The Cost of Avoiding Crime: The Case of Bogotá

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Abstract

We use hedonic price models to estimate the value households are willing to pay to avoid crime, and in particular, high homicides rates, in Bogotá. We and find that households living in the highest socioeconomic stratum, stratum 6, are paying up to 7.2% of their house values to keep their average homicide rates and avoid increasing them in one standard deviation. On their part, households in strata 5, that with the next group of richest population in the city, would be paying up to 2.4% of their house values to keep their average homicide rates.

The result reveals the willingness to pay for security by households in Bogotá, and additionally, reveals that a supposed pure public good like security, ends up propitiating urban private markets that auction security. These markets imply different levels of access to public goods among the population, and actually, the exclusion of the poorest.

We find as well evidence of negative capitalization of the rate of attacks against life, and positive capitalization of the presence of police authority in the form of Centers of Immediate Attention, CAIS.

1. Introduction

Quantifying the costs of crime is a very useful endeavor as it allows societies to build awareness of the social conflict that characterizes them, and allows policy makers to prioritize and design cost-effective policies to diminish its perverse effects. As explained by Krug et. al. (2002), the quantifiable costs of violence is usually estimated on what it represents in terms of health care expenditures and lost to national economies, as the ones coming from days lost from work, law enforcement and lost investment.[1]

These costs estimations nonetheless, do not usually consider the costs posed by violence in general, and crime in particular, to households within cities, in terms of the different risks they face across neighborhoods, and the mechanism they have available to deal with them. Specifically, within city variation of crime rates generate markets for this characteristic, which ends up being an additional amenity households chose at the moment to decide where they live.

There are at least two relevant issues to analyze regarding the way households get to an equilibrium in markets for this amenity: (i) quantifying the cost of the amenity to households, which usually is a cost paid by the better off, and (ii) identifying the barriers these costs pose to most citizens, since even though most households might be willing to pay for avoiding crime, just a few of them might be able to do it, making the crime rate, an indicator tied to security, a pure public good, being subject to private markets, with the standard exclusions that characterizes them.

In this paper we study these issues for the case of Bogotá, and find that households living in the highest socioeconomic stratum, stratum 6, are paying up to 7.2% of their house values to keep their average homicide rates and avoid increasing them in one standard deviation. On their part, households in strata 5, that with the next group of richest population in the city, would be paying up to 2.4% of their house values to keep their average homicide rates.

The result reveals the willingness to pay for security by households in Bogotá, and additionally, reveals that a supposed pure public good like security, ends up propitiating urban private markets that auction security. These markets imply different levels of access to public goods among the population, and actually, the exclusion of the poorest.

We now proceed to describe the levels of crime in Colombia and some previous work on the topic. Then we describe our data, empirical methodology and identification strategy. Finally, we present the results and offer some conclusions.

