Borradores de ECONOMÍA

Quality of Life in Urban Neighborhoods in Colombia: The Cases of Bogotá and Medellín□□□

Por:Carlos Medina, Leonardo Morales y Jairo Núñez

No. 536
2008

tá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Col

BANCO DE LA REPÚBLICA
COLOMBIA

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

Carlos Medina[*]
Leonardo Morales[**]
Jairo Núñez[***]

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 and present evidence that the main two Colombian cities are highly 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. Not surprisingly, our estimated quality of life indexes resemble the mentioned segregation patterns in each city. We present evidence that the spatial agglomeration is statistically significant 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 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 rank the specific determinants of quality of life, and these determinant depend on the approach, their implied aggregated indexes suggest that they 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 among the most important challenge to face in order to improve quality of life in main Colombian cities.

[♣] This study was co-funded by the Interamerican Development Bank and developed as part of one of its Research Network projects. We thank Eduardo Lora, Andrew Powell, Pablo Sanguinetti, and Bernard M.S. van Praag for detailed comments to previous versions, and participants of the meetings of the study "Quality of Life in Urban Neighborhoods in Latin America and the Caribbean", of the Research Network of the Research Department of the Inter-American Development Bank for comments. We also thank seminar participants at the *Banco de la República* in Bogotá and Medellín for comments, and Francisco Lasso for assistance.

[*] Researcher, *Banco de la República de Colombia*, Medellín Branch. cmedindu@banrep.gov.co
[**] Researcher, *Banco de la República de Colombia*, Medellín Branch. lmoralzu@banrep.gov.co
[***] Researcher, *Centro Nacional de Consultoría*. jnunez@cable.net.co

Key words: Quality of Life, Life Satisfaction, Happiness, Segregation, Hedonic Models, Public Goods.

JEL Codes: D60, H7, I3, J0, J1

Resumen

Con base en datos para Bogotá y Medellín se describen varios indicadores de calidad de vida y se ilustra su segregación espacial a nivel de sector censal. Se presenta evidencia de que estas ciudades están muy segregadas espacialmente de acuerdo a la educación de su población, la cobertura de los servicios públicos, los hogares con jefatura femenina y otras variables como la fecundidad adolescente. Nuestras estimaciones de calidad de vida a nivel de sector censal reflejan los patrones de segregación descritos. Se presenta evidencia de que la segregación especial es estadísticamente significativa para cada una de las variables enumeradas.

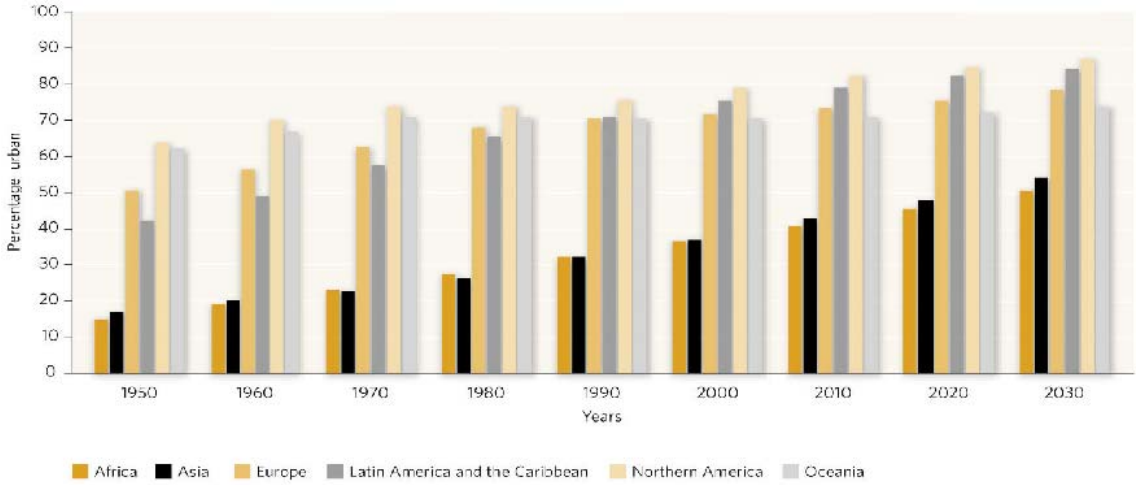
Se estiman modelos hedónicos del valor de la vivienda y la satisfacción subjetiva de los hogares para cada ciudad y se encuentra que el promedio de educación en el sector censal es muy importante al momento de determinar el valor de la vivienda. Se comparan los resultados de las estimaciones para Bogotá y Medellín y se encuentra que Bogotá está mejor dotada que Medellín en las variables consideradas en el análisis, en particular, tiene niveles más altos de educación, y adicionalmente, la educación se encuentra distribuida en forma más equitativa al interior de los sectores censales. También tiene mejor acceso a gas domiciliario, y sus viviendas tienen mejores condiciones. Los modelos de calidad de la vivienda y de satisfacción con la vida generan índices de estándares de vida muy similares. Aunque ambas aproximaciones nos permiten rankear los determinantes de la calidad de vida, y éstos dependen de la aproximación utilizada, los índices estimados con base en las mismas sugieren que ellas son solo dos caras de la misma historia.

Desde una perspectiva de política, la evidencia sugiere que rediseñar el actual sistema de estratificación de una forma que aun permita alcanzar a los más pobres mientras se evita que la segregación se agudice, podría ser uno de los retos más importante a enfrentar con el objeto de mejorar la calidad de vida en las principales ciudades de Colombia.

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 was 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 countries, LAC, went through the 50% threshold during the 1960s, moving 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



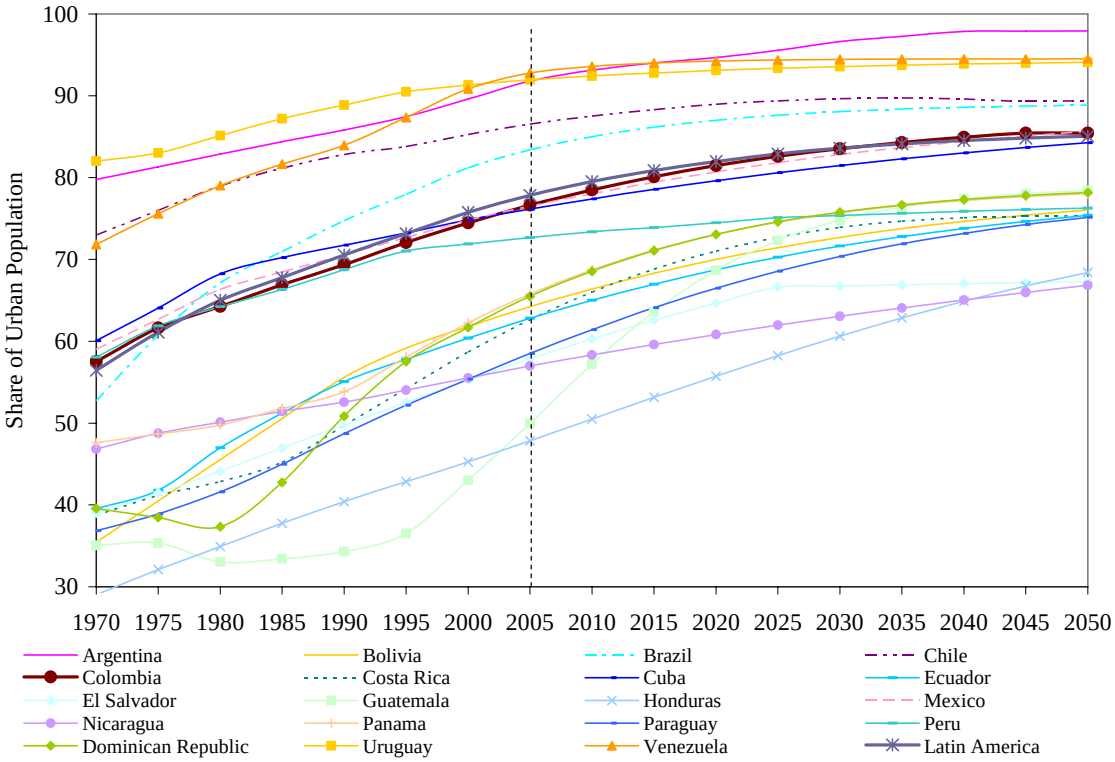
Source: UNFPA (2007)

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.

According to figures published by CELADE, South America had in 2000 35 cities with more than one million inhabitants, although there were just five cities in 1950. Brazil, with 16 cities, was the country with more cities in that set; next, there were Venezuela and Colombia, with four cities each. The four Colombian cities were Bogotá, Medellín, Cali and Barranquilla, which together accounted 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).

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

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



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. Section 4 presents hedonic models based on property values to get estimates of quality of housing, QoH, and section 5 presents hedonic life satisfaction models that allow us to estimate QoL across neighborhoods 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 and policy implications.

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 and official records, to get 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 5).

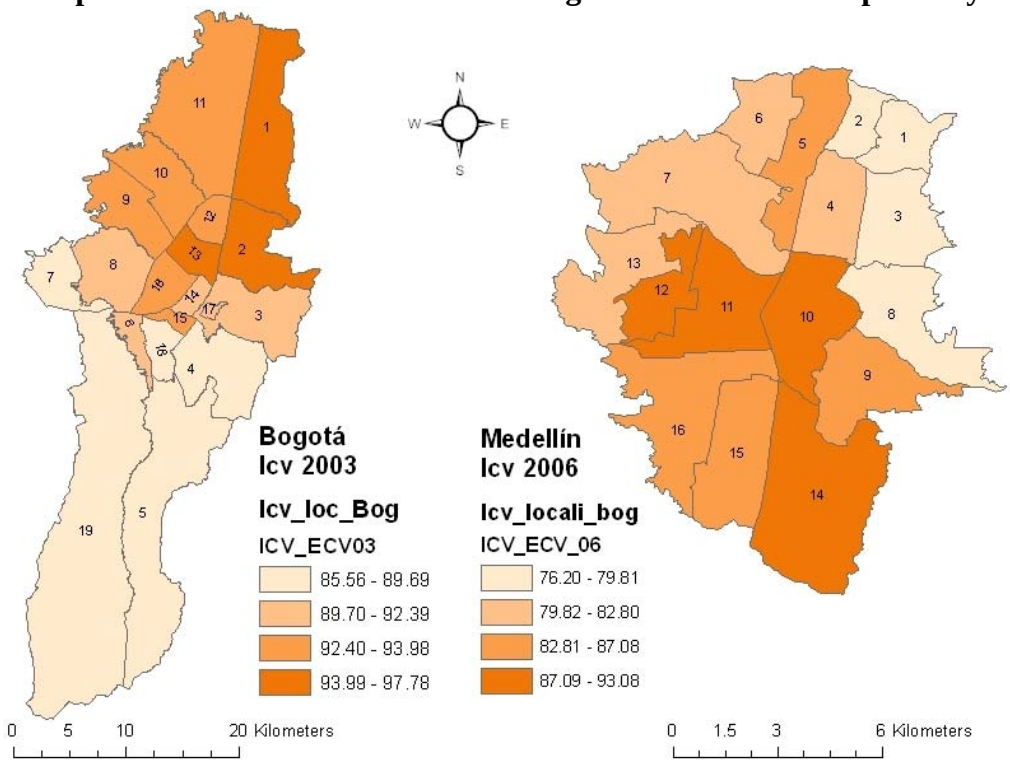
Data for Medellín

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] Estimates based on Colombia's 2005 Population Census.
[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] Urban areas are split into six socioeconomic strata in which, the first one with the lowest QoL levels.

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 (See map 2). 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 5).

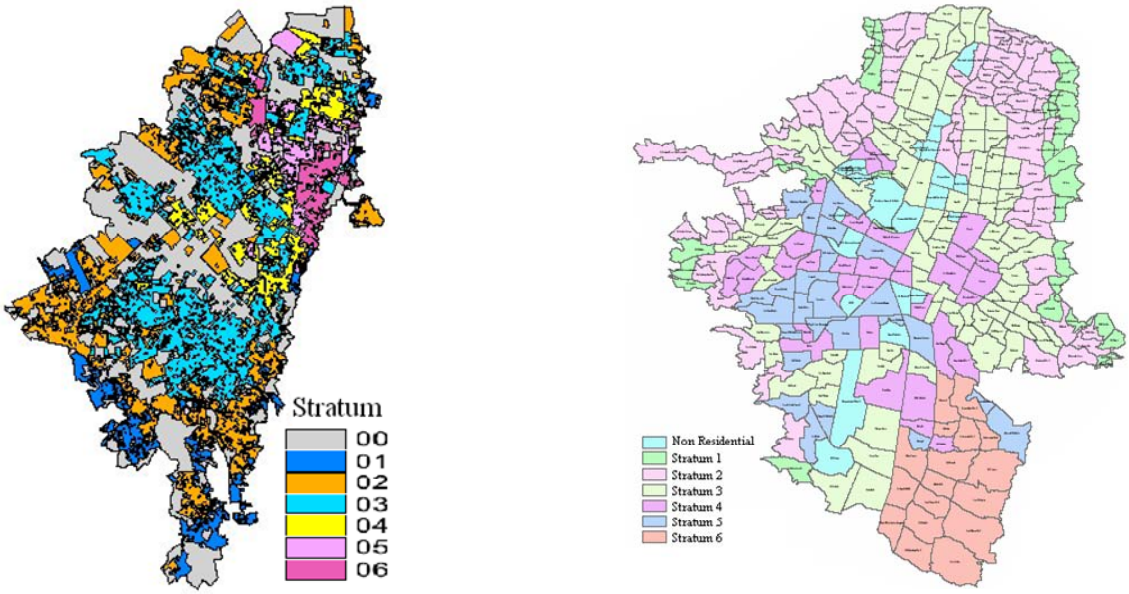
Map 1. *Localidades* and *Comunas* of Bogotá and Medellín respectively.



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.

Variables related to Quality of Life

The list of variables related to quality of life and their grouping is shown in annex 1. 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. Annex 1 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, forest), hydrography (rivers, humid soils), massive transportation systems (*Transmilenio* for Bogotá and *Metroplus* and the metro for Medellín), use of land, and perspectives for use of land -POT-.[8] Descriptive statistics of the variables that were ultimately used in the empirical exercises are reported in annex 2.

[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.

3. Statistical Analysis of QoL of Neighborhoods

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.[9] 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 2 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.

[9] 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 2. 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

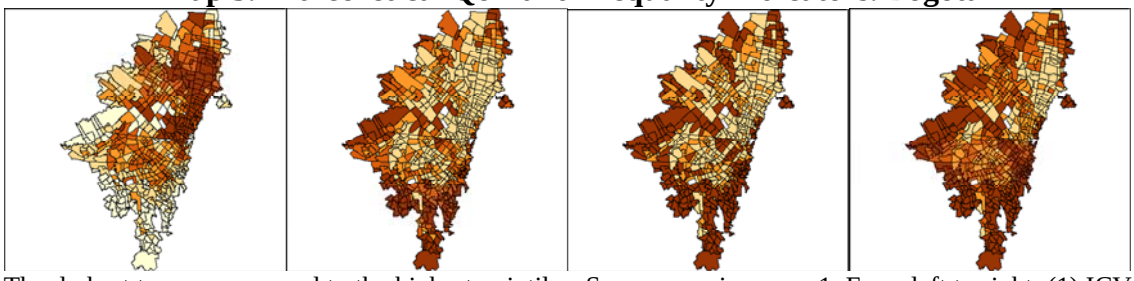
Map 3 shows quintiles of some a-theoretical QoL indicators: the denominated indexes of "Quality of Life", ICV, "Unsatisfied Basic Needs", NBI, "Misery", and the Gini of education, which measures the inequality in the distribution of the years of education in each census sector.

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.[10]

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 annex 1. From left to right: (1) ICV, (2) NBI, (3) Misery, (4) Gini coefficient of the years of education.

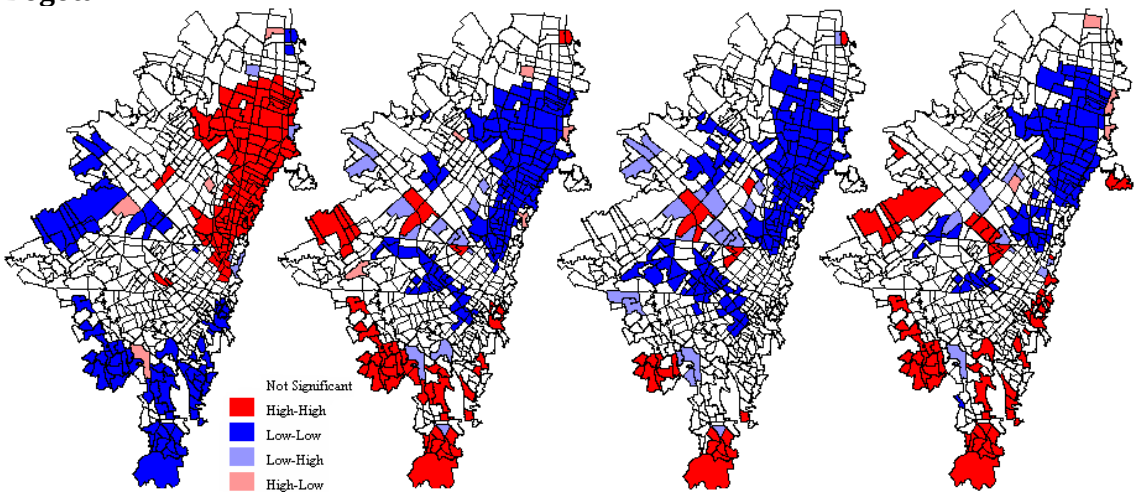
The map illustrates a very consistent pattern among the ICV, NBI and Misery indicators in which the poorest are consistently located over the southern and western census sectors of the city, and those better off are located in the sectors that match the highest socioeconomic strata in map 2. In addition, 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.

