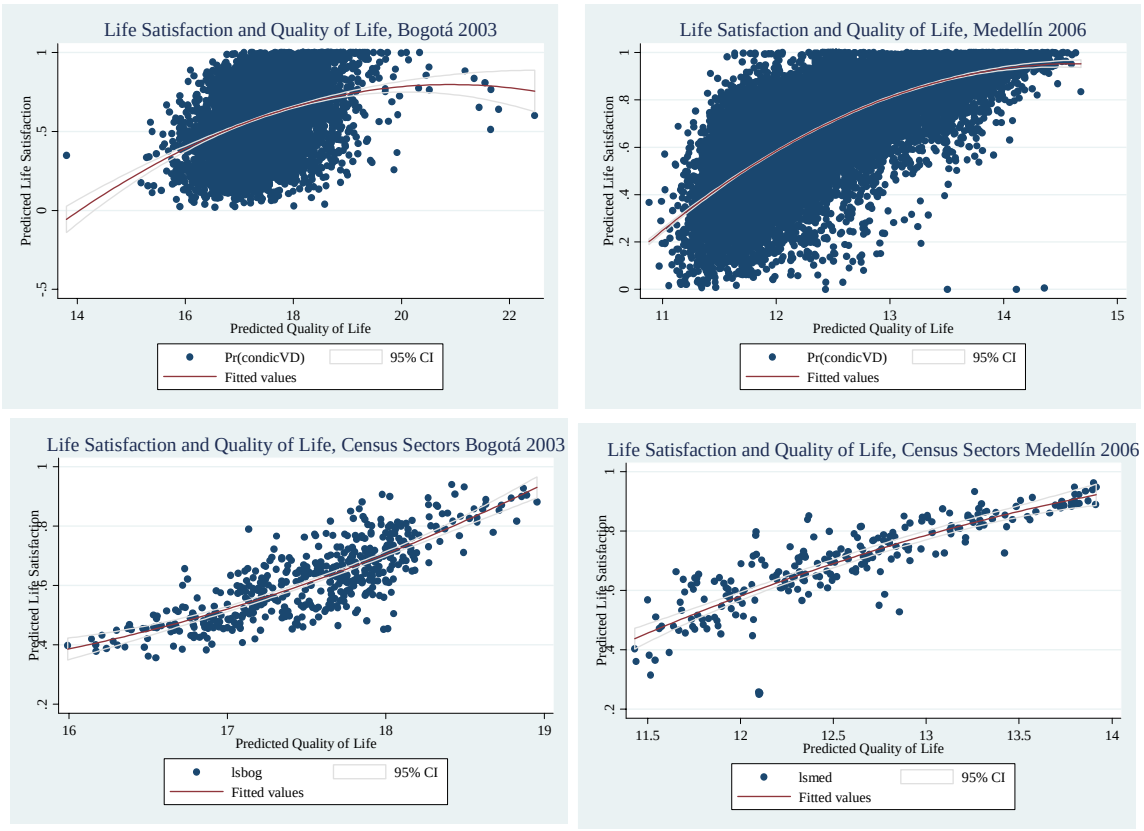
The graph at the top of figure 8 shows the distribution of the hedonic index when we use as unit of observation the average index at the census sector level rather than at the household level. In contrast to figure 6, it is Medellín's curve the one that looks more disperse now, suggesting that, relative to Bogotá, a good part of the dispersion observed in Medellín could be explained by between census sector differences rather than by within census sectors differences.

The graph at the middle of figure 8 shows the distribution of the life satisfaction index in this case. There again life satisfaction is on average higher and less disperse in Medellín.

The last graph in figure 8 shows the distribution of our A-theoretical QoL index based on the first principal component of the average levels by census sector of the covariates included in the hedonic regression estimated with house values. This index looks more disperse than the previous ones.