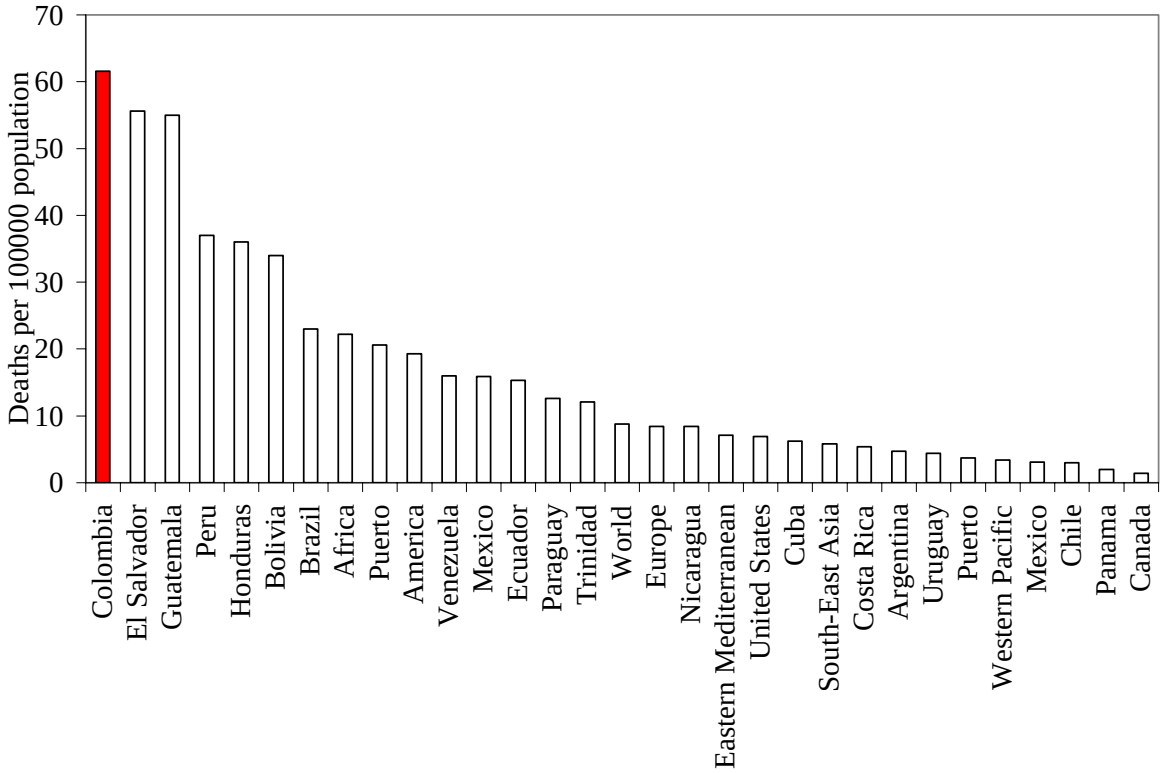
1. Crime in Colombia and Previous Work

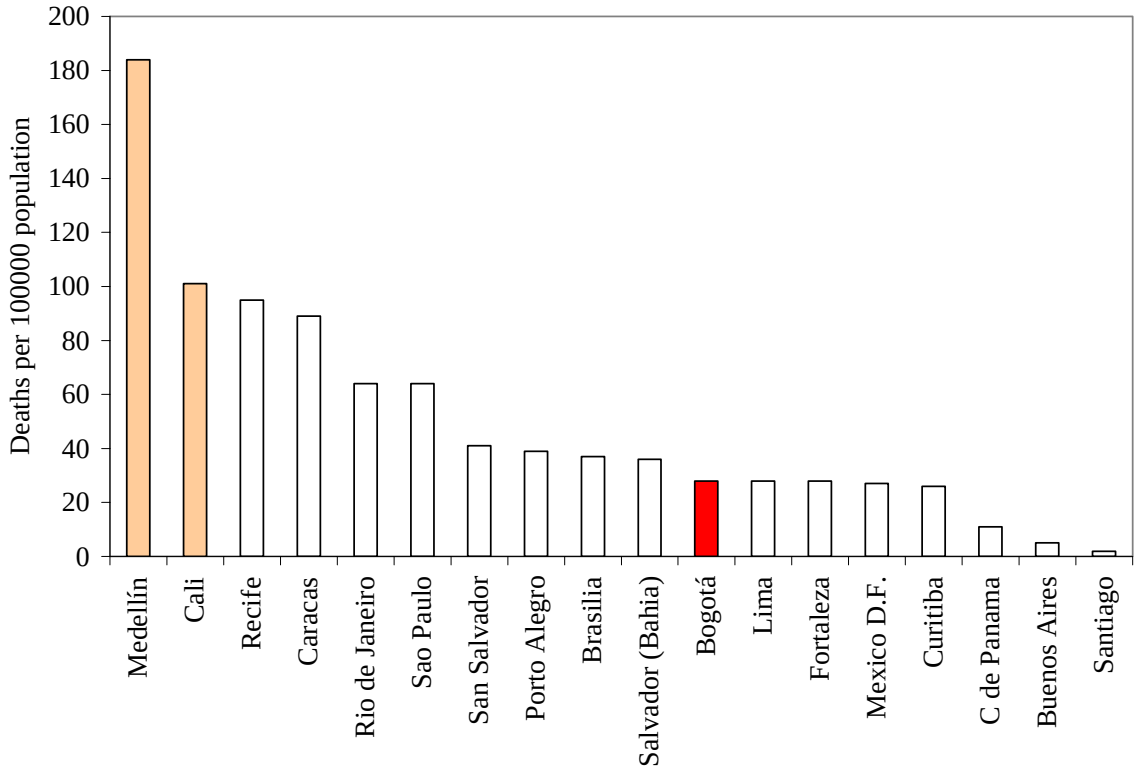
As it is shown in figure 1, Colombian homicide rate is among the highest among Latin American and Caribbean countries, with about six times the world's rate and three times the rate in America. On the other hand, the homicide rate in Bogotá is comparable to that of