[10] See DNP (1997)

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



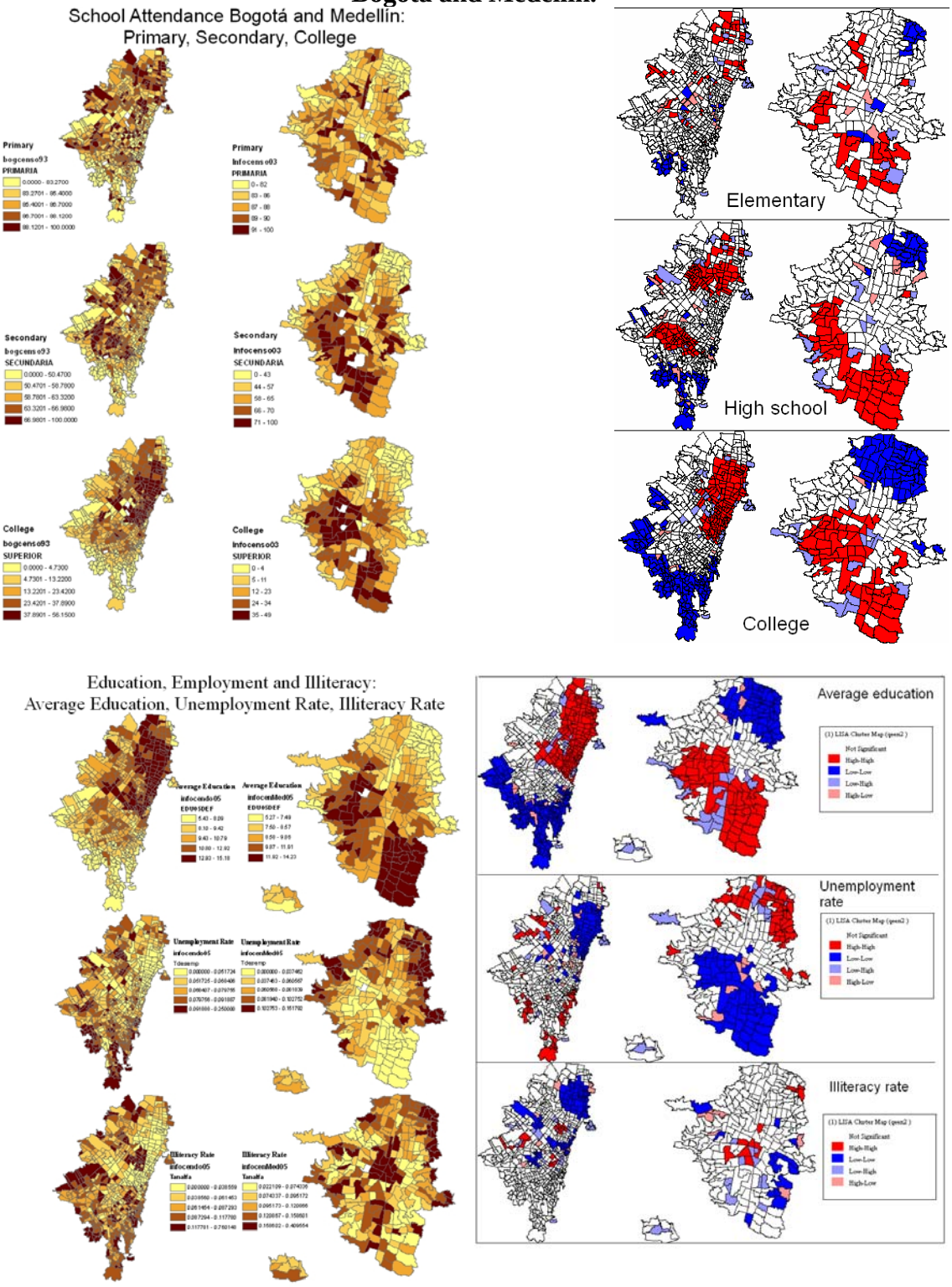
See sources in annex 1. ICV, (2) NBI, (3) Misery, (4) Gini coefficient of the years of education

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.

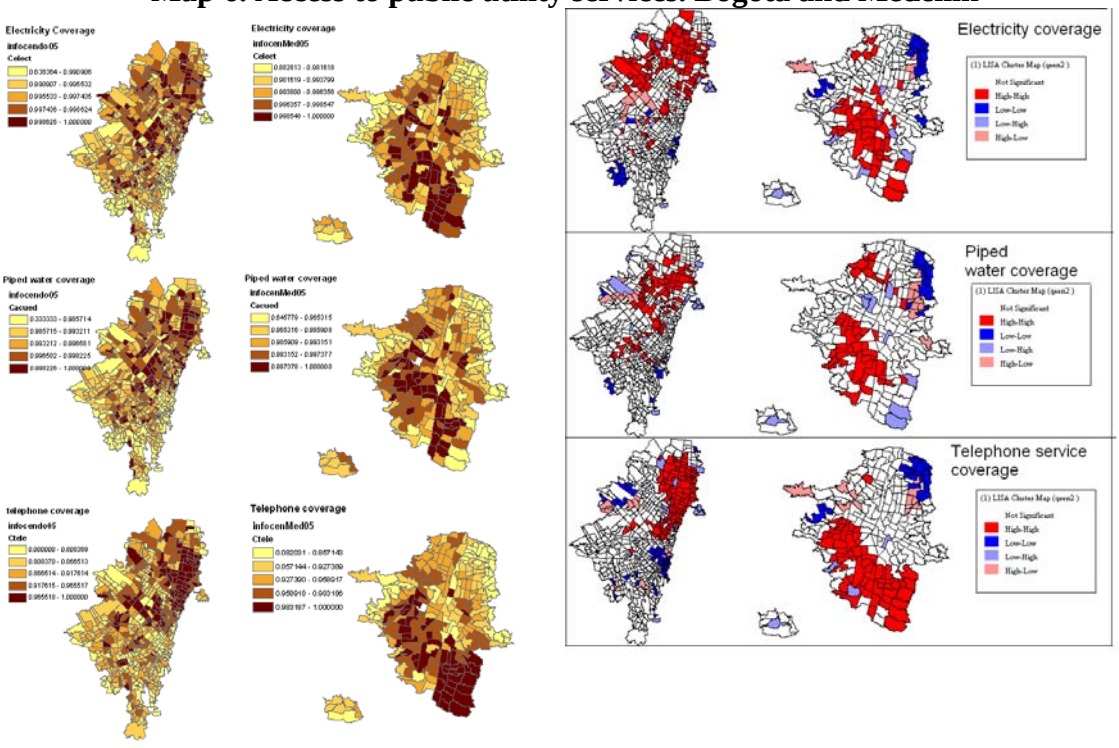


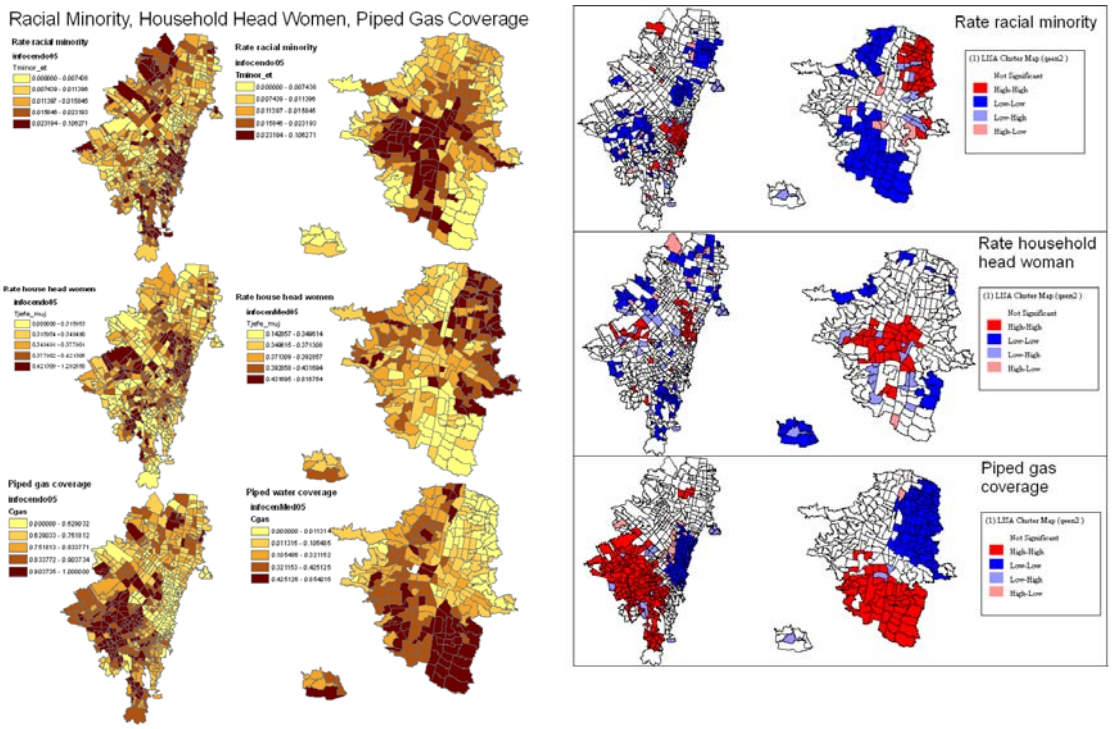
3.3 Public utility services

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

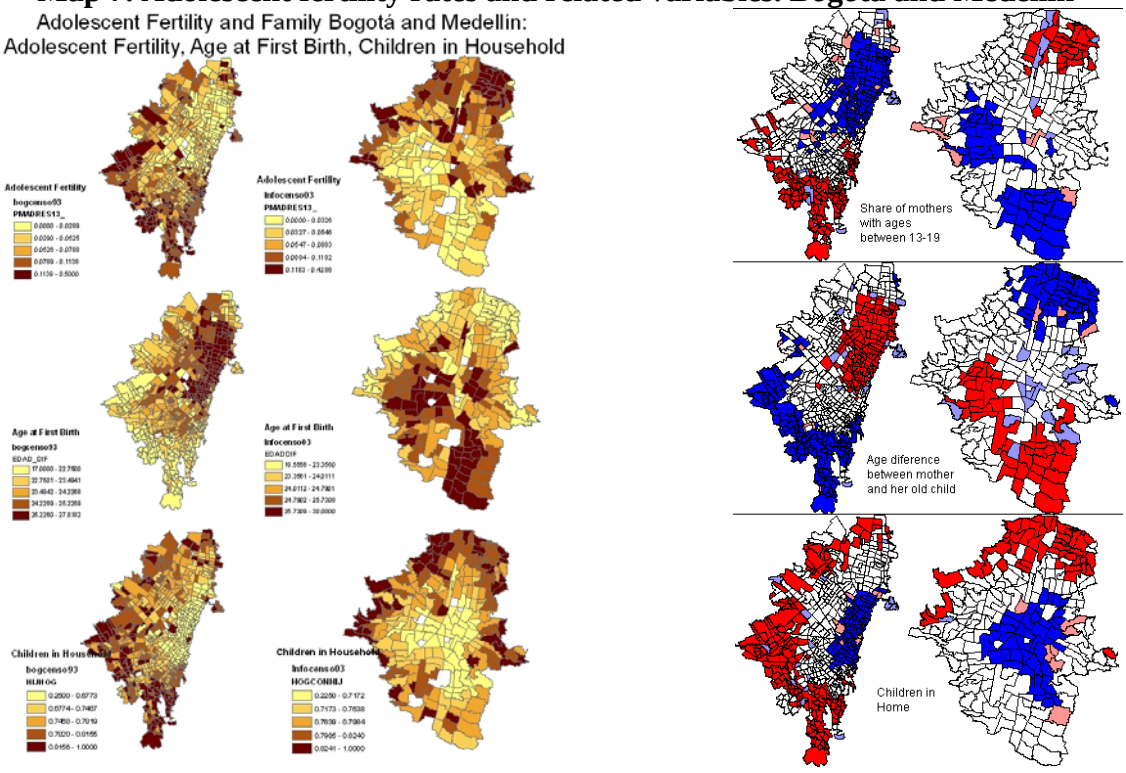




3.4 Reproductive and sexual health

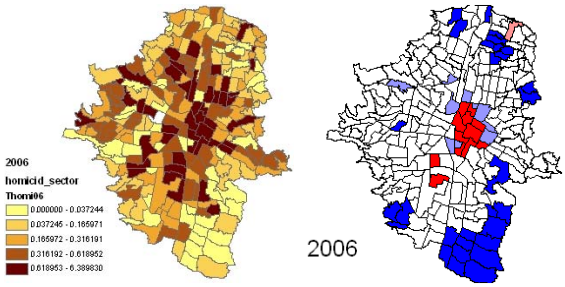
Spatial segregation of households according to variables related to reproductive and sexual health had been previously documented for Bogotá by Gaviria et. al. (2008). Here we complement their results with the ones for Medellín. Map 7 presents evidence of spatial segregation according to all of the variables 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. Hedonic prices approach to infer prices of characteristics

In this section we estimate standard hedonic models to infer the prices of housing characteristics and amenities, which will be used in chapter 6 to construct indexes of quality of housing, QoH.[11] 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 house i variables, and A_j is a vector of amenities in census sector j. 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 variables bias problem, the most common in these cases. Implicit prices of housing characteristics and amenities can be gotten by linearization of the hedonic regression, leading to linearized coefficients,

$$\alpha_X \overline{P}, \forall X \quad (2)$$

which are used to obtain the monetary value of each of the i housing characteristics and amenities, according to $\alpha_{1i} \overline{P} \cdot \overline{H_i}$ and $\alpha_{2j} \overline{P} \cdot \overline{A_j}$ respectively, where $\overline{P}$, $\overline{H_i}$, and $\overline{A_j}$ are average values of house values, house characteristic i, and amenity j, respectively.

4.1 Results for Bogotá

Our data for Bogotá allows us to estimate hedonic equations using cadastral values of houses, which we can complement with reported prices by household owners. Table 3A 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 first panel of the table presents the results of estimating this equation using the cadastral value, and the second panel increases the number of observations by including those households that could not be matched to cadastral data, but reported the value of their houses.

For both 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 not statistically significant at the 90% level of confidence.[12] Each panel has five columns that contain the estimated coefficients, their t statistic, 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 estimated implicit prices and monetary values.

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

[11] See Rosen (1974) for more details on hedonic regressions.

[12] We begin with a model that includes all variables in annex 1 related to housing or neighborhood characteristics.

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 supply, schools per capita, and surprisingly, to average illiteracy rate.[13] House values are also higher if there is no terminal of ground transportation in the neighborhood, with lower homicide rates and attacks against life, lower inequality of education, distance to universities, lower unemployment rates, and lower shares of female heads of household among others.[14]

We include the distance to the nearest *Transmilenio* 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.[15] 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 residential (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.[16]

On the other hand, the results obtained when we use the extended data that includes both cadastral and household's reported property values are very similar to the ones described.

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 3A and then we

[13] Clearly, this coefficient should be negative and the one of piped gas coverage positive –rather than negative-, which suggests they might be capturing the presence of unobserved characteristics not accounted for in the regression.

[14] 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.

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

[16] 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*.

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 3A presents the standardized beta coefficients. These coefficients allow us to compare the importance of the different control variables, since it quantifies how many standard deviations change the house value when each control variable is increased a one standard deviation. Thus, 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 constructed area would imply nearly 0.43 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 0.19 standard deviations in the average value of its houses. [17] 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 0.16 standard deviations in the house value. The most important variable according to this criteria would be the constructed area, a house variable, 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.[18]

The next variables in terms of their importance are the area of land and the number of rooms, which increase house values in 9.4 and 5.2 percent of a standard deviation if either was increased a one standard deviation.

The share of female household heads in the census sector, the distance to the nearest university, and having a garden in the house, affect the house value in the range of 4.3 and 4.8 percent of a standard deviation. It is important to highlight that not only the level, but also the inequality in the distribution of education, as measured by the Gini coefficient of education of the census sector, are relevant variables (an increase of one standard deviation in the Gini of education of the census sector would decrease the value of the house 3.5 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

[17] Since the shares of households in all socioeconomic strata must always add up to one, think of having a marginal change of 0.43 times a very small fraction of a one standard deviation of the house price caused by a change of the same very small fraction of a one standard deviation in the share of households in stratum 4, compensated with a reduction of the same magnitude in the share of households in stratum 1, and maintaining the shares of households in the other strata equal.

[18] 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.

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. [19]

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.[20]

Table 3B 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.

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%.[21]

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.

Implicit prices and monetary value of characteristics

The implicit price of the variables and their monetary value estimated according to equation (2) (columns 4 and 5 in each panel), show that the largest monetary value capitalized in house values is due to the average education in the census sector,

[19] For rents (results not reported), 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.

[20] 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 $\sum_k s_k(\sigma^2) = R^2$. A similar approach is followed by Fields (2002).