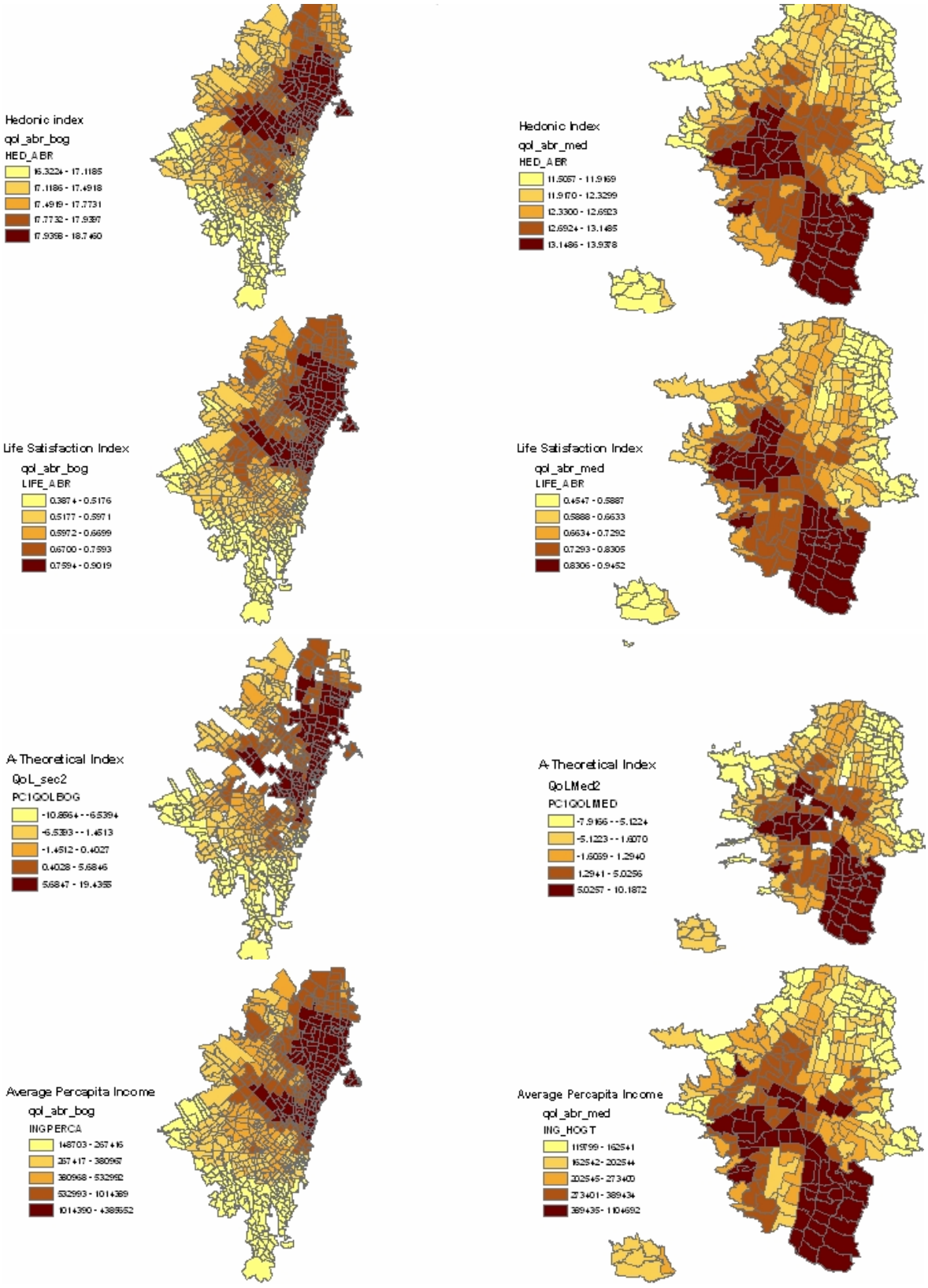
Both across households and across census sectors, the hedonic QoL is positively related to predicted life satisfaction, as it is shown in figure 9. The figure shows on the top the graphs for Bogotá and Medellín that relate predicted life satisfaction as a function of predicted QoL estimated with the hedonic model with household information, and at the bottom the respective graphs with information by census sector.