[1] Other economic and personal costs are much less quantifiable, like the ones coming from pain and suffering of victims of violence.

some of the countries with the highest homicide rates, namely Peru, Honduras and Bolivia, although it is still much lower than that of the most violent cities in the country: Medellín and Cali.

Figure 1. Homicide Rates in LAC Countries in the 1990s and Cities in 2002.





Source: Krug et. al. (2002), Gaviria and Pages (2000), and LLorente and Rivas (2005)

Attempts to estimate the costs crime poses to households have been made internationally, while for the case of Colombia, only some characterization of who pays its burden has been made. For the case of the United States, Krug et. al. (2002) quote studies that find direct and indirect annual costs of gunshot wounds at US$ 126 billion, and costs of cutting or stab wounds for an additional US$ 51 billion. Costs of specific crimes have been valued by Atkinson et. al. (2005), who find that common assaults, moderate wounding, and serious wounding, are £5,300, £31,000 and £36,000 per average victim household per year respectively.

Among the studies that seek to estimate households' willingness to pay for security, Cohen et. al (2004) use a contingent valuation methodology to find that a typical American household would be willing to pay between US$100 and US$150 per year for crime prevention programs that reduce specific crimes by 10 percent in their communities, with the amount increasing according to the severity of crime: US$104 for burglaries and US$146 for murders. Previously, Cook and Ludwig (2000), and Ludwig and Cook (2001), had estimated that the average household would be willing to pay US$200 per year to reduce gun violence caused by criminals and juvenile delinquents by 30%.

Although studies that estimate hedonic price models have often included crime variables in the estimations, the identification of causal effects of the specific coefficient of these variable have not been their goal. For example, Roback (1982) does not find a statistically significant coefficient of crime rates on log earnings.

For Colombia, the closest attempt to quantify distributional effects of crime variables is that of Gaviria and Velez (2001), who find that rich households are more likely to be victims of property crime, to modify their behavior for fear of crime, to feel unsafe in the cities, and to invest more in crime avoidance, while the poorest are more likely to be victims of homicides and domestic violence, and the richest of kidnapping.

Other studies have focused in estimating the economic costs of violence in Colombia. Trujillo and Badel (1998) estimated the gross costs of urban criminality and armed conflict in Colombia between 1991 and 1996 in 4.25% of GDP. Badel (1999) estimated the gross direct costs of violence and armed conflict between 1990 and 1998 in 4.5% of GDP. Londoño and Guerrero (2000) estimate the direct costs of violence on health (medical attention and lost years of life) and material lost (public and private security, and justice) in 4.9% of GDP for a subset of Latin American and Caribbean countries, and 11.4% of GDP for Colombia (5.0% in health, and 6.4% in material loses). Furthermore, their estimate of indirect costs of violence (productivity, investment, work and consumption) and transfers, amount to 9.2% of GDP for the same countries, and 13.3% of GDP for Colombia. These studies nonetheless, did not quantify the willingness to pay of household to avoid urban violence the way we do.