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

followed by constructed area, the availability of potable water and the share of female heads of household. Notice that the important monetary value of stratum 3 despite is lower (when compared to the higher socioeconomic strata) implicit price, is explained by the huge share of houses in that stratum (43%, versus 10%, 4% and 3% in strata 4, 5 and 6 respectively).

Table 3A. Hedonic regression for Bogotá, 2003

Variable	Log of cadastral values[1]					Log of cadastral values or reported by hholds[2]				
	Number of obs 8868			R-squared 0.7963		Number of obs 10832			R-squared 0.5657	
	Coefficient	*t*	beta	Implicit P (USD $)	Value (USD $)	Coefficient	*t*	beta	Implicit P (USD $)	Value (USD $)
Number of rooms	0.0354	10.12	0.0519	661	2,264	0.0540	10.98	0.0772	1,043	3,570
House with piped gas service						0.0993	3.05	0.0421	1,918	1,342
Household cocks with piped gas						-0.0706	-2.27	-0.0311	-1,363	-898
Bad quality of garbage collection service						-0.0920	-2.18	-0.0144	-1,776	-52
Bad quality of fixed phone line service						-0.0768	-3.13	-0.0160	-1,483	-76
House with garden	0.0928	8.48	0.0436	1,732	742	0.1671	12.69	0.0779	3,228	1,382
House with court yard	0.1160	3.75	0.0227	2,166	99	0.1554	4.16	0.0303	3,002	137
House with garage	0.0860	7.49	0.0368	1,606	487	0.0938	6.43	0.0408	1,811	550
House with terrace						0.1700	11.71	0.0680	3,283	749
House	-0.0890	-6.33	-0.0417	-1,663	-685	-0.1825	-12.99	-0.0851	-3,525	-1,451
House with potable water service	0.3096	3.46	0.0234	5,783	5,728					
High quality floor material	0.0401	2.86	0.0147	749	613	0.1062	5.70	0.0383	2,052	1,682
Stratum 2	0.2637	9.83	0.1190	4,925	1,658	0.2936	9.13	0.1305	5,671	1,909
Stratum 3	0.4468	13.47	0.2080	8,346	3,580	0.4894	12.41	0.2273	9,452	4,055
Stratum 4	0.6813	15.85	0.1871	12,724	1,259	0.6341	11.95	0.1803	12,246	1,212
Stratum 5	0.9161	16.87	0.1732	17,109	730	0.9011	13.41	0.1711	17,404	743
Stratum 6	1.1218	17.61	0.1714	20,951	632	1.1695	14.74	0.1911	22,587	681
Constructed area (squared meters)	0.0037	10.38	0.4267	68	11,168					
Area of land (squared meters)	-0.0003	-1.86	-0.0936	-4.74	-542					
Parks in neighborhood						-0.1511	-8.04	-0.0496	-2,919	-441
House in area vulnerable to natural disasters	-0.0523	-2.86	-0.0126	-976	-71	-0.0901	-3.86	-0.0221	-1,741	-127
Factories in neighborhood						0.0628	3.14	0.0179	1,212	125
Terminals of ground transportation in neighborhood	-0.0541	-2.72	-0.0087	-1,011	-39	-0.0883	-3.60	-0.0159	-1,706	-66
Land use is productive housing						0.0877	6.19	0.0406	1,695	695
Class of soil is integral renovation						0.0860	3.08	0.0126	1,661	42
Distance to nearest school[3]	-0.0002	-3.58	-0.0213	-3.01	-628	-0.0003	-5.07	-0.0381	-5.50	-1,149
Distance to nearest university	-0.00005	-6.76	-0.0470	-0.86	-1,315	-0.0001	-10.61	-0.0907	-1.74	-2,650
Distance to nearest place of public administration	-0.0001	-5.60	-0.0364	-1.05	-1,072	-0.0001	-6.59	-0.0587	-1.74	-1,784
Distance to nearest place of defense or justice						0.0001	5.92	0.0488	0.97	1,688
Distance to nearest place of food provision	0.00002	4.00	0.0227	0.34	678					
Number of social welfare places per 1000 population						0.1473	5.80	0.0327	2,845	528
Number of cultural places per 1000 population	-0.0974	-5.24	-0.0328	-1,818	-237	-0.1122	-6.63	-0.0366	-2,167	-282
Number of schools per 1000 population	0.1361	4.35	0.0390	2,542	732	0.1901	8.10	0.0524	3,671	1,058
Lakes area (M^2) per 1000 population	0.0000	6.19	0.0237	0.15	79	0.00001	3.92	0.0257	0.17	91
Crime rate (murders per 100000 population)	-0.0395	-5.41	-0.0236	-738	-1,226	-0.0630	-6.51	-0.0359	-1,217	-2,023
Attacks						-0.1127	-6.95	-0.0495	-2,176	-696
Gini coefficient of education	-0.3636	-2.60	-0.0352	-6,790	-2,406	-0.3244	-2.13	-0.0321	-6,265	-2,220
Number of attacks against life per 10000 population	-0.0351	-4.69	-0.0237	-655	-262					
Population Density						0.0003	3.01	0.0179	5.53	306
Unemployment rate	-1.9299	-5.48	-0.0371	-36,045	-2,751	-3.5641	-8.92	-0.0700	-68,836	-5,253
Average of education years by census track	0.0755	9.30	0.1552	1,411	14,420	0.0732	6.94	0.1530	1,413	14,449
Share of female heads	-2.1022	-6.00	-0.0484	-39,263	-3,771	-3.6747	-9.27	-0.0831	-70,973	-6,817
Illiteracy rate	0.4015	2.77	0.0171	7,499	610	0.7285	5.54	0.0310	14,070	1,144
Piped gas coverage	-0.2812	-5.38	-0.0365	-5,251	-4,217	-0.4042	-6.49	-0.0522	-7,807	-6,270
Constant	16.0133	96.06				17.0915	95.68			

[1] Only includes households for which cadastral values are available. [2] Cadastral values if available, otherwise, the value reported by households surveyed. [3] All distances are in meters. *t* statistics computed based on robust standard errors corrected by clustering at the census sector level. Definitions and description of variables are available in annex 1. The exchange rate in June 2003 was $2827/USD.

Table 3B. 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 4A. 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 five columns that contain the estimated coefficients, their *t* statistic, 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 implicit price of the variables and their monetary value.

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.[22] House rents also increase with the distance to inter-municipal roads, the distance to public utilities and to places of cultural value, and the 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 4A 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 3, 4, 5 and 6 houses in a specific census sector a one standard deviation from its current level, would imply an increase of 0.16, 0.19, 0.23 and 0.19 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 0.11, 0.11 and 0.08 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 0.05 standard deviations (that is, decreasing distance to the nearest station 1 kilometer would increase house value about 5% approximately, since the standard deviation of the rent is similar to its mean).

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

[22] 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.

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 4B. 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.

Implicit prices and monetary value of characteristics

The implicit price of the variables and their monetary value estimated according to equation (2) (columns 4 and 5 in each panel), show that the largest monetary value capitalized in house values is due to the average education in the census sector, followed by the availability of potable water, the number of rooms, and having a kitchen as an additional room. Here again, stratum 3 despite is lower implicit price, is explained by the larger share of houses in that stratum (32%, versus 11%, 9% and 3.4% in strata 4, 5 and 6 respectively).

Table 4A. Hedonic regression for Medellín, 2006

	Rent paid + rent estimated[1]					Rent paid[2]				
	Number of obs 16323			R^2 = 0.7636		Number of obs 6275			R^2 = 0.7246	
Variable	Coeff.	*t*	beta	Implicit P (USD $)	Value (USD $)	Coeff.	*t*	beta	Implicit P (USD $)	Value (USD $)
Number of rooms	0.0674	22.46	0.1085	10	41	0.0717	14.74	0.1201	8.80	37
Number of bathrooms	0.0944	12.62	0.0781	14	20	0.1133	11.48	0.0838	14	20
House with fixed telephone line	0.1238	7.34	0.0242	18	17	0.1072	4.37	0.0249	13	13
House with piped gas service	0.0789	7.73	0.0376	11	3.51	0.0535	3.91	0.0246	6.57	2.01
Household cocks with piped gas	-0.0276	-3.49	-0.0141	-4.01	-1.62					
House with GPL service	0.0315	3.35	0.0160	4.57	1.78	0.0234	2.13	0.0132	2.87	1.12
House with interenet service	0.0719	7.24	0.0295	10	2.04	0.0634	4.22	0.0255	7.78	1.52
House with Satellite television service	0.0447	5.94	0.0229	6.48	3.69	0.0383	3.32	0.0216	4.70	2.67
House	-0.0189	-2.51	-0.0098	-2.74	-1.37	-0.0287	-2.73	-0.0162	-3.52	-1.76
House with garage	0.1082	7.93	0.0433	16	2.86	0.1408	7.59	0.0532	17	3.15
High quality floor material	0.1469	16.43	0.0633	21	16	0.1677	13.30	0.0786	21	16
High quality wall material	0.1022	2.67	0.0111	15	15					
House with potable water service	0.3633	1.90	0.0056	53	53					
Kitchen is an aditional room	0.1564	5.51	0.0213	23	22	0.1657	3.83	0.0270	20	20
Stratum 2	0.1046	5.93	0.0521	15	5.37	0.0751	3.47	0.0411	9.22	3.27
Stratum 3	0.3340	13.67	0.1618	48	15	0.2821	9.48	0.1523	35	11
Stratum 4	0.5760	19.28	0.1870	84	9.34	0.4847	13.21	0.1713	60	6.65
Stratum 5	0.7762	20.65	0.2305	113	10	0.6529	14.03	0.1915	80	7.16
Stratum 6	1.0358	19.63	0.1941	150	5.17	0.9056	12.80	0.1277	111	3.83
House in area vulnerable to natural disasters	-0.0613	-3.09	-0.0142	-8.89	-0.48	-0.0973	-2.38	-0.0226	-11.95	-0.65

Class of soil is urban						0.5543	5.82	0.0301	68.07	67.47
Class of soil is rural						0.4971	4.65	0.0226	61.04	0.38
Class of soil is residential	-0.0223	-2.06	-0.0091	-3.23	-2.60	-0.0269	-1.94	-0.0122	-3.30	-2.65
Distance to nearest cultural place[3]	0.00003	2.55	0.0159	0.005	3.32					
Distance to nearest place of public administration	-0.00002	-1.45	-0.0120	-0.003	-3.21	-0.00005	-3.64	-0.0322	-0.006	-6.99
Distance to nearest metro or metroplus station	-0.0001	-6.46	-0.0491	-0.008	-10	0.0000	-4.86	-0.0467	-0.006	-7.66
Distance to nearest place of refugee for children and the elder	-0.00005	-5.23	-0.0443	-0.007	-8.22	-0.00007	-6.21	-0.0701	-0.009	-10.42
Distance to nearest market place	0.00002	4.17	0.0349	0.004	9.04	0.00002	2.13	0.0260	0.002	5.45
Distance to nearest place of recreation or sports						0.0000	-1.87	-0.0145	-0.003	-2.72
Distance to nearest church/worship place						-0.0001	-1.60	-0.0094	-0.007	-1.99
Distance to nearest place of vigilance	-0.00003	-2.14	-0.0154	-0.005	-3.60					
Distance to nearest place related with utility services	0.0001	3.61	0.0199	0.008	5.04	0.00003	2.51	0.0142	0.004	2.83
Distance to nearest place of help in case of disasters	0.00002	2.69	0.0306	0.003	6.80					
Distance to nearest river or stream	-0.00002	-1.97	-0.0261	-0.003	-6.45	-0.00002	-1.89	-0.0226	-0.002	-4.45
Distance to nearest hill						0.00002	2.72	0.0221	0.003	5.12
Distance to nearest place identified as cultural Heritage						0.0001	2.43	0.0349	0.006	6.52
Distance to nearest road connecting the city to neighbor cities	0.00001	2.03	0.0138	0.001	4.18	0.00001	1.97	0.0169	0.001	4.31
Distance to nearest university	-0.00003	-4.49	-0.0276	-0.005	-7.47	-0.00004	-4.88	-0.0343	-0.005	-7.25
Number of social welfare places per 1000 population						-0.1619	-2.11	-0.0156	-20	-0.83
Number of cultural places per 1000 population	0.0987	1.64	0.0094	14	0.48	0.1795	2.97	0.0208	22	0.74
Number of places of public administration per 1000 population	-0.0016	-0.18	-0.0005	-0.23	0.00	0.0132	1.31	0.0077	1.62	0.02
Number of metro or metroplus stations per 1000 population						-0.0559	-1.15	-0.0090	-6.87	-0.14
Number of market places per 1000 population	0.3535	2.33	0.0094	51	0.12	0.2948	2.16	0.0101	36	0.09
Number of places related with utility services per 1000 population						-0.0760	-1.66	-0.0076	-9.33	-0.28
Population Density						0.00002	1.29	0.0043	0.00	0.14
Average of education years by census track	0.0529	9.61	0.1111	7.67	71	0.0546	8.69	0.1156	6.70	62
Crime rate (murders per 100000 population)	-0.0039	-6.20	-0.0336	-0.56	-6.06	-0.0028	-3.41	-0.0258	-0.34	-3.67
constant	10.4345					10.3699				

[1] Rent actually paid or value or rent households estimate they would pay under lease. [2] Rent actually paid.
[3] All distances are in meters. The exchange rate in October 2006 was $2364/USD.

Table 4B. 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 rent values, since we do not have house values for Medellín.

Results of this exercise are reported in table 5. 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, standard deviation, 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 7% 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.[23]

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 favors Bogotá, there is the issue of the much more progressive targeting of this public service in Bogotá. Actually, in 2005, when the population census was collected, 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.

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

Table 5. Comparing Bogotá and Medellín

Variable	Bogotá				Medellín				Differences Bog-Med			
	Mean	Desv. Std.	Coeff.	t	Mean	Desv. Std.	Coeff.	t	Δmean	*t*	ΔCoeff.	*t*
Number of bedrooms	3.42	1.51	0.179	21.72	4.21	1.54	0.073	23.4	-0.78	-46.2	0.11	12.0
Number of bathrooms	2.120	0.949	0.016	1.76	1.443	0.807	0.100	12.9	0.68	67.5	-0.08	-7.2
House with piped gas service	0.700	0.458	-0.093	-2.98	0.309	0.462	0.067	7.3	0.39	76.3	-0.16	-4.9
Household cocks with piped gas	0.658	0.474	0.187	5.71	0.407	0.491	-0.015	-2.3	0.25	46.9	0.20	6.1
House with garage	0.303	0.460	0.134	7.62	0.181	0.385	0.122	8.9	0.12	25.3	0.01	0.5
House	0.412	0.492	0.070	4.70	0.499	0.500	-0.022	-2.8	-0.09	-15.8	0.09	5.5
House with potable water service	0.991	0.097	0.161	1.46	0.985	0.121	0.372	1.9	0.01	4.6	-0.21	-0.9
High quality floor material	0.820	0.385	0.131	7.82	0.763	0.425	0.163	17.6	0.06	12.7	-0.03	-1.7
High quality wall material	0.989	0.102	0.336	4.27	0.984	0.126	0.124	3.2	0.01	4.5	0.21	2.4
Kitchen as an aditional room	0.969	0.173	0.188	5.94	0.980	0.142	0.174	6.1	-0.01	-5.7	0.01	0.3
Stratum 2	0.337	0.473	0.075	2.64	0.358	0.479	0.093	5.0	-0.02	-4.0	-0.02	-0.5
Stratum 3	0.429	0.495	0.193	5.39	0.314	0.464	0.338	13.2	0.11	21.3	-0.14	-3.3
Stratum 4	0.099	0.299	0.398	7.64	0.110	0.313	0.581	18.5	-0.01	-3.3	-0.18	-3.0
Stratum 5	0.043	0.202	0.658	10.79	0.085	0.279	0.757	19.3	-0.04	-16.2	-0.10	-1.4
Stratum 6	0.030	0.171	1.05	9.15	0.038	0.190	1.07	22.4	-0.01	-3.7	-0.02	-0.1
House in area vulnerable to natural disasters	0.073	0.260	-0.026	-1.14	0.054	0.227	-0.073	-3.3	0.02	6.5	0.05	1.5
Crime rate (murders per 100000 population)	1.66	2.83	-0.018	-2.13	10.75	8.41	-0.003	-4.2	-9.09	-139.5	-0.01	-1.7
Gini coefficient of education	0.354	0.109	-0.337	-1.61	0.398	0.120	-0.185	-1.2	-0.04	-33.4	-0.15	-0.6
Distance to nearest university	1,524	1,068	-0.000024	-3.17	1,595	1,013	-0.00003	-3.4	-70.52	-5.9	0.000002	0.2
Distance to nearest cultural place	385	309	0.000018	0.91	710	478	0.00003	2.8	-325.05	-74.2	-0.000014	-0.6
Distance to nearest medical center	532	331	-0.000004	-0.17	513	311	-0.00002	-1.3	18.20	4.9	0.000018	0.6
Distance to nearest place of public administration	1,023	700	-0.000065	-5.82	1,134	599	-0.00001	-0.7	-111.05	-14.7	-0.000056	-3.3
Distance to the neaters public transportation station	1,894	1,242	-0.000002	-0.34	1,257	1,039	-0.00003	-3.9	637.15	48.0	0.000028	3.0
No. of public administration places per 1000 population	0.113	0.661	0.008	0.70	0.014	0.300	-0.136	-4.4	0.10	15.9	0.14	4.4
Number of cultural places per 1000 population	0.130	0.369	0.005	0.24	0.034	0.092	0.213	3.1	0.10	29.0	-0.21	-2.9
Average of education years by census track	10.22	2.23	0.053	4.05	9.24	2.03	0.046	4.3	0.98	39.9	0.01	0.4
Unemployment Rate	0.076	0.021	-1.19	-2.45	0.077	0.032	-0.635	-1.8	0.00	-1.8	-0.55	-0.9
Piped gas coverage	0.803	0.142	-0.393	-6.43	0.231	0.204	0.163	3.2	0.57	296.1	-0.56	-7.0
Constant			10.74	43.78			10.64	42.3			0.10	0.3
Number of Observations	12,769				19,367							