Figure 9. Comparing QoL and LS indexes of households and census sectors for Bogotá and Medellín

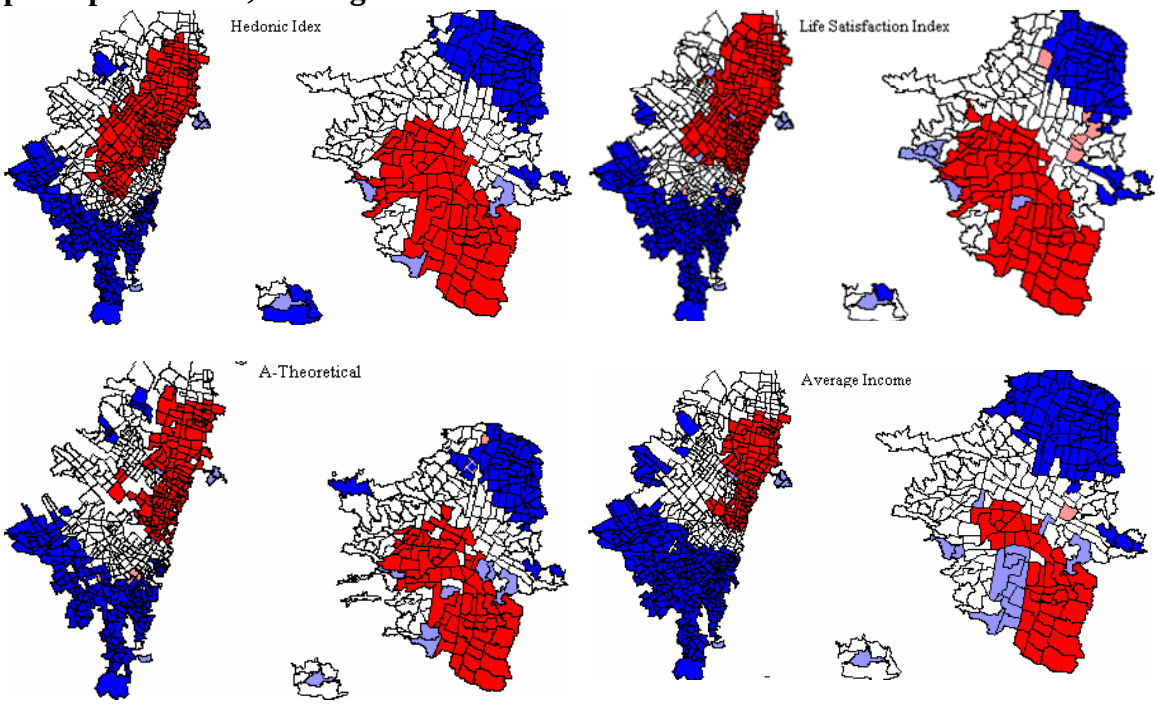


Map 10 illustrates the spatial distribution of QoL according to the hedonic, life satisfaction and A-Theoretical indexes, and additionally, it includes the spatial distribution of household per capita income. There are important similarities among the three QoL indexes, all of which reveal a highly segregated pattern of high versus low QoL neighborhoods, as it is confirmed by the local Moran estimates illustrated in map 11. As map 11 shows, each city is basically divided between two cities, one with high QoL (the red ones) and another with low QoL (the dark blue), separated by a group of neighborhoods with mixed level of QoL. The maps with the quintiles and clusters of per capita income are highly related to the maps of the QoL indexes. In map 11 though, it can be observed a blue cluster located at the southwest of the city, implying the existence of a neighborhood of households with below average levels of per capita income, surrounded by households with above average levels. Despite their having below average income levels, those households seem to be as well off as the better off households of the city according to our QoL indexes.

Map 10. Quintiles of Hedonic, Life Satisfaction, and A-Theoretical QoL indexes, and Average per capita Income, for Bogotá and Medellín.

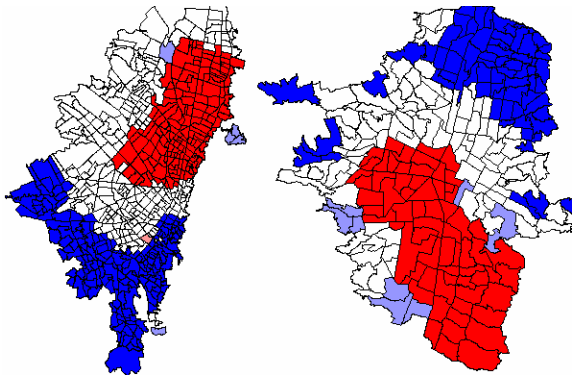


Map 11. Clusters of Hedonic, Life Satisfaction and A-Theoretical QoL indexes, and per capita income, for Bogotá and Medellín



Map 11 shows that the cluster with the highest levels of income in Bogotá and Medellín are smaller than the clusters with the highest levels in our QoL indexes shown in their respective maps, while the cluster with the lowest levels of income in these cities are larger than their respective QoL counterparts. This regularity goes in line with a distribution of income much more unequal than the distribution of variables than determine QoL in these cities.