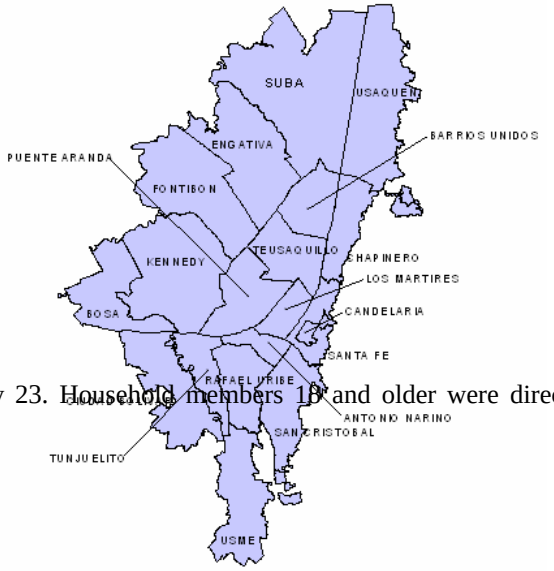
An area in which more evidence has been collected for violence in Colombia, and in particular, in Bogotá, is the related to spatial patterns of crime. Núñez and Sánchez (2001) find statistically significant spatial correlation for objects theft, assaults, cars theft, residential and commercial theft rates. Similarly, Llorente et. al. (2001) illustrate graphically the spatial segregation of homicides in Bogotá, and additionally, study its dynamics, finding that homicides are spatially very persistent, they take place mostly around the same places of the city with different degrees of intensity.

In what follows, we use several of this literature and provide additional elements that support our assumptions in the estimations of the costs homicide rates pose on house values and rents. We continue describing the data used for our exercise, before proceeding to present the methodology and results of the empirical model.

3. Data[2]

We use data at the household level from the *Encuesta de Calidad de Vida*, collected by the Administrative Department of National Statistics of Colombia, DANE, in 2003.[4] That LSMS survey, has detailed information about living conditions of household in Bogotá,

Map 1. *Localidades* of Bogotá.[3]



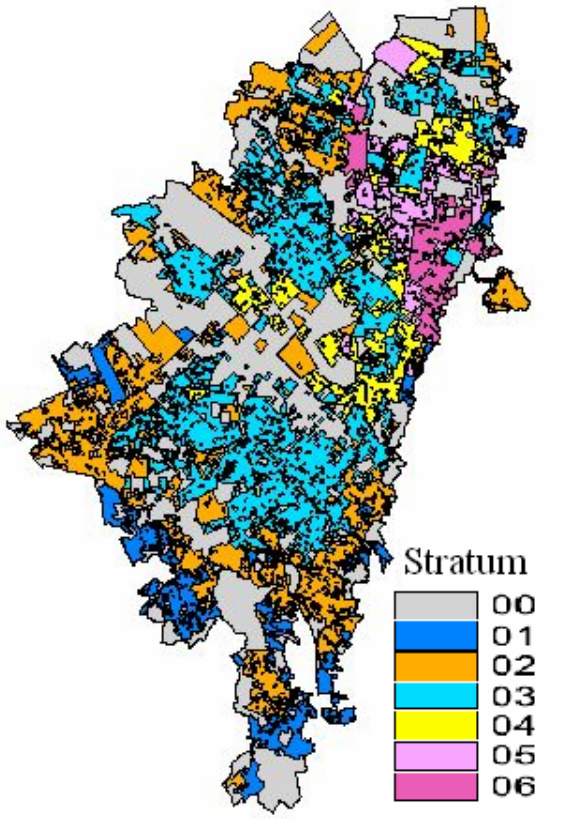
[2] This section builds heavily on Medina et. al. (2007)
[3] Source: Medina et. al. (2007)
[4] The survey was collected between June 6 and July 23. Household members 10 and older were directly interviewed.

with more than 12,770 households interviewed in each of 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] Map 2 illustrates where the better and worse off households live in the city: the former at the northeast, and the later mostly in the south and the peripheries.

The survey is meant to allow researchers to build unemployment rates estimates at the *localidad* level with a 5% relative error.

Finally, we use 1993 Population Census data along with official records, to collect information at the census sector level that allow us to split Bogotá into more than 500 sectors, with an average of about 12,000 inhabitants per sector (See map 3).[7]

Map 2. Socioeconomic Strata in Bogotá.