A summary of differences in endowments and characteristics between these two cities can be illustrated by estimating the parameters of the Oaxaca-Blinder decomposition, according to which differences in house values can be expressed as a function of differences in the coefficients and endowments of the two cities. Formally,

$$\ln\left(P_{ij}^{B}\right)-\ln\left(P_{ij}^{M}\right)=\left[\left(\hat{\alpha}_0^{B}-\hat{\alpha}_0^{M}\right)+\left(\hat{\alpha}_1^{M}-\hat{\alpha}_1^{M}\right)H_i^{B}+\left(\hat{\alpha}_2^{B}-\hat{\alpha}_2^{M}\right)A_j^{B}\right] + \left[\hat{\alpha}_1^{M}\left(H_i^{B}-H_i^{M}\right)+\hat{\alpha}_2^{M}\left(A_j^{B}-A_j^{M}\right)\right] \quad (3)$$

Where the first bracket is the part of the difference in house values between the cities explained by the differences in their coefficients and the second is the part explained by the differences in their endowments. The results of estimating the decomposition are shown in table 6. The first row of the table shows the results when all the variables of the model are used to get the decomposition. In addition, given that socioeconomic strata are composed by both housing and amenities, we estimate two different decompositions. In the following two rows we first estimate separately the decomposition for housing variables including socioeconomic strata and amenities, while in the last two rows we estimate separately the decomposition for housing variables without socioeconomic strata, and amenities including socioeconomic strata. Finally, in order to distinguish differences in the prices of the characteristics that vary within the city from those that only vary between them, the decompositions are estimated both with and without the intercept, which only implies changes in the term related to the differences in the coefficients. The idea is that, as we previously mentioned, the higher observed prices of houses in Bogotá is ultimately explained by differences in the prices and levels of the characteristics included in our model, but also by differences in characteristics that vary between cities but not within them (temperature, contamination, altitude, etc.).

The results show that as a whole, Bogotá is a cheaper and better endowed city when considering the characteristics included in our model (decomposition without intercept). The lower costs would be mainly explained by cheaper amenities rather than cheaper housing characteristics, while the better endowment is found for both housing variables and amenities. The table shows that on average, citizens of Medellín are paying 22%

more for the characteristics we use to explain house prices, although citizens of Bogotá are getting endowments 21% more valuable. When these figures are disaggregated between the part composed by housing characteristics and the one composed by amenities, we find that more than 80% of the differences in endowments are explained by differences in the endowments in amenities (better in Bogotá), while only differences in the coefficients of amenities remain statistically different (lower prices of amenities in Bogotá).

Once we include the constant term in the decomposition, the prices of the characteristics are not statistically different anymore. In other words, someone moving from Bogotá to Medellín would find on average a city with less developed and relatively more expensive public goods (the ones we are accounting for), but in terms of power parity purchase (including the whole basket of characteristics capitalized in house prices), with comparable prices to those of Bogotá. Other way to put it is that the relative price between the characteristics we account for and those we do not is higher in Medellín, but the whole basket is as expensive.

Table 6. Oaxaca-Blinder Decomposition of differences in house values. Bogotá-Medellín

Variables			Differences in Coefficients		Differences in Endowments
			Not including the intercept	Including the intercept*	
All Variables		**Estimate**	-0.221	0.027	0.206
		t	6.74	0.83	-6.51
1	**Housing with Strata**	**Estimate**	0.136		0.028
		t	-0.55		-3.34
	Amenities without Strata	**Estimate**	-0.460	-0.212	0.177
		t	1.71	-0.86	-5.68
2	**Housing without Strata**	**Estimate**	0.230		0.035
		t	-0.94		-4.53
	Amenities with Strata	**Estimate**	-0.554	-0.305	0.171
		t	2.03	-1.13	-5.47

* Including the constant term (10% higher for Bogotá) and correcting for price changes between May 2003 and October 2006 (approximately 16%, implying an increase in the constant term for Bogotá).

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 seems 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.[24]

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 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.

The equation estimated is

$$LS_{ij} = \alpha_0 + \alpha_1 H_{ij} + \alpha_2 A_j + \alpha_3 h_{ij} + \rho \ln(y_{ij}) + u_{ij} \qquad (4)$$

Where LS_{ij} is our measure of life satisfaction for household head i that lives in census sector j, H_i is a vector of house variables of his house, A_j is a vector of amenities in census sector j, and in this case, we include house variables like the age and age squared of the household head, the number of children in household, etc., in h_i, and y_{ij} is the per capita income of household i. Implicit prices of housing characteristics and amenities can be gotten by estimating the standard trade-off between any of the control

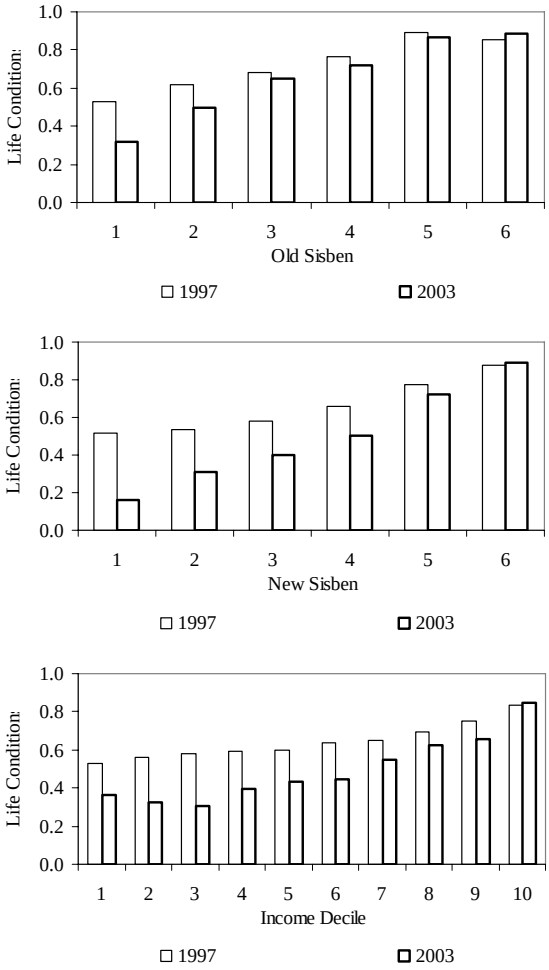
$$\frac{\partial LS}{\partial X} \Big/ \frac{\partial LS}{\partial y} = \frac{\alpha_X \bar{y}}{\rho}, \forall X \qquad (5)$$

[24] 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.

variables *X* and income,
which are used to obtain the monetary value of each of the *i* housing characteristics, amenities, and household variables, according to $\alpha_{1i}\,\overline{y}\cdot\overline{H}_i/\rho$ and $\alpha_{2j}\,\overline{y}\cdot\overline{A}_j/\rho$, and $\alpha_{2j}\,\overline{y}\cdot\overline{h}_j/\rho$, respectively.[25]

5.1 Results for Bogotá

Figure 3. Life Cond. and Welfare, Bog.



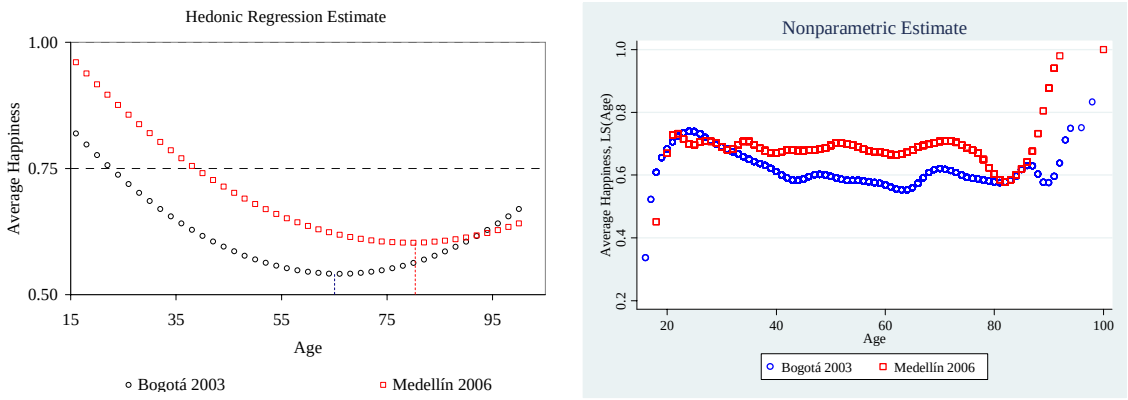
In order to describe how self reported data on life satisfaction behaves for the case of Bogotá, figure 3 illustrates the relation of this variable to three variables related to welfare: Old and New Sisben, and income decile.[26] As it becomes clear from the figure, self reported life satisfaction is positively related to all three indicators of welfare in Bogotá, consistent with results reported elsewhere.[27] 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.

Table 7 presents our regression results. There are six columns in the table. The first presents the coefficients of estimating a probit model using as dependent variable of life satisfaction a dummy variable equal to one if the answer to the question "currently living conditions in your household are:" was either *very good* or *good*, and zero if it was *fair* or *bad*; the second and third columns present the *t* statistics of these coefficients and the marginal effect on life satisfaction of increasing the control variable respectively.[28] These marginal effects are used to estimate the implicit prices of characteristics according to equation (4) and presented in column four. Column five estimates the monetary value of each characteristic, and finally, the last column 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 reviewed and obtained by Ferrer-i-Carbonell and Frijters (2004). For example, for all

[25] Find similar applications in Ferrer-i-Carbonell and Van Praag (2001), and in Di Tella and MacCulloch (2007).
[26] Old and New Sisben are Proxy-means tests used to target social public expenditure in Colombia.
[27] See for example Fray and Stutzer (2002), Layard (2003), and the references therein.
[28] Similar results are found if we estimated an ordered probit model using as dependent variable the actual four answers of households.

models, the linear term of the age of the household 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 pattern of the hedonic model in the case of Bogotá, but is much flatter in the case of Medellín, suggesting levels of happiness much more neutral to age.

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 between two and five are negative and significant. In addition, widowed 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 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.[29]

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

[29] 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.[30] 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. 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 absence of uncontrolled for variables, 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 date at first birth, to capture the effects of variations in households that come from women's early pregnancy from those that do not. 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 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 column 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

[30] Easterlin (2003, 2005).

couple living in partnership, living with children under 18, makes happiness to increase 0.11 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.

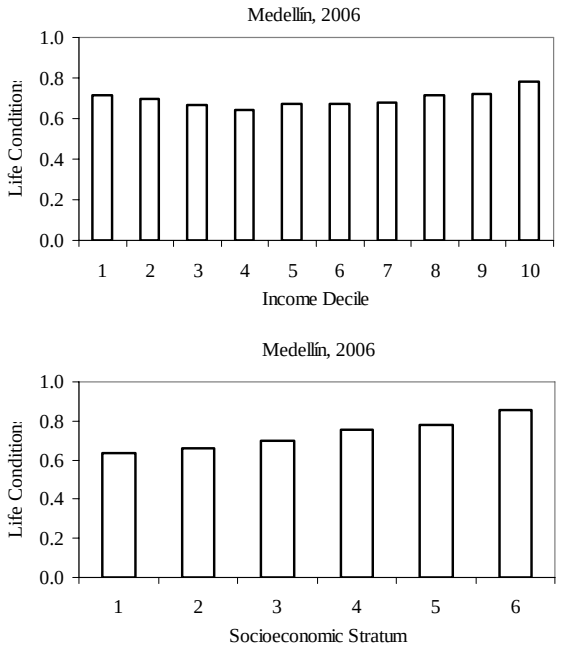
Table 7. Life-Satisfaction regression for Bogotá

Variable	N=12621			R2=0.1853		
	Coeff.	*t*	Marg. Eff.	Implicit P (USD $)	Value (USD $)	beta
Number of rooms	0.0814	6.18	0.0302	67	229	0.0808
House with piped gas service	0.1483	3.99	0.0556	123	86	0.0413
Bad quality of the energy service	-0.2657	-2.43	-0.1024	-227	-5.4	-0.0267
Bad quality of garbage collection service	-0.2503	-2.73	-0.0963	-213	-6.3	-0.0273
Bad quality of fixed phone line service	-0.2153	-3.52	-0.0824	-182	-9.4	-0.0310
Parks in neighborhood	0.1019	1.83	0.0373	83	12	0.0178
High quality floor material	0.1338	3.19	0.0504	112	91	0.0412
Stratum 2	-0.0096	-0.14	-0.0035	-7.86	-2.64	-0.0003
Stratum 3	-0.1039	-1.27	-0.0387	-86	-37	-0.0283
Stratum 4	-0.2054	-1.82	-0.0783	-173	-17	-0.0407
Stratum 5	-0.2013	-1.47	-0.0770	-170	-7.3	-0.0326
Stratum 6	0.0092	0.07	0.0034	7.56	0.23	-0.0273
Do you feel safe in your neighborhood	0.4045	11.32	0.1532	339	234	0.1252
Number of attacks against wealth per 10000 population	-0.0395	-2.31	-0.0147	-32	-10	-0.0246
Number of bars per 10000 population	0.0420	2.90	0.0156	35	21	0.0269
No. of places selling drugs/narcotics per 10000 population	0.0621	3.46	0.0230	51	25	0.0325
Distance to nearest social welfare institution****	-0.0002	-2.18	-0.0001	-0.16	-45	-0.0268
Distance to places for recreation or sports	0.0000	2.31	0.0000	0.03	42	0.0209
No. of places of food provision per 1000 population	0.5994	1.74	0.2225	493	2.01	0.0114
No. of churches/worship places per 1000 population	-0.2207	-2.23	-0.0819	-181	-12	-0.0200
No. of places of defense or justice per 1000 population	-0.1585	-2.08	-0.0588	-130	-2.62	-0.0132
Number of places for vigilance per 1000 population	-0.3801	-2.87	-0.1411	-313	-9.40	-0.0181
Land use is productive housing	-0.0846	-2.12	-0.0315	-70	-29	-0.0308
Average of education by census track	0.0422	2.72	0.0157	35	355	0.0626
Piped gas coverage	-0.5701	-3.96	-0.2116	-469	-376	-0.0494
Population density	-0.0005	-1.91	-0.0002	-0.38	-21	-0.0192
Log of household's per capita income	0.2723	11.79	0.1011	0.00035	224	0.2110
Household head with complete high school	0.2009	3.29	0.0724	160	27	0.0569
Household head with incomplete college	0.2761	4.69	0.0980	217	31	0.0598
Household head with complete college	0.3103	4.32	0.1100	244	45	0.0665
age	-0.0477	-7.60	-0.0177	-39	-1,848	-0.4503
age square	0.0004	6.22	0.0001	0.30	734	0.3495
Number of children in household	-0.0886	-1.99	-0.0329	-73	-14	-0.0230
Widowed household head	0.1160	2.06	0.0422	94	8.39	0.0216
unemployed household head	-0.3809	-5.25	-0.1477	-327	-19	-0.0612
Household head has any kind of health insurance	0.2637	6.08	0.1004	222	181	0.0763
Household head has any chronic disease	-0.1671	-4.05	-0.0631	-140	-27	-0.0443
Household head was sick any time during last 30 days	-0.1879	-3.88	-0.0714	-158	-17	-0.0385
Hhold head was hospitalized any time during last 12 months	-0.1224	-2.03	-0.0463	-102	-7.31	-0.0208
Mean difference between age and education for <25	-0.0065	-1.64	-0.0024	-5.38	-26	-0.0095
Percentage of <25 that assists to a public school or college	-0.0922	-2.28	-0.0342	-76	-23	-0.0345
Hhold head's mother with complete elementary school	0.0927	2.68	0.0341	76	19	0.0310
Hhold's per capita income *(No. children <18) ($000)	0.00028	4.49	0.000103	0.000	68.271	0.0192
Married*(Number of childrens under 18)	0.1493	5.19	0.0554	123	90	0.1085
Hhold head with complete high school*(No children <18)	-0.0742	-1.97	-0.0275	-61	-10	-0.0221
Hhold head with college*(No children under 18)	-0.1446	-3.32	-0.0537	-119	-32	-0.0288
Hhold head with college*(No children under 4)	0.1880	2.40	0.0698	155	13	0.0266
Age of Household head*(No children under 18)	-0.0033	-4.33	-0.0012	-2.69	-97	-0.0755
constant	-2.5633	-6.99				

****All distances are in meters. Dependent variable=1 if the answer to the question: "Currently, living conditions in your households are:" is *very goo*d or *good*, and zero if the answer is *fair* or *bad.*

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 4. 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 8, 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, the survey does not let us know whether the household head suffers of any chronic disease).