Map 12. Clusters of stratification



To highlight the importance of socioeconomic stratification in Colombia, we present map 12 which shows the clusters of socioeconomic strata in Bogotá and Medellín. Even though we do not know whether had not stratification been put in place several years ago we would have today higher or lower levels of spatial segregation, we can show to what extent current spatial segregation is associated to socioeconomic stratification in Bogotá and Medellín. As it becomes clear, the similarities found from comparing maps 11 and 12 are striking.

Global Moran indexes for our QoL indexes and per capita income are shown in table 9. All variables shown in the table have higher levels of spatial autocorrelation in Bogotá than Medellín, and each of them is in turn larger that the values reported in table 3 for all

variables included there but for the share of households with piped gas in Medellín, which actually has a larger spatial autocorrelation that per capita income in that city. Not surprisingly, given the evidence previously presented, the levels of segregation of the socioeconomic strata continuous variable is similar to those of our QoL indexes for each city.

Table 9. Global Moran indexes for QoL indexes and household per capita income.

Variables	Bogotá			Medellín		
	Rank	I (Moran)	p-value	Rank	I (Moran)	p-value
PC1QoLBog	1	0.836	0.0001	3	0.642	0.0001
LSBog	2	0.834	0.0001	2	0.686	0.0001
QoLBog	3	0.831	0.0001	1	0.688	0.0001
Per capita income	4	0.769	0.0001	4	0.586	0.0001
Socioeconomic strata (continuos variable: 1 to 6)		0.838	0.0001		0.629	0.0001

8. Discussion and Conclusions

The first empirical regularity that emerges from this article and previous Colombian literature in this topic is that the main two Colombian cities are highly spatially segregated. Household are spatially segregated according to their education levels and access to education, coverage of public services, and households headed by women among other variables. In addition, we complement previous evidence for Bogotá provided by Gaviria et al. (2008) with evidence for Medellín, that households are spatially segregated according to key demographic variables. Not only are households segregated according to their current levels of adolescent pregnancy, but also they are highly segregated according to a proxy variable for households emerging from adolescent pregnancy. In addition, social phenomena like crime, measured by the homicide rates at the census sector level, present as well clusters of higher incidence in these cities. Not surprisingly, our estimated quality of life indexes resemble the mentioned segregation patterns in each city. We present estimates of spatial agglomeration that show the statistical significance of this phenomenon for each of the variables enumerated.

The importance of the average level of education at the census sector level to determine house prices is striking, mostly given the huge segregation found in Bogotá and Medellín. We show that neighborhoods are currently segregated according to education levels, and also that given segregation in enrollment rates at all levels of education, this pattern is likely to prevail for most neighborhoods. The importance of this variable in determining life satisfaction is much more limited than to determine house values in the case of Bogotá, and it is not even significant in the case of Medellín. On the other hand, in Medellín the importance of socioeconomic strata is very high in both hedonic and life satisfaction models, while in Bogotá they only determine QoL according to the hedonic model. We provide preliminary evidence that socioeconomic strata in Medellín affects life satisfaction through unobservables related to those fixed effects, and given our rich battery of controls, and our test based on a sub sample of households located close to the boundaries of their socioeconomic strata, we hypothesize that their effect might have subjective grounds, possibly linked to households' culture, their social networks or any form of social stigma.

Various studies have analyzed the importance of average education of neighborhoods for people at the moment they are choosing where to live. Average education is often taken as a proxy for socioeconomic status that is considered by households for location purposes, as it is assumed by Bayer et al. (2005). It is also a source of complementarities and various externalities that are anticipated by households to affect current and future socioeconomic outcomes of their members, as it is studied by Bayer et al. (2005), Benabou (1996a, b), Borjas (1995, 1998), Cutler and Glaeser (1997), and Kremer (1997), among others. Finally, to the extent that households that differ in education are also likely to differ in other dimensions (not only class, but also habits, culture, race, etc.), it is likely to be linked to segregation by tipping, the one that places cut off levels to these variables up to which they would rather leave the neighborhood rather than staying sharing with their neighbors, as it was formerly modeled by Schelling (1969, 1972).

The challenged posed by the segregation according to education has an additional ingredient in the Colombian cities: the existence of the socioeconomic stratification

mechanism to target public social subsidies. Socioeconomic stratification in addition, is among the most important determinants of house values, as it is shown in tables 4A and 4B, and it is as well among the most important in determining life satisfaction in Medellín. Given that even in the absence of this targeting mechanism it is difficult to reverse segregation, once the mechanism takes part of the picture the problem seems much more irreversible. There is need for policies to equalize education and several other key variables across neighborhoods of the main Colombian cities, but a large part of any effort that could be exerted to achieve equalization of education or other characteristics, is going to be severely limited by the socioeconomic stratification mechanism that has been working in these cities for decades.

We also compare hedonic models for Bogotá and Medellín. Bogotá is better endowed than Medellín in the variables included in the analysis, in particular, it has higher education levels, and additionally, education is more equally distributed within census sectors. Bogotá has also a much better targeted supply of gas, and has in general houses with better conditions.

The hedonic models based on house values and life satisfaction approaches used in this article lead to similar conclusions in the aggregate when comparing their implied quality of life indexes. Although each approach allows us to determine the key specific determinants of QoL, and these are not always the same, the information contained in their implied aggregated indexes suggest that these factors are just different faces of the same story.

From a policy perspective, the evidence suggests that redesigning the current socioeconomic stratification system in a way that still allows reaching the poorest while preventing segregation to deepen, might be the most important challenge to face in order to improve quality of life in main Colombian cities.

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Annex 1. The Questionnaire and its Methodology

A1.1.1 Population

The target population is composed of men and women, 18 years old or older, of socioeconomic levels 1 through 6, who live in Bogotá.

A1.1.2 Sample Size

We propose a probability sample using telephone interviews to households in Bogotá. To be able to obtain results for each of the 20 localities in Bogotá, we propose 96 interviews per locality for a total of 1920 interviews for Bogotá.

The sample size per locality gives us a sample error of 10% with a 95% confidence level, assuming p=0.5. The overall sample error for the 1920 interviews is 2.2% with a 95% confidence level.

The sample for each locality will be distributed on the six socioeconomic levels (Estrato 1 through 6) according the weight of each socioeconomic level in the population of the locality.

A1.1.3 Sample Frame

The sample frame to be used in the proposed research includes the phone books with all the residential phone numbers of Bogotá. The Centro Nacional de Consultoría maintains a database with all phone numbers and their associated locality and socioeconomic level, so the sample can be done for each locality-estrato.

The telephone penetration in Bogotá is relatively high, so a survey using telephone interviews includes most of the households that live in the city (around 90%) (see table below).

Socioeconomic level (Estrato)	**Total Households**	**% with telephone**
Stratum 1	114.239	78.8%
Stratum 2	568.032	84.5%
Stratum 3	739.901	92.2%
Stratum 4	220.419	98.1%
Strata 5 and 6	139.212	99.2%
Total	1.781.802	89.8%

Source: Encuesta de Capacidad de Pago 2004.

A1.1.4 Sample Selection

The sample selection uses a multistage process. First, we select phone numbers using the lists of households per locality-estrato, and then we select people within the household to interview. The selection stages will be conducted as follows:

Household Selection: On each locality-estrato, phone numbers are randomly selected. If there is no answer or the telephone number is busy, then the CATI (Computer Aided Telephone Interviews) system will try to contact the households for at least 3 times.

Individual Selection: The field interviewer will take the names of all the male or female members of the household 18 years old or older. The person to be interviewed will be selected randomly by the CATI software.

A1.2 Survey Work Plan

A1.2.1 Questionnaire Design Phase

The Centro Nacional de Consultoría will design a questionnaire to be used in the field for data collection and will develop field manuals for interviewers and supervisors.

In order to test the questionnaire and manuals, the Centro Nacional de Consultoría will perform a pilot test to verify the flow of questions, the clarity of the questions and the length of the survey.

Note: We estimate that the questionnaire for this project to be include 8 questions and take less than 5 minutes to complete.

A1.2.2 Interviewer and Supervisor Selection Phase

The selection of interviewers and supervisors will consider the following criteria:

- Experience as interviewer for similar research projects and 1 year as interviewer
- High school and college education (partial or completed)
- Excellent interpersonal skills
- Excellent oral, written and reading skills
- Patience, tolerance, and good manners

The criteria for selecting field supervisors for this research project are the following:

- Leadership skills
- Two years of experience managing people and supervising fieldwork
- High school and college education
- Initiative and problem solving capabilities
- Ability to receive and transmit instructions

A1.2.3 Training Phase

The field coordinator will provide the training to all interviewers and supervisors that participate in the project. The training will cover theoretical as well as practical aspects of the work. The training will also cover the instructions on how to complete each chapter of the questionnaire.