In contrast to what was found for Bogotá, 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 higher strata 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. For example, increasing a one standard deviation the number of children under 18 in the household reduces 16% of one standard deviation happiness of the household head, but very importantly, the household head would have an increase in happiness of 11% of a standard deviation if the probability of having at least one child living in the household with his or her mother would move one standard deviation beyond the average. This figures are consistent with households that have difficulties in bearing the costs of

raising children under 18, being those costs much smaller when their mother lives with them. The socioeconomic strata, the education of the household head and its marital status (happier if married or widowed) 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 8. Life-Satisfaction regression for Medellín

Variable	Pseudo R2=0.122			No. Obs=1890		
	Coeff.	*t*	Marg. Eff.	Implicit P (USD $)	Value (USD $)	beta
Number of rooms	0.0365	1.35	0.0125	311	1,316	0.0415
Satelital TV service	0.1904	2.31	0.0655	1,632	928	0.0664
High quality floor material	0.1756	1.77	0.0614	1,530	1,185	0.0576
Stratum 3	0.2342	2.54	0.0779	1,942	621	0.0796
Stratum 4	0.6448	4.19	0.1835	4,574	511	0.1216
Stratum 5	0.6167	3.13	0.1752	4,367	390	0.1034
Stratum 6	0.8775	3.25	0.2193	5,465	188	0.0783
Distance to nearest cultural place****	0.0001	1.77	0.00004	1.05	749	0.0481
Distance to nearest place of public administration	0.0002	2.74	0.0001	1.43	1,620	0.0613
Distance to nearest road connecting the city to neighbor cities	0.0000	-1.91	-0.00001	-0.33	-1,467	-0.0602
Number of prisons per 1000 population	2.7019	3.56	0.9208	22,955	69	0.0384
Number of cultural places per 1000 population	0.5402	1.40	0.1841	4,589	154	0.0337
No. hospitals or medical centers per 1000 population	-0.6895	-3.05	-0.2350	-5,858	-364	-0.0752
No. of places related with utility services per 1000 population	0.3633	0.76	0.1238	3,086	92	0.0189
No. of places for help in case of disasters per 1000 population	3.2814	2.85	1.1183	27,877	101	0.0368
Class of soil is rural	-1.1154	-5.00	-0.4230	-10,543	-65	-0.0301
Class of soil is residential	-0.2080	-2.18	-0.0682	-1,701	-1,368	-0.0573
Unemployment rate	-1.6462	-1.15	-0.5610	-13,986	-1,083	-0.0338
Population density	0.0001	0.67	0.00003	0.86	48	0.0079
age	-0.0444	-3.13	-0.0151	-377	-19,444	-0.4706
Age squared	0.0003	2.44	0.0001	2.49	7,357	0.3461
Log of household's per capita income	0.0133	2.17	0.0045	0.00042	113	0.0441
Household head with complete elementary school	0.1425	1.43	0.0479	1,193	344	0.0596
Household head with incomplete high school	0.1317	0.67	0.0436	1,086	134	0.0259
Household head with complete high school	0.2298	1.76	0.0752	1,875	416	0.0775
Household head with incomplete college	0.0841	0.37	0.0282	703	122	0.0422
Household head with complete college	0.2871	1.49	0.0911	2,272	273	0.0605
Number of children under 18	-0.2165	-2.57	-0.0738	-1,839	-1,370	-0.1591
Married household head	0.2171	2.63	0.0738	1,838	818	0.0769
Widowed household head	0.2525	2.32	0.0815	2,032	294	0.0645
Household head have any kind of health insurance	0.3811	2.35	0.1405	3,502	3,326	0.0524
Mother or father unemployed or inactive * No of children under 5	-0.1834	-2.27	-0.0625	-1,558	-238	-0.0593
Percentage of <25 that assists to a public school or college	-0.1445	-1.98	-0.0492	-1,227	-483	-0.0463
Hhold head with complete primary *(Number children under 18)	0.1459	1.35	0.0497	1,240	244	0.0741
Hhold head with complete high school*(No children under 18)	0.0756	0.70	0.0258	642	129	0.0373
Household head with college*(Number of children under 18)	0.1409	1.22	0.0480	1,197	284	0.0592
Children living with their mother in household	0.3733	4.06	0.1331	3,317	2,446	0.1071
Constant	0.6533	1.45				

**** All distances are in meters; ** Dependent variable=1 if the answer to the question: "Currently, living conditions in your households are:" is *very good* or *good*, and zero if the answer is *fair* or *bad*.

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 identifying 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, variables 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, since its scope goes beyond what just education means, and would work as signal of overall socioeconomic status in the census sector. 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.

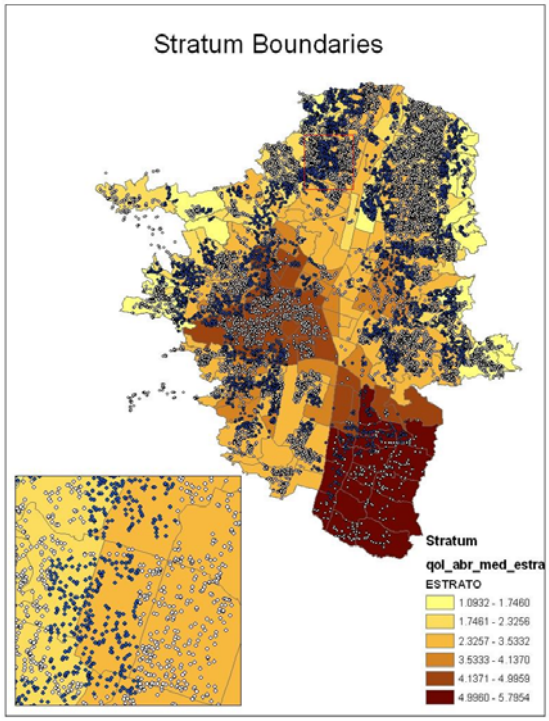
On the other hand, at the moment of determining whether houses on a specific street belong to one stratum or the other, the local authority uses to limit each socioeconomic stratum from its neighbor strata with natural barriers like streams, parks, etc., or existent infrastructure like highways, airports, 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.[31]

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 are exactly the same at the common boundary between socioeconomic strata.

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

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 dots represent the households among we select the sample of households near the boundaries of their socioeconomic strata (the blue dots).

The estimated coefficients of the socioeconomic strata are shown in table 9. The panel on the left includes the estimates of table 8 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 9. Life satisfaction models with sets of households according to their distance to the boundaries of their socioeconomic strata. Medellín, 2006.
Both models control for all the covariates include in table 8.

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

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

In this section we present the results of estimating QoH and QoL indexes at the census sector level, for Bogotá and Medellín, based on our hedonic and life satisfaction estimates. As we mentioned in sections 3 and 4, the QoH index is estimated based on the coefficients of the hedonic regression ran in section 3 on housing prices, while the QoL index is estimated based on the results of the life satisfaction model of section 4. We refer to the first index as a quality of housing index, since using only the hedonic regression we cannot estimate quality of life parameters the way previous work do.[32] In addition, we must bear in mind that since we estimate one model by city, we can only identify implicit prices of house characteristics and amenities that vary within each city, not the ones that are as well capitalized in house prices but do not vary within the cities considered, like weather, temperature, different forms of contamination, access to markets, etc.

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 the LSMS variables at the census sector level non-parametrically, and then we use these means by census sector to estimate their respective indexes.[33] 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.[34]

[32] The hedonic models estimated in previous work are based on differences on both housing and labor markets, based on which they construct implicit prices of amenities that allow them to estimate quality of life for each city. Since our exercise only considers variations across neighborhoods that share the same labor market, we cannot estimate quality of life the way Blomquist et al. (1988), Roback (1982) or Hall et al. (2008) do. That is, since people who live in the same city earn the same wage unconditional on the place of residence within the city, variations in location within the city cannot be explained by variation in wages the way they do when people live in different cities.

[33] To estimate indexes by census sector, we use the nearest 200 neighbors to the centroid of each census sector (either located in that specific census sector or not), 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.

[34] 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.

Figure 6 shows the distribution of our estimates of house values and rents, and life satisfaction, for Bogotá and Medellín. The distribution of house values in Bogotá contains more extreme values, but once we trim the figure the shape becomes similar although more disperse than of rents for Medellín. The difference in the levels between the two curves is precisely because we use the log of house values for Bogotá and the log of rent values for Medellín. Both reported and estimated life satisfaction show that household heads from Medellín are happier on average, and their happiness is less heterogeneous.

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

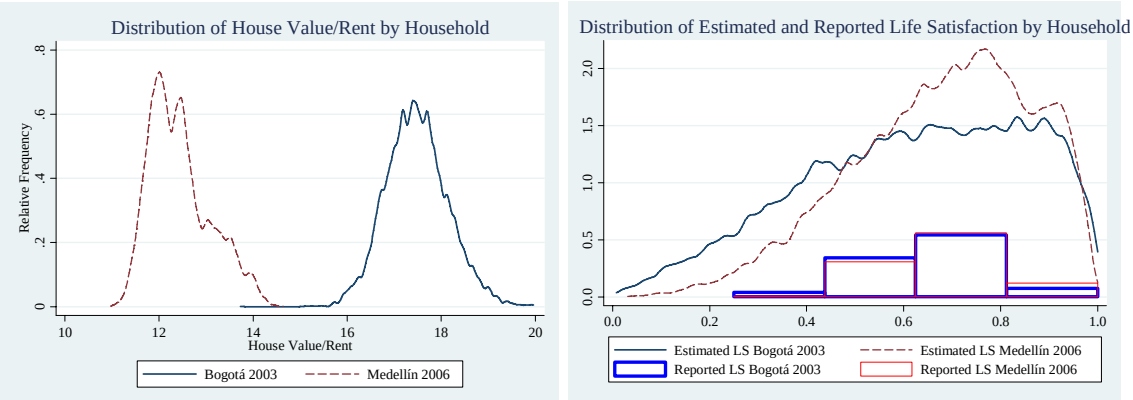


Figure 7. Distribution of Reported Life Satisfaction by Socioeconomic Stratum

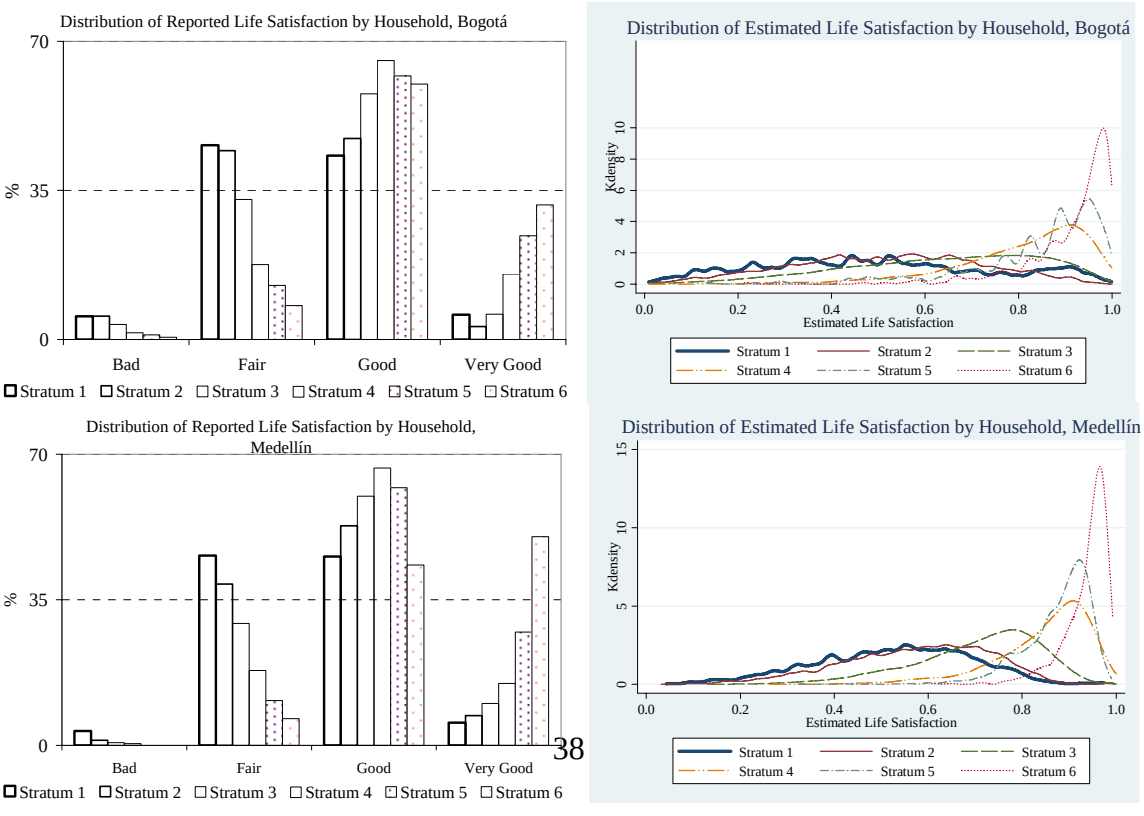
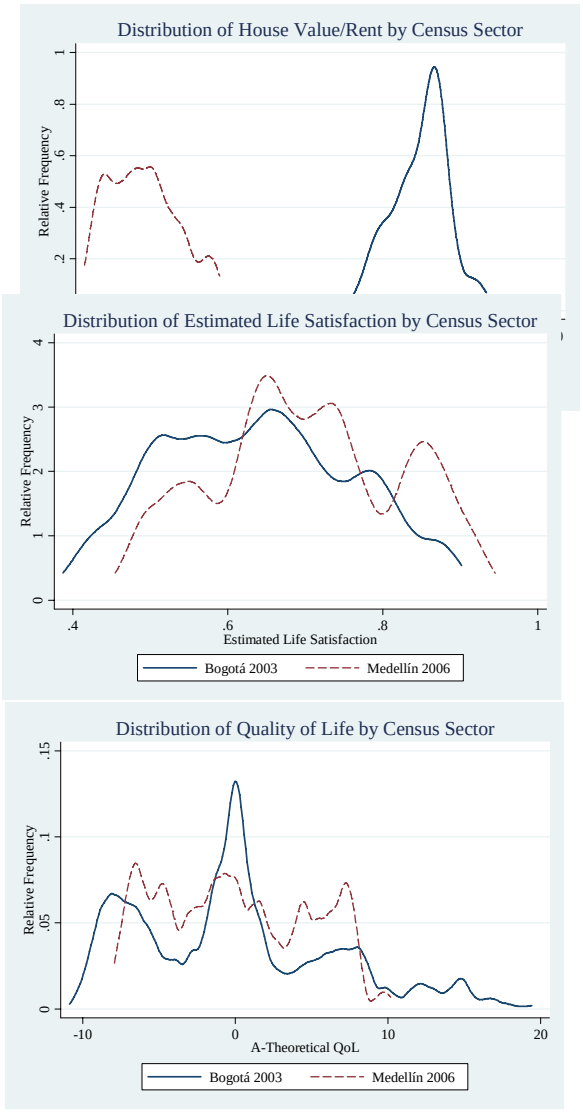


Figure 8. Distribution of QoL indexes of census sectors. Bogotá and Medellín



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 estimated house value or rent for Bogotá and Medellín respectively, when we use as unit of observation their average 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 estimated life satisfaction in this case. There again life satisfaction is on average higher and less disperse in Medellín.

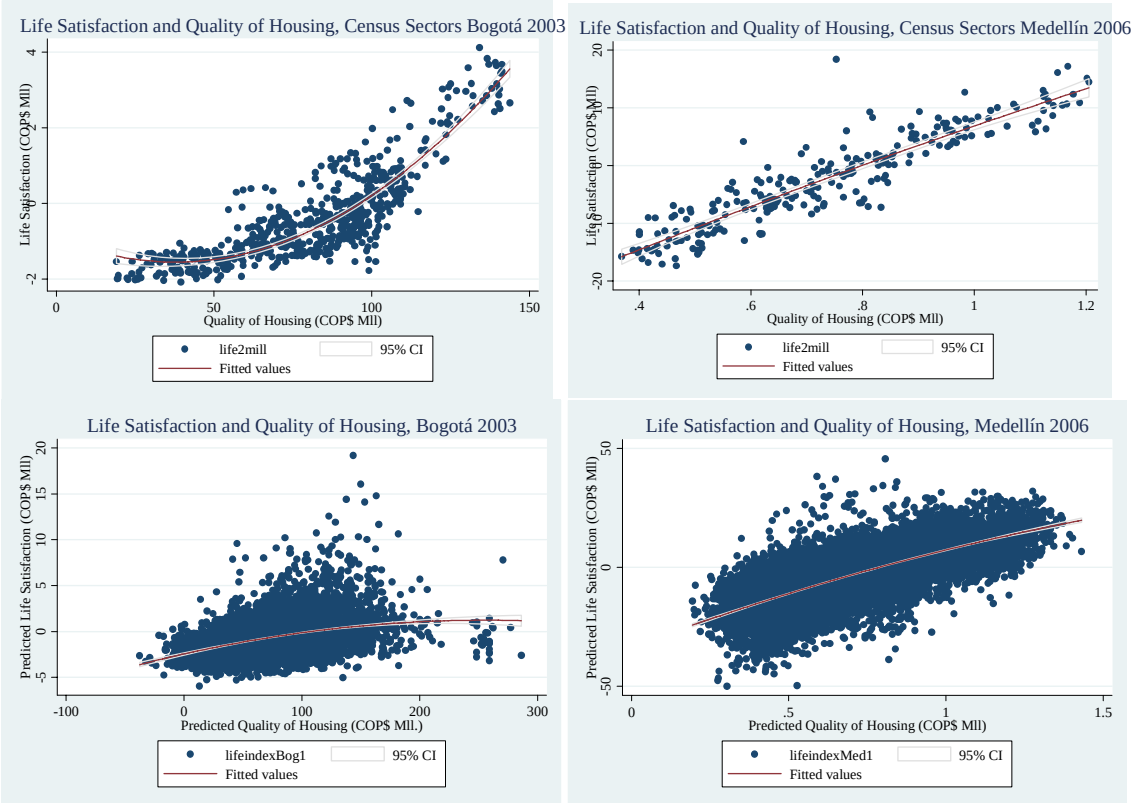
The last graph in figure 8 shows the distribution of our A-theoretical QoL index based on the first principal component of the average levels by census sector of the covariates included in the hedonic regression estimated with house values. This index looks more disperse than the previous ones.

We now proceed to estimate QoH and QoL indexes for each city. To do it, we just add the monetary values of all the characteristics included in equations (1) and (4) respectively. In addition, we estimate these indexes for each of the urban areas in each city, based solely on the monetary value of different sets of the characteristics used to explain them: (i) amenities, (ii) housing characteristics, and (for the index based on life satisfaction) (iii) household characteristics.

First we show how the estimated indexes are related once we use all the characteristics to estimate them by household and census sector. Both across households and across census sectors, the QoH is positively related to the QoL based on life satisfaction, as it is shown in figure 9. The figure shows on the top the graphs for Bogotá and Medellín that relate QoL as a function of QoH with household information, and at the bottom the respective graphs with information by census sector.

Map 10 illustrates the spatial distribution of quality of life according to our QoH, QoL and A-Theoretical indexes. In addition, it includes the spatial distribution of household per capita income. There are important similarities among the three indexes, all of which reveal a highly segregated pattern of high versus low quality of life 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 quality of life (the red census sectors, which show that in those census sectors, the levels of quality of life are statistically higher than those of their neighbors) and another with low quality of life (the dark blue census sectors, which show that in those census sectors the levels of quality of life are statistically lower than those of their neighbors), separated by a group of neighborhoods with levels of quality of life not statistically different to the average of the city.

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

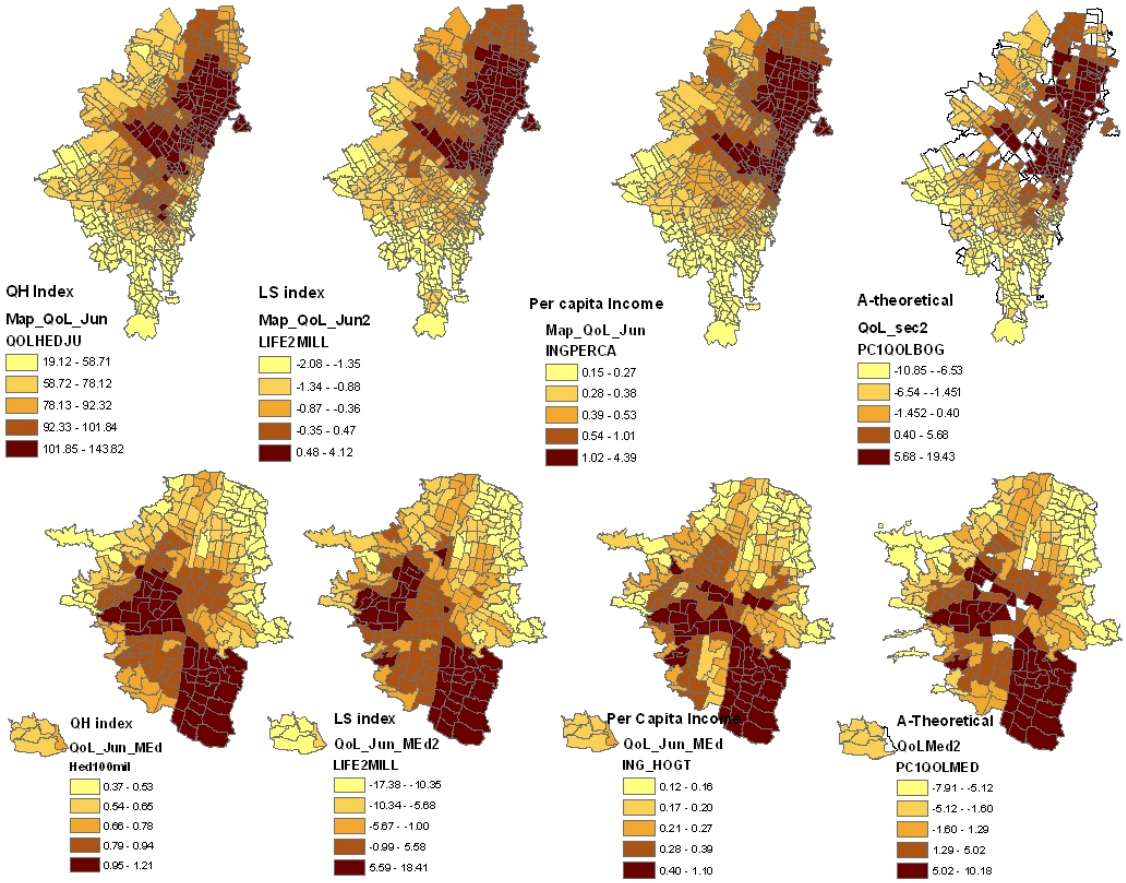


The maps with the quintiles and clusters of per capita income are highly related to the maps of the quality of life indexes. In Map 11 though, it can be observed the existence in Medellín of a light blue cluster located at the southwest of the city, implying the existence of a neighborhood of households 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 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

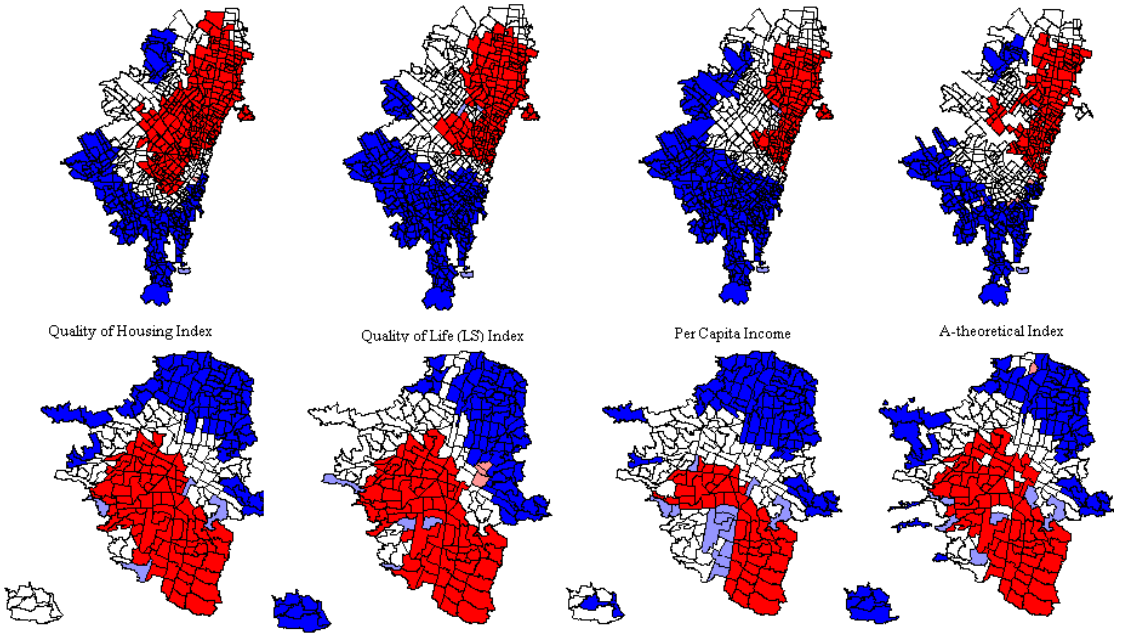
larger than their respective QoL counterparts. This regularity goes in line with a distribution of income much more unequal than the distribution of variables that determine QoL in these cities.

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

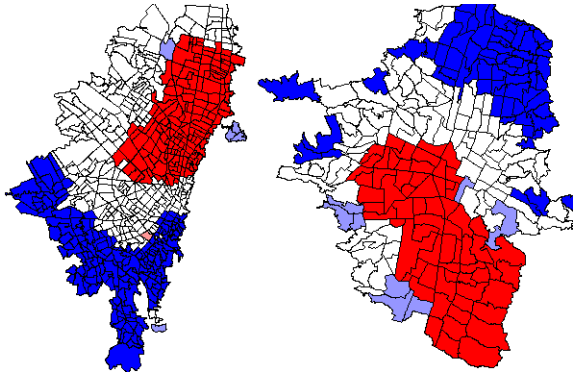


* Figures of the QoH, QoL and household per capita income are in millions.

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



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 3 and 4 are striking.

Global Moran indexes for our QoL indexes and per capita income are shown in table 10. All variables shown in the table have higher levels of spatial autocorrelation in Bogotá than Medellín.[35] Not surprisingly, given the evidence previously presented, the level of segregation of the socioeconomic strata continuous variable is similar to those of our indexes for each city.

[35] Also, each of them is in turn larger that the global Moran indexes of education variables like the average years of education in the census sector and the college enrollment rate, and demographic variables like the presence of children at home, the age at first pregnancy, and the share of mother with ages between 13 and 19 in the census sector; the unemployment rate and the rate of racial minority. The share of households with piped gas in Medellín has a global Moran index of 0.635, which is actually higher than the index of per capita income in that city.

Table 10. 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
QoL (Life Satisfaction)	2	0.834	0.0001	2	0.686	0.0001
QoH (Hedonic Model based on House value/Rent)	3	0.831	0.0001	1	0.688	0.0001
Household 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

Indexes by area within each city

Maps 3 and 4 illustrate the variation of our QoH and QoL indexes at the census sector level. Now we estimate these indexes for each of the administrative urban areas in which each city is divided: 19 *localidades* in Bogotá and 16 *Comunas* in Medellín.

The results are presented in annex 3. The first thing to note is the high similarity of the rankings obtained in each city regardless of whether we use just housing variables, or household variables, or amenities, or even just the socioeconomic stratum. The correlation of all the 12 indexes obtained for Bogotá (six QoH -housing, stratum, amenities, amenities and stratum and total- and seven QoL –those in QoH plus household) averages 0.94, while that for the indexes estimated for Medellín averages 0.96. Similar results are obtained when we estimate rank correlations in either case. In addition, when we estimate the rank correlations of the indexes for Medellín with the one obtained by Castaño (2005), the average correlation is 0.926. The index more related to the one obtained by Castaño is that estimated with housing characteristics in the life satisfaction model, and with housing characteristics in the hedonic price model.[36]

When we compare the necessary compensation from moving someone from the best neighborhood to the worst, based on individual indexes (that is, based exclusively on one of: household, housing, socioeconomic strata, or amenities) that is, the range of the indexes, the largest compensation in all individual cases but the life satisfaction model for Bogotá, is the one implied by the index based exclusively on the socioeconomic strata. The most important individual factor in the QoL model for Bogotá is that based on household characteristics. When we estimate the average difference between two consecutive ranking according to the total QoH for Bogotá, we find that moving someone from one *localidad* to the next in the ranking would require a compensation of somewhat more than USD1500. The same exercise for Medellín would lead us to a compensation of just USD21, but since this was obtained with a flow (rent paid) rather than a stock (house value), we could estimate the net present value of the flow in about USD2500.[37] The life satisfaction model would imply compensations of USD100 in Bogotá and USD800 in Medellín.

[36] It is a bit surprising the negative average obtained for the indexes based on the life satisfaction models, being more negative in Medellín than in Bogotá. According to our approach, it would imply that individuals are pricing negative characteristics in a magnitude they cannot afford to fully compensate with their reported income. This fact suggests a gap between the way household heads consider things should be and what they are actually willing to pay to make things come true.

[37] 12 times the amount as an annual perpetuity at the 10% discount rate. A discount rate of 15% would imply a present value of USD1700, very similar to the one for Bogotá.

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, households headed by women, and adolescent pregnancy, among other variables. 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 contribute substantially in the estimation of the QoH index based on the hedonic price 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), Conley and Topa (2002), Cutler and Glaeser (1997), Kremer (1997), and Topa (2001) 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 2A and 3A, 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. On average, the price of the characteristics included in the analysis is smaller in Bogotá, but that is likely to be affecting mostly relative prices between those characteristics and the other ones that determine house values, rather than increasing the total costs of houses *conditioning on characteristics*.

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 and rankings of specific neighborhoods of the cities. 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.

Policy Recommendations

Some policies that oriented to learn more about the condition and dynamics of quality of life within cities could be the following:

(i) Establishing a system to monitor quality of life within cities. There already exist efforts in this direction, an example of which is the program lead by several ONGs that began monitoring socioeconomic indicator in Bogotá, and now is monitoring other cities like Medellín.[38] This network for monitoring cities collect data from several secondary sources, and also collect their own survey to assess their citizen's satisfaction with the current local administration. In addition, they promote debates and meetings with the local administration and local actors (industry, commerce, academia, etc.). Their most valuable asset is their independent and technical approach to local issues, which they must safeguard.

Institutions like this should move ahead and look for a much more detailed monitoring of local issues. The local administration of both cities, Bogotá and Medellín, have advanced substantially in the generation of information to allow these institutions and the academia to analyze the local situation, and that have made possible for us to generate additional information contained in this article.

(ii) There are still some procedures that could be improved in order to get timely and better information. One direction of potential improvement is towards

[38] These are the programs know as "Bogotá"and "Medellín""*Cómo Vamos?*", which are part of a wider cities monitoring network denominated "*Red de Ciudades*".

standardization of data. While Bogotá's LSMS survey is collected by The National Department of Statistics, Dane, Medellín LSMS is collected by local firms, which prevents comparison with other cities and regions included in the national LSMS collected by Dane as important as the unemployment, poverty and misery rates, coverage and quality of public utility services, education, health care and health insurance, etc.

(iii) Given the possibility to learn from hedonic models like the ones used in this article, producing detailed updated cadastral data becomes crucial. Although the National government counts with the Geographic Institute Agustin Codazzi, IGAC, which is in charge of keeping updated cadastral information of the whole country, three regions composed by two departments (Antioquia among them, where Medellín is located) and Bogotá, decided at some point they would do the task by themselves. In this direction there is room for improvements, possibly more in the case of Medellín. The IGAC has supported these cities previously and can continue doing it so that cadastral data becomes available for further analysis.

(iv) As it was shown in this article, the lack of accessible cadastral data can be substituted for several purposes by very simple and easily to collect information like the one on life satisfaction. It is very important though that life satisfaction questions keep comparability with previous experiences.

(v) There is a lot of information that can be used from the population censuses to build indicators to monitor quality of life and several other topics of interest at very detailed levels within the city. Local authorities should keep contributing to make administrative records available to the analysts, since ultimate beneficiaries of their findings are themselves. Multilateral organizations have as well a paramount opportunity, and a huge responsibility, in finding the mechanisms by which multiple sources of data from several countries, like the well known Gallup, LSMS and employment surveys among others, can be made available to analysts and researchers from public and private institutions in need of these data.

(vi) Finally, making data available is a good way to avoid policies to depend on the institutional capacity and specific interests of the exclusive institutions that currently provide them or have access to it.

References

Ansellin L. (1988) "Spatial Econometrics Methods and Models" Boston: Kluwer Academic Publishers, University of California, Santa Barbara.

Argyle, M. (1999) "Causes and Correlates of Happiness" in: Kahneman, D., Diener, E. and Schwarz, N. (eds.). *Well-Being: The Foundations of Hedonic Psychology* Russell Sage Foundation, New York. Chapter 18.

Bayer, Patrick; Fang, Hanming, and McMillan, Robert (2005) "Separate When Equal? Racial Inequality and Residential Segregation" NBER WP 11507, June.

Benabou, Roland (1996a) "Equity and Efficiency in Human Capital Investment: The Local Connection" *The Review of Economic Studies*, Vol. 63, No. 2, April, pp. 237-264.

Benabou, Roland (1996b) "Heterogeneity, Stratification, and Growth: Macroeconomic Implications of Community Structure and School Finance" *The American Economic Review*, June, pp. 584-609.

Black, Sandra (1999) "Do Better Schools Matter? Parental Valuation of Elementary Education" *Quarterly Journal of Economics* 114, No. 2: 577-99.

Blanchflower, D. and Oswald, A. (2000) "Well-being over Time in Britain and the USA" NBER WP 7487, February.

Blinder, A. S. (1973) "Wage Discrimination: Reduced Form and Structural Estimates" *Journal of Human Resources* 8, 436-55.

Blomquist, G.C.; Berger, M.C. and Hoehn, J.P. (1988) "New Estimates of Quality of Life in Urban Areas", *American Economic Review*, 78, pp.89-107.

Bogotá (2004) "Diagnóstico físico y socioeconómico de las localidades de Bogotá, D.C."

Borjas, George (1995) "Ethnicity, Neighborhoods, and Human-Capital Externalities" *The American Economic Review*, Vol. 85, No. 3, June, pp.365-390.