A1.2.4 Field Work Phase

The telephone interviews will be completed using the call center of the Centro Nacional de Consultoría in Bogotá, with the CATI (Computer Aided Telephone Interviews)

system. The CATI controls the interviewing process, displaying the questions to the interviewers, recording the answers and making the appropriate validations.

Supervisors are simultaneously listening the interviews, verifying that the way the interviews are being conducted. The supervision is transparent to the interviewee and to the interviewers.

The Centro Nacional de Consultoría will present weekly reports on the progress of the fieldwork, including statistics on the number of interviews completed, number of interviews remaining, number of supervised interviews, etc.

A1.2.5 Coding and Data processing Phase

The coding phase includes the coding open ended questions, by assigning numbers to each class of answer.

The data processing will be completed using QUANTUM and SPSS, two powerful statistics software packages for processing surveys. Both packages are very flexible and produce tables that are easy to read and analyze.

The cross tabulation that can be generated for the project could include:

- Total population
- Per locality
- Per sex, age or education level
- Per socioeconomic level
- Any other demographic variable that influences the responses of the population

A1.3 the Questionnaire

1. En una escala del 1 al 10, donde 1 es muy poco satisfecho y 10 es muy satisfecho, ¿Cuán satisfecho esta usted con los siguientes aspectos del barrio en el cual vive actualmente? [Grade 50]

	Aspectos	**Puntaje**	**Aspectos**	**Puntaje**
a.	Cantidad de parques/áreas verdes [G: IDB 24]		d. Facilidades de transporte público [G: WP91]	
b.	Calidad del aire [G: WP94]		e. El flujo de tráfico vehicular [G: IDB 21]	
C	Servicio de recolección de basura		f. Seguridad	

2. Esta usted satisfecho o insatisfecho viviendo en el barrio en el cual vive actualmente. [G: WP83]

Satisfecho	**Insatisfecho**	**(No Sabe)**	**(No Responde)**
1	2	3	4

3. Considera que el barrio en la cual usted vive actualmente es un Buen lugar para vivir? (Encuestador: lea todas las opciones) [G: 39a]

Es un Buen Lugar	No es un Buen Lugar	No Sabe	No Responde
1	2	3	4

4. Considera que el barrio en la cual vive actualmente está mejorando o empeorando como lugar para vivir? **(Encuestador: no lea la opción 2)** [G: 35a]

Mejorando	(Igual)	Empeorando	(No Sabe)	(No Responde)
1	2	3	4	5

5. Considerando todos los aspectos, qué tan satisfecho está usted con su vida actualmente? Use una escala de 0 a 10, donde 0 es insatisfecho y 10 es satisfecho. [G: WP4656]

10	Satisfecho	4	
9		3	
8		2	
7		1	Insatisfecho
6		98	(No Sabe)
5		99	(No Responde)

6. Imagine una escala de 10 peldaños, en la que en el escalón 1 se ubican las personas con la más baja calidad de vida y en el 10 se ubican las de más alta calidad de vida, ¿dónde se ubicaría usted? [LB: P9STA]

10	Más alta Calidad de Vida	4	
9		3	
8		2	
7		1	Más baja Calidad de Vida
6		98	(No Sabe)
5		99	(No Responde)

7. ¿Usted se considera pobre? [ECV03: M12]

1		**Si**
2		**No**

8. Por falta de dinero, algún miembro del hogar no consumió al menos una de las tres comidas (desayuno, almuerzo, comida), uno o más días de la semana pasada? [ECV03: M20]?

Siempre	Algunas veces	Rara vez	Nunca
1	2	3	4

9. Actualmente las condiciones de vida en su hogar son: [ECV03: M04]

1		**Muy buenas**
2		**Buenas**
3		**Regulares**
4		**Malas**

10. Está usted satisfecho o insatisfecho con su vivienda, o lugar en el cual vive actualmente? [G: WP29]

Satisfecho	**Insatisfecho**	**(No Sabe)**	**(No Responde)**
1	2	3	4