Borjas, George (1998) "To Ghetto or Not to Ghetto: Ethnicity and Residential Segregation" *Journal of Urban Economics*, 44, pp. 228-253.

Castaño, Elkin (2005) "Evolución de las Condiciones de Vida y Reestimacióndel Indicador de Calidad de Vida para la Ciudad de Medellín" Departamento Administrativo de Planeación de Medellín – Centro de Estudios de Opinión, Universidad de Antioquia, Marzo.

Conley, Timothy G. and Topa, Giorgio (2002) "Socio-Economic Distance and Spatial Patterns in Unemployment", *Journal of Applied Econometrics*, Vol. 17, 2002, 303-327.

Cutler, David and Glaeser, Edward (1997) "Are Ghettos Good or Bad? *The Quarterly Journal of Economics*

Davidson, R.J. (2000) "Affective Style, Psychopathology and Resilience: Brain Mechanisms and Plasticity" *American Psychologist*, 55, 1196-1214.

Davidson, R.J., Jackson, D.C. and Kalin, N.H. (2000) "Emotion Plasticity, Context and Regulation: Perspectives from Affective Neurosciences" *Psychologycal Bulletin*, 126, 890-906.

Departamento Nacional de Planeación, DNP (1997) "Índice de Condiciones de Vida Urbano-Rural" Misión Social.

Di Tella, R. and MacCulloch, R. (2007) "Happiness, Contentment and other Emotions for Central Banks" NBER WP No. 13622, November.

Di Tella, R,; MacCulloch, R. and Oswald, A. (2001) "Preferences over Inflation and Unemployment: Evidence from a Survey of Happiness" *American Economic Review*, March.

Echeverri, Juan C.; Ibáñez, Ana M.; Moya, Andrés, and Hillón, Luis C. (2005) "The Economics of *Transmilenio*, a Mass Transit System for Bogotá" Economía, Vol. 5, No. 2, Spring.

Ferrer-i-Carbonell, A. and Frijters, P. (2004) "How Important is Methodology for Estimates of the Determinants of Happiness?" The Economic Journal, Vol. 114, Issue 497, July.

Ferrer-i-Carbonell, A. and Van Praag, Bernard (2002) "The subjective costs of health losses due to chronic diseases: An alternative model for monetary appraisal" *Health Economics*, 11: 709-722.

Fields, Gary S. (2002) "Accounting for Income Inequality and its Change: A New Method, with Application to the Distribution of Earnings in the United States" mimeo, Cornell University. Forthcoming in *Research in Labor Economics.*

Frey, B. and Stutzer, A. (2002) "What Can Economist Learn from Happiness Research?" *Journal of Economic Literature*, June

Frijters, Paul; Haisken-DeNew, John P., and Shileds, Michael A. (2004a) "Money Does Matter! Evidence from Increasing Real Income and Life Satisfaction in East Germany Following Reunification" *The American Economic Review*, June

Frijters, Paul; Haisken-DeNew, John P., and Shileds, Michael A. (2004b) "Investigating the Patterns and Determinants of Life Satisfaction in Germany Following Reunification" *The Journal of Human Resources*, *XXXIX*, 3.

Gaviria, Alejandro, Medina, Carlos, Morales, Leonardo, and Núñez, Jairo (2008) "The Cost of Avoiding Crime: The Case of Bogotá" *Borradores de Economía* No. 508.

González, J; Fresneda, O.; Martínez, P.; Rodríguez, O.; Sarmiento, A.; Oviedo, M.; Lasso, F.; and Camacho, D. (2004) "Evolución de los Principales Indicadores Sociales de Bogotá (1990-2003)" mimeo, Alcaldía de Bogotá.

Gyourko, J.; Kahn, M. and J. Tracy (1999) "Quality of Life and Environmental Comparisons," Handbook of Regional and Urban Economics, Volume 3, edited by Paul Cheshire and Edwin Mills, 1413-1454. New York, North-Holland, 1999.

Hakim, C. (2003b) "Work-Lifestyle Choices in the 21st Century: Preference Theory" Oxford University Press.

Hall, P.; Fisher, N.I., and Hoffman, B. (1994) "On the Non-Parametric Estimation of Covariance Functions" *The Annals of Statistics*, Vol. 22, No. 4 (December), pp. 2115-2134.

Kohler, Hans Peter; Berhmab, Jere, and Skytthe, Axel (2005) "Partner + Children = Happiness? An Assessment of the Effect of Fertility and Partnership on Subjective Well-Being" *Population and Development Review*, 31 (3): 407-445 (September)

Kremer, Michael (1997) "How Much Does Sorting Increase Inequality?" *The Quarterly Journal of Economics*.

Layard, Richard (2003) "Happiness: Has Social Science a Clue?" Lionel Robbins Memorial Lectures, London School of Economics, March

McLanahan, S. and Adams, J. (1987) "Parenthood and Psychological Well-Being" *Annual Review of Sociology* 13: 237-257.

Medina, Carlos, and Morales, Leonardo (2007) "Stratification and Public Utility Services in Colombia: Subsidies to Households or Distortions on Housing Prices?" *Economia*, Vol. 7, No. 2, Spring.

Mendieta, Juan C., and Perdomo, Jorge A. (2007) "Especificación y Estimación de un Modelo de Precios Hedónicos Espacial para Evaluar el Impacto de Transmilenio sobre el Valor de la Propiedad en Bogotá" Documento CEDE 22, Octubre.

Moran P. (1948) “The interpretation of statistical maps”, *Journal of the Royal Statistical Society* B, 10, 243-251.

Nomaguchi, K. M. and Milkie, M. A. (2003) “Costs and Rewards of Children: The Effects of Becoming a Parent on Adult’s Lives” *Journal of Marriage and the Family* 65 (2): 356-374

Oaxaca, R. (1973) “Male-Female Wage Differentials in Urban Labor Markets” *International Economic Review* 14, 693-709.

Paz Pública (2000) “Escenarios del Crimen en los Barrios y Localidades de Bogotá” Investigación “Caracterización de la Violencia Homicida en Bogotá”, Documento de Trabajo No. 1. Bogotá: Paz Pública-CEDE-UNIANDES and Alcaldía de Bogotá.

Rosen, Sherwin (1974) “Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition” *Journal of Political Economy* 82, No. 1 (January): 34-55.

Schelling, Thomas C. (1969) “Models of Segregation” The American Economic Review, Vol. 59, No. 2 May, pp. 488-493.

Schelling, Thomas C. (1972) “A Process of Residential Segregation: Neighborhood Tipping” In *Racial Discrimination in Economic Life*, Edited by Anthony H. Pascal, Lexinton, Mass: Lexinton.

Shorrocks, A. F. (1982) “Inequality Decomposition by Factor Components” *Econometrica*, Vol. 50, No. 1 (Jan.), pp. 193-211.

Topa, Giorgio (2001) “Social Interactions, Local Spillovers and Unemployment”, *Review of Economic Studies*, Vol. 68 (2), April, 261-295.

United Nations Population Fund, UNFPA (2007) “State of World Population 2007: Unleashing the Potential of Urban Growth”. Download

Van Praag, Bernard M.S. (2007) “Perspectives from the Happiness Literature and the Role of New Instruments for Policy Analysis” CESifo Economic Studies, March 2007; 53: 42 - 68.

Annex 1. 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 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.

Annex 2. Descriptive statistics of key variables for Bogotá and Medellín

Bogotá

Variable	Mean	Std. Dev.
Cadastral value ($Mll)*	52.8	56.0
Cadastral value or value estimated by owner ($Mll)*	54.6	58.1
Log of the cadastral value*	17.45	0.76
Log of the cadastral value or value estimated by owner	17.48	0.77
log of the rent paid	12.41	0.79
log of the rent paid or rent estimated by the owner**	12.13	0.70
Currently, living conditions in your households are:***	0.617	0.486
Number of rooms	3.42	1.51
Number of bathrooms	2.12	0.95
House with piped gas service	0.700	0.458
Household cocks with piped gas	0.658	0.474
Bad quality of the electricity service	0.024	0.153
Bad quality of garbage collection service	0.029	0.169
Bad quality of fixed phone line service	0.051	0.221
House with garden	0.428	0.495
House with court yard	0.045	0.208
House with garage	0.303	0.460
House with terrace	0.228	0.420
House	0.412	0.492
House with potable water service	0.991	0.097
High quality floor material	0.820	0.385
High quality wall material	0.989	0.102
Stratum 2	0.337	0.473
Stratum 3	0.429	0.495
Stratum 4	0.099	0.299
Stratum 5	0.043	0.202
Stratum 6	0.030	0.171
Constructed area (squared meters)	163.14	123.49
Area of land (squared meters)	114.34	390.89
Parks in neighborhood	0.151	0.358
Do you feel safe in your neigborhood	0.689	0.463
House in area vulnerable to natural disasters	0.073	0.260
Factories in neighborhood	0.103	0.304
Garbage collection in neigborhood	0.024	0.155
Airports in neighborhood	0.036	0.185
Terminals of ground transportation in neighborhood	0.039	0.193
Land use is productive housing	0.410	0.492
Class of soil is integral improvement	0.279	0.448
Class of soil is integral renovation	0.025	0.156
Distance to nearest school****	209	144
Distance to nearest university	1,524	1,068

Distance to nearest place of public administration	1,023	700
Distance to nearest social welfare institution	285	203
Distance to places for recreation or sports	1,588	1,016
Distance to nearest cultural place	385	309
Distance to nearest place of defense or justice	1,737	1,050
Distance to nearest place of food provision	1,973	1,353
Distance to nearest place of fairs	5,552	3,177
Number of places of food provision per 1000 population	0.004	0.026
Number of churches/worship places per 1000 population	0.065	0.139
Number of places of defense or justice per 1000 population	0.020	0.129
Number of places for vigilance per 1000 population	0.030	0.079
Number of social welfare institutions per 1000 population	0.186	0.249
Number of cultural places per 1000 population	0.130	0.369
Number of schools per 1000 population	0.288	0.304
Lakes area (M^2) per 1000 population	541.18	2,982
Number of places of fairs per 1000 population	0.0020	0.033
Parks area (M^2) per 1000 population	3,015	7,302
Forest area (M^2) per 1000 population	138.42	2,756
Land use is productive housing	0.410	0.492
Crime rate (murders per 100000 population)	1.662	2.833
Cars theft rate	0.378	0.613
Attacks	0.320	0.466
Gini coefficient of education	0.050	0.013
Number of attacks against life per 10000 population	0.400	0.791
Number of attacks against wealth per 10000 population	0.590	0.897
Number of bars per 10000 population	0.615	1.070
Number of casinos/places for bets per 10000 population	0.105	0.608
Number of places selling drugs/narcotics per 10000 population	0.488	0.851
Population Density	55.29	70.72
Unemployment rate	0.076	0.021
Average of education years by census track	10.22	2.23
Share of female heads	0.096	0.024
Illiteracy rate	0.081	0.046
Piped gas coverage	0.803	0.142
Household's per capita income ($Thousands)	632.9	2,932
Log of household's per capita income	12.62	1.12
Household head with complete high school	0.170	0.376
Household head with incomplete college	0.143	0.350
Household head with complete college	0.183	0.387
Age	47.13	14.85
Age square	2,442	1,514
Number of children in household	0.193	0.461

Widowed household head	0.090	0.286
Unemployed household head	0.059	0.235
Household head has any kind of health insurance	0.814	0.389
Household head has any chronic disease	0.191	0.393
Household head was sick any time during last 30 days	0.106	0.308
Hhold head was hospitalized any time during last 12 months	0.071	0.257
Mean difference between age and education for <25	4.92	3.96
Percentage of <25 that assists to a public school or college	0.297	0.439
Hhold head's mother with complete elementary school	0.256	0.437
Hhold's per capita income *(No. children < 18) ($Thousands)	299	704
Married*(Number of childrens under 18)	0.736	1.075
Hhold head with complete high school*(No children under 18	0.170	0.575
Hhold head with college*(No children under 18)	0.265	0.679
Hhold head with college*(No children under 4)	0.082	0.324
Age of Household head*(No children under 18)	36.05	45.00
Number of observations	12,769	
Number of households	1,934,575	

* 8,868 observations, 1'369,791 households; ** 5,360 observations, 767,030 households; *** "Standardized" options are: very good (1), good (0.75), fair (0.5), bad (0.25); **** All distances are in meters.

Medellín

Variable	**Mean**	**Std. Dev.**
Log of rent paid (or value estimated by the owner)*	12.44	0.74
Log of rent paid*	12.34	0.66
Currently, living conditions in your households are:***	0.685	0.465
Number of rooms	4.24	1.55
Number of bathrooms	1.45	0.81
House with fixed telephone line	0.960	0.196
House with piped gas service	0.307	0.461
Household cocks with piped gas	0.405	0.491
House with GPL service	0.388	0.487
House with internet service	0.196	0.397
House with Satellite television service	0.569	0.495
House	0.499	0.500
House with garage	0.182	0.386
High quality floor material	0.774	0.418
High quality wall material	0.986	0.117
House with potable water service	0.997	0.056
Kitchen is an aditional room	0.981	0.137
Stratum 2	0.354	0.478
Stratum 3	0.320	0.466
Stratum 4	0.112	0.315
Stratum 5	0.089	0.285
Stratum 6	0.034	0.182
House in area vulnerable to natural disasters	0.054	0.227

Class of soil is urban	0.991	0.093
Class of soil is rural	0.006	0.078
Class of soil is residential	0.804	0.397
Distance to nearest cultural place****	710	478
Distance to nearest place of public administration	1,134	599
Distance to nearest metro or metroplus station	1,258	1,038
Distance to nearest place of refugee for children and the elder	1,164	878
Distance to nearest market place	2,535	1,537
Distance to nearest place of recreation or sports	818	485
Distance to nearest church/worship place	301	182
Distance to nearest place of vigilance	795	777
Distance to nearest place related with utility services	669	371
Distance to nearest place of help in case of disasters	2,005	1,449
Distance to nearest river or stream	2,107	1,353
Distance to nearest hill	2,046	1,133
Distance to nearest place identified as cultural heritage	1,055	972
Distance to nearest road connecting the city to neighbor cities	4,424	2,133
Distance to nearest university	1,596	1,013
Number of jails per 1000 population	0.003	0.060
Number of social welfare places per 1000 population	0.042	0.083
Number of cultural places per 1000 population	0.033	0.091
No. hospitals or medical centers per 1000 population	0.062	0.182
Number of places of public administration per 1000 population	0.014	0.300
Number of metro or metroplus stations per 1000 population	0.021	0.125
Number of market places per 1000 population	0.002	0.024
No. of places related with utility services per 1000 population	0.030	0.085
Number for help in case of disasters per 1000 population	0.004	0.026
Population Density	55.61	126.74
Average of education years by census track	9.24	2.03
Crime rate (murders per 100000 population)	10.75	8.41
Age	51.59	17.10
Age squared	2,954	7,217
Log of Income percapita	12.08	0.98
Number of sons and daugthers minor than 18	0.745	1.037
Married household head	0.445	0.497
Widowed household head	0.145	0.352
Household head have any kind of medical secure	0.950	0.219
Mother or father unemployed or inactive * No of children under 5	0.152	0.432
Percentage of <25 that assists to a public school or college	0.394	0.476
Hhold head with complete primary *(Number children under 18)	0.197	0.644
Hhold head with complete high school*(No children under 18)	0.201	0.614
Household head with college*(Number of children under 18)	0.237	0.653
Mean difference between age and education for people under 25	25.06	6.88
Number of observations	19,655	
Number of households	553,402	

Annex 3. Ranking of *localidades* of Bogotá and *Comunas* of Medellín according to our quality of housing, QoH, and quality of life, QoL, indexes

Table A3.1 QoH by *localidad*. Bogotá, 2003.

	Amenities		Stratum		Amenities + Stratum		Housing		Total	
1	Barrios Unidos	8,371,543	Chapinero	43,132,797	Chapinero	47,367,804	Los Martires	71,708,020	Barrios Unidos	103,920,558
2	Usaquén	7,608,590	Usaquén	37,289,294	Usaquén	44,897,885	Antonio Nariño	71,032,885	Chapinero	101,263,532
3	Suba	5,930,696	Teusaquillo	32,471,591	Barrios Unidos	37,111,045	Puente Aranda	68,825,474	Usaquén	100,638,299
4	Teusaquillo	4,474,754	Barrios Unidos	28,739,502	Teusaquillo	36,946,345	Barrios Unidos	66,809,513	Antonio Nariño	95,649,052
5	Chapinero	4,235,006	Suba	28,709,570	Suba	34,640,265	Tunjuelito	64,463,287	Los Martires	94,376,609
6	Antonio Nariño	1,126,135	Fontibón	26,271,372	Fontibón	25,195,235	La Candelaria	61,833,116	Teusaquillo	93,370,211
7	Los Martires	-827,634	Los Martires	23,496,224	Antonio Nariño	24,616,166	Fontibón	61,423,024	Suba	89,635,952
8	Fontibón	-1,076,137	Antonio Nariño	23,490,031	Los Martires	22,668,590	Engativa	57,353,334	Puente Aranda	88,972,817
9	Engativa	-1,861,510	Puente Aranda	23,462,228	Engativa	21,244,515	Teusaquillo	56,423,866	Fontibón	86,618,259
10	Puente Aranda	-3,314,885	Engativa	23,106,025	Puente Aranda	20,147,343	Usaquén	55,740,414	Engativa	78,597,849
11	Kennedy	-4,264,068	Kennedy	20,833,379	Kennedy	16,569,312	Bosa	55,279,541	Tunjuelito	74,499,366
12	Tunjuelito	-7,635,458	Rafael Uribe	17,673,727	Tunjuelito	10,036,078	Kennedy	55,243,638	Kennedy	71,812,949
13	La Candelaria	-9,817,124	Tunjuelito	17,671,536	Rafael Uribe	7,720,447	Suba	54,995,687	La Candelaria	65,724,009
14	Bosa	-9,865,556	Santafé	17,220,651	Bosa	4,261,242	Rafael Uribe	54,868,463	Rafael Uribe	62,588,910
15	Rafael Uribe	-9,953,280	San Cristóbal	14,839,514	La Candelaria	3,890,893	Chapinero	53,895,728	Bosa	59,540,783
16	San Cristóbal	-14,259,901	Bosa	14,126,798	San Cristóbal	579,613	San Cristóbal	53,280,809	San Cristóbal	53,860,422
17	Ciudad Bolivar	-18,009,783	La Candelaria	13,708,017	Santafé	-3,537,536	Santafé	50,248,407	Santafé	46,710,871
18	Usme	-18,190,350	Usme	10,892,814	Usme	-7,297,536	Ciudad Bolivar	47,668,137	Ciudad Bolivar	38,068,795
19	Santafé	-20,758,188	Ciudad Bolivar	8,410,441	Ciudad Bolivar	-9,599,341	Usme	44,028,074	Usme	36,730,538

Table A3.2 QoL by *localidad*. Bogotá, 2003.

	Housing		Stratum		Amenities		Stratum+Amenities		Household		Total		Total without SES	
1	Usaquén	1,301,422	Usme	-17,844	Chapinero	1,096,164	Chapinero	885,846	Chapinero	149,588	Chapinero	2,404,008	Chapinero	2,193,690
2	Puente Aranda	1,256,835	Ciudad Bolivar	-25,251	Teusaquillo	1,054,115	Candelaria	863,427	Usaquén	-121,107	Usaquén	2,115,113	Usaquén	1,856,494
3	Engativá	1,253,779	Bosa	-41,879	Usaquén	934,797	Santafé	723,147	Teusaquillo	-1,011,178	Teusaquillo	1,257,450	Teusaquillo	843,462
4	Antonio Nariño	1,228,016	San Cristobal	-58,882	Candelaria	930,378	Usaquén	676,179	Suba	-1,515,775	Suba	446,784	Suba	180,104
5	Teusaquillo	1,214,513	Candelaria	-66,951	Barrios Unidos	889,425	Teusaquillo	640,127	Barrios Unidos	-1,697,620	Barrios Unidos	350,106	Barrios Unidos	16,669
6	Suba	1,208,587	Tunjuelito	-107,834	Santafé	840,414	Barrios Unidos	555,987	Candelaria	-1,896,160	Engativá	-108,694	Candelaria	-214,454
7	Kennedy	1,176,343	Santafé	-117,267	Suba	753,972	Suba	487,292	Engativá	-2,009,505	Antonio Nariño	-314,148	Engativá	-339,344
8	Barrios Unidos	1,158,301	Rafael Uribe	-124,951	Antonio Nariño	649,685	Engativá	416,381	Fontibón	-1,997,088	Candelaria	-147,503	Santafé	-424,515
9	Chapinero	1,158,255	Kennedy	-178,818	Engativá	647,031	Antonio Nariño	409,227	Santafé	-1,916,088	Fontibón	-238,170	Fontibón	-532,165
10	Fontibón	1,141,009	Chapinero	-210,318	Fontibón	617,909	Mártires	335,403	Puente Aranda	-2,151,593	Puente Aranda	-457,258	Antonio Nariño	-554,607
11	Tunjuelito	1,089,697	Engativá	-230,650	Mártires	574,403	Fontibón	323,914	Antonio Nariño	-2,191,849	Santafé	-307,247	Puente Aranda	-696,669
12	Rafael Uribe	1,083,073	Mártires	-239,000	Puente Aranda	437,500	Usme	307,145	Kennedy	-2,264,543	Mártires	-619,104	Mártires	-858,103
13	Mártires	1,059,325	Puente Aranda	-239,410	Usme	324,989	San Cristobal	261,539	Tunjuelito	-2,370,955	Kennedy	-808,076	Kennedy	-986,894
14	Bosa	995,148	Antonio Nariño	-240,458	San Cristobal	320,421	Puente Aranda	198,089	Mártires	-2,252,832	Tunjuelito	-989,482	Tunjuelito	-1,097,316
15	Ciudad Bolivar	970,962	Usaquén	-258,619	Tunjuelito	291,776	Tunjuelito	183,942	Bosa	-2,507,114	Rafael Uribe	-1,238,694	Rafael Uribe	-1,363,645
16	Usme	933,514	Suba	-266,680	Kennedy	280,125	Kennedy	101,306	Ciudad Bolivar	-2,549,417	San Cristobal	-1,350,009	San Cristobal	-1,408,890
17	San Cristobal	916,575	Fontibón	-293,995	Rafael Uribe	183,048	Rafael Uribe	58,098	Rafael Uribe	-2,504,815	Usme	-1,405,277	Usme	-1,423,121
18	Candelaria	818,278	Barrios Unidos	-333,438	Bosa	39,052	Bosa	-2,827	San Cristobal	-2,587,005	Bosa	-1,472,913	Bosa	-1,514,792
19	Santafé	768,427	Teusaquillo	-413,988	Ciudad Bolivar	-50,423	Ciudad Bolivar	-75,674	Usme	-2,663,780	Ciudad Bolivar	-1,628,878	Ciudad Bolivar	-1,654,129

Table A3.3 Correlation coefficients between the different indexes. Bogotá, 2003

		Quality of Housing					Quality of Life					
		Amenities	Socioeconomic Stratum	Amenities +Stratum	Housing	Total	Housing	Socioeconomic Stratum	Amenities	Amenities +Stratum	Household	Total
Quality of Housing	Amenities	1.0000										
	Stratum	0.9501	1.0000									
	Amenities +Stratum	0.9884	0.9757	1.0000								
	Housing	0.9528	0.9632	0.9667	1.0000							
	Total	0.9892	0.9255	0.9713	0.9290	1.0000						
Quality of Life	Housing	0.9784	0.9231	0.9613	0.9251	**0.9909**	1.0000					
	Stratum	0.9724	0.9454	0.9722	0.9764	0.9663	0.9575	1.0000				
	Amenities	**0.9898**	0.9600	0.9906	0.9621	0.9831	0.9763	0.9783	1.0000			
	Amenities +Stratum	0.9798	0.9793	**0.9913**	**0.9848**	0.9617	0.9536	0.9771	0.9834	1.0000		
	Household	0.8299	0.9498	0.8838	0.8999	0.7858	0.7741	0.8374	0.8436	0.9050	1.0000	
	Total	0.9087	**0.9810**	0.9459	0.9407	0.8728	0.8634	0.8996	0.9136	0.9574	0.9813	1.0000

Table A3.4 QoH by *Comuna*. Medellín, 2006.

	Amenities		Stratum		Amenities + Stratum		Housing		Total		Castano (2005)
1	EL POBLADO	235,851	EL POBLADO	316,131	EL POBLADO	551,982	EL POBLADO	605,202	EL POBLADO	1,157,184	Poblado
2	LAURELES-ESTADIO	199,523	LAURELES-ESTADIO	245,726	LAURELES-ESTADIO	445,249	LAURELES-ESTADIO	573,057	LAURELES-ESTADIO	1,018,305	Laureles Estadio
3	BELEN	181,981	LA AMERICA	174,745	LA AMERICA	354,887	LA AMERICA	519,697	LA AMERICA	874,584	América
4	LA AMERICA	180,143	LA CANDELARIA	149,481	LA CANDELARIA	327,546	BELEN	513,300	BELEN	839,329	Belén
5	LA CANDELARIA	178,065	BELEN	144,048	BELEN	326,029	LA CANDELARIA	483,262	LA CANDELARIA	810,808	Candelaria
6	GUAYABAL	160,269	GUAYABAL	121,203	GUAYABAL	281,471	GUAYABAL	483,086	GUAYABAL	764,558	Guayabal
7	ROBLEDO	114,412	CASTILLA	102,883	CASTILLA	213,639	CASTILLA	449,378	CASTILLA	663,017	Castilla
8	BUENOS AIRES	113,042	BUENOS AIRES	89,312	BUENOS AIRES	202,354	BUENOS AIRES	449,314	BUENOS AIRES	651,668	Robledo
9	CASTILLA	110,756	ARANJUEZ	80,625	ARANJUEZ	178,205	ROBLEDO	435,436	ARANJUEZ	611,614	Buenos Aires
10	SAN JAVIER	104,417	ROBLEDO	60,713	ROBLEDO	175,125	ARANJUEZ	433,409	ROBLEDO	610,561	Aranjuez
11	ARANJUEZ	97,580	SAN JAVIER	57,524	SAN JAVIER	161,941	DOCE DE OCTUBRE	430,830	SAN JAVIER	587,189	12 de Octubre
12	VILLA HERMOSA	82,332	DOCE DE OCTUBRE	52,425	VILLA HERMOSA	133,577	SAN JAVIER	425,248	DOCE DE OCTUBRE	557,931	San Javier
13	DOCE DE OCTUBRE	74,676	VILLA HERMOSA	51,245	DOCE DE OCTUBRE	127,101	MANRIQUE	416,650	VILLA HERMOSA	543,592	Manrique
14	MANRIQUE	73,021	MANRIQUE	43,897	MANRIQUE	116,917	VILLA HERMOSA	410,015	MANRIQUE	533,568	VillaHermosa
15	SANTA CRUZ	69,551	SANTA CRUZ	34,629	SANTA CRUZ	104,180	SANTA CRUZ	394,288	SANTA CRUZ	498,468	Santa Cruz
16	POPULAR	22,741	POPULAR	27,206	POPULAR	49,947	POPULAR	376,142	POPULAR	426,089	Popular

Rank Corr con Castano	0.968	0.982	0.974	0.997	0.985

Table A3.5 QoL by *Comuna*. Medellín, 2006.

	Housing		Stratum		Amenities		Stratum+Amenities		Household		Total		Castano (2005)
1	EL POBLADO	11,048,093	EL POBLADO	11,854,197	LA AMERICA	-903,927	EL POBLADO	10,386,203	BELEN	-8,997,374	EL POBLADO	12,145,483	Poblado
2	LAURELES-ESTADIO	10,707,786	LAURELES-ESTADIO	10,355,856	EL POBLADO	-1,467,994	LAURELES-ESTADIO	7,793,033	EL POBLADO	-9,288,814	LAURELES-ESTADIO	7,382,149	Laureles Estadio
3	LA AMERICA	10,018,424	LA AMERICA	7,941,392	SAN JAVIER	-1,611,504	LA AMERICA	7,037,464	LA AMERICA	-11,174,688	LA AMERICA	5,881,200	América
4	BELEN	9,631,911	LA CANDELARIA	7,290,867	ROBLEDO	-1,849,516	BELEN	2,850,570	LAURELES-ESTADIO	-11,118,670	BELEN	3,485,107	Belén
5	LA CANDELARIA	9,281,231	BELEN	6,338,172	DOCE DE OCTUBRE	-2,373,913	GUAYABAL	2,766,052	LA CANDELARIA	-12,286,548	GUAYABAL	-630,834	Candelaria
6	GUAYABAL	9,219,740	GUAYABAL	5,228,231	GUAYABAL	-2,462,179	LA CANDELARIA	1,219,233	CASTILLA	-12,493,884	LA CANDELARIA	-1,786,084	Guayabal
7	CASTILLA	8,710,647	CASTILLA	4,004,240	LAURELES-ESTADIO	-2,562,824	SAN JAVIER	450,906	ROBLEDO	-12,510,473	CASTILLA	-3,625,064	Castilla
8	BUENOS AIRES	8,028,077	BUENOS AIRES	3,358,701	BELEN	-3,487,602	CASTILLA	158,173	SAN JAVIER	-12,598,714	ROBLEDO	-5,012,887	Robledo
9	DOCE DE OCTUBRE	7,941,994	ARANJUEZ	2,828,426	MANRIQUE	-3,608,793	ROBLEDO	-139,890	GUAYABAL	-12,616,625	SAN JAVIER	-5,052,471	Buenos Aires
10	ROBLEDO	7,637,476	SAN JAVIER	2,062,411	CASTILLA	-3,846,067	DOCE DE OCTUBRE	-1,136,728	BUENOS AIRES	-12,854,022	DOCE DE OCTUBRE	-6,702,126	Aranjuez
11	ARANJUEZ	7,533,632	ROBLEDO	1,709,626	ARANJUEZ	-4,322,524	ARANJUEZ	-1,494,099	MANRIQUE	-13,383,684	BUENOS AIRES	-6,904,632	12 de Octubre
12	SAN JAVIER	7,095,337	VILLA HERMOSA	1,512,887	VILLA HERMOSA	-4,519,245	BUENOS AIRES	-2,078,687	DOCE DE OCTUBRE	-13,507,391	ARANJUEZ	-7,620,614	San Javier
13	MANRIQUE	6,571,716	DOCE DE OCTUBRE	1,237,185	BUENOS AIRES	-5,437,388	MANRIQUE	-2,895,530	ARANJUEZ	-13,660,148	MANRIQUE	-9,707,497	Manrique
14	VILLA HERMOSA	6,241,057	MANRIQUE	713,263	POPULAR	-5,657,676	VILLA HERMOSA	-3,006,357	VILLA HERMOSA	-13,685,052	VILLA HERMOSA	-10,450,352	VillaHermosa
15	SANTA CRUZ	5,410,419	POPULAR	0	LA CANDELARIA	-6,071,634	POPULAR	-5,657,676	SANTA CRUZ	-13,793,202	SANTA CRUZ	-14,539,590	Santa Cruz
16	POPULAR	4,423,730	SANTA CRUZ	0	SANTA CRUZ	-6,156,808	SANTA CRUZ	-6,156,808	POPULAR	-13,963,263	POPULAR	-15,197,209	Popular

Rank Corr con Castano	0.532	0.447	0.271	0.471	0.632	0.512	

Table A3.6 Correlation coefficients between the different indexes. Medellín, 2006

		Quality of Housing					Quality of Life					
		Amenities	Socioeconomic Stratum	Amenities +Stratum	Housing	Total	Housing	Socioeconomic Stratum	Amenities	Amenities +Stratum	Household	Total
Quality of Housing	Amenities	1.0000										
	Stratum	0.9344	1.0000									
	Amenities +Stratum	0.9777	0.9873	1.0000								
	Housing	0.9651	0.9847	0.9925	1.0000							
	Total	0.9751	0.9882	0.9993	0.9962	1.0000						
Quality of Life	Housing	**0.9700**	0.8934	0.9393	0.9400	0.9400	1.0000					
	Stratum	0.9678	**0.9827**	**0.9909**	**0.9907**	**0.9923**	0.9415	1.0000				
	Amenities	0.9520	0.8793	0.9221	0.9176	0.9209	0.9832	0.9367	1.0000			
	Amenities +Stratum	0.9581	0.9634	0.9755	0.9781	0.9778	0.9572	0.9780	0.9389	1.0000		
	Household	0.9170	0.9773	0.9654	0.9790	0.9711	0.8949	0.9738	0.8843	0.9544	1.0000	
	Total	**0.9704**	0.9552	0.9755	0.9823	0.9785	0.9713	0.9820	0.9594	0.9906	0.9542	1.0000

Table A3.7 Rank Correlations of Indexes for Medellín and that by Castaño (2005)

		QoH						QoL					
		Amenities	**Stratum**	**Amenities + Stratum**	**Housing**	**Total**	**Castano (2005)**	**Housing**	**Stratum**	**Amenities**	**Stratum+Amenities**	**Household**	**Total**
QoH	**Amenities**												
	Stratum	0.9618											
	Amenities + Stratum	0.9647	0.9971										
	Housing	0.9647	0.9882	0.9794									
	Total	0.9676	**0.9971**	**0.9941**	0.9912								
Castano (2005)		0.9676	0.9824	0.9735	**0.9971**	0.9853							
QoL	**Housing**	0.9412	0.9735	0.9588	0.9912	0.9765	**0.9853**						
	Stratum	0.9529	0.9912	**0.9941**	0.9676	**0.9882**	0.9588	0.95					
	Amenities	0.5029	0.4441	0.4235	0.4882	0.4647	0.5147	0.5029	0.4324				
	Stratum+Amenities	0.9265	0.9235	0.9118	0.9294	0.9294	0.9382	0.9294	0.9206	**0.6765**			
	Household	0.9206	0.8824	0.8765	0.9088	0.8941	0.9176	0.8971	0.8706	0.5647	0.9147		
	Total	0.95	0.9441	0.9324	0.9618	0.95	0.9706	0.9618	0.9265	0.6412	**0.9853**	**0.9353**	

Annex 4. The Questionnaire of Life Satisfaction for Medellín and its Methodology

A4.1.1 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.

A4.1.2 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.

A4.1.3 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.

A4.1.4 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.

A4.2 Survey Work Plan

A4.2.1 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.

A4.2.2 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

A4.2.3 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.

A4.2.4 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.

A4.2.5 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

A4.3 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