Map 3. Census Sectors in Bogotá

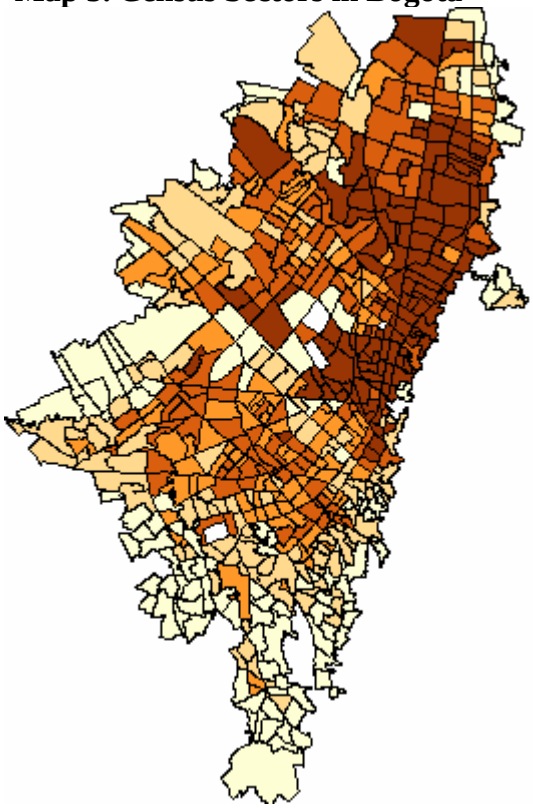


Table 1 describes the available set of variables and its sources. As the table shows, most households in Bogotá live in socioeconomic strata 2 and 3 (75%), and just about 6% in strata 5 and 6, the better off households, about as many as those in stratum 1. Coverage of public utility services is very high in the city, with nearly 100% in electricity, and 90% in

[5] Bogotá is split into 20 *localidades*, 19 urban and one rural.
[6] There are six socioeconomic strata in which urban areas are split in Colombia, being the first the one with the lowest QoL levels, and the sixth the one with the highest.
[7] Figures of the 2005 Colombia Population Census have not been made available yet.

fixed phone lines. It will become important, at the moment of interpreting our results, to bear in mind that the higher socioeconomic strata have nearly 100% coverage in fixed phone lines, thus, remaining variation of that variable will be privative of the poorest strata, which implies that such variable might partially work as a proxy for poverty. As shown in the table, we have cadastral data for nearly 70% of the households. Our variables related to crime, include objects theft rate, assaults rate, residential and commercial assaults rate, cars theft rate, homicide rate, attacks of terrorists groups, attacks against life, and attacks against wealth.[8] The distribution of these variables is illustrated in figure 1, where it becomes clear how skewed they are, in particular, the objects theft and homicide rates. The police Center of Immediate Attention, CAIS, have a similar shape.

We have cadastral data on property values for close to 8900 houses in Bogotá. In addition, we have household's reported property values for households owning houses where they live. Reported rent prices are available for houses 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?). As it can be seen in figure 2, the distribution of property values obtained of using exclusively cadastral data is very similar to the one obtained when it is complemented with household reported data from the ECV survey.

[8] For the purposes of this study, we understand homicides as the activity by jeans of which un person kills another. (Art. 323 penal Code), attacks against life, as hurting someone's body or health (Art. 332 Código Penal), and objects theft as the act of substracting someone else's goods for own benefit. (Art. 349 Penal Code).

Table 1. Descriptive Statistics

Variable	N	Mean	Std. Dev.
Stratum 2	12,744	0.325	0.468
Stratum 3	12,744	0.434	0.496
Stratum 4	12,744	0.116	0.320
Stratum 5	12,744	0.030	0.170
Stratum 6	12,744	0.032	0.175
Cadastral House Value (as Opposed to Reported)	12,871	0.690	0.463
Number of rooms	12,771	3.37	1.52
Number of bathrooms	12,760	1.558	0.842
House with piped gas service	12,771	0.656	0.475
House with telephone	12,771	0.877	0.329
Good quality of electricity	12,746	0.899	0.302
Good quality of garbage collection	12,750	0.891	0.312
Water available 24 hrs a day	12,678	0.982	0.133
Water available every day of the week	12,771	0.967	0.178
Good quality of phone line	12,871	0.731	0.444
House with garden	12,771	0.419	0.493
House with court yard	12,771	0.046	0.210
House with garage	12,771	0.285	0.451
House with terrace	12,771	0.217	0.412
Parks in neighborhood	12,771	0.131	0.338
The house has suffered because of a natural disaster	12,771	0.046	0.209
House in area vulnerable to natural disasters	12,771	0.070	0.255
Factories in neighborhood	12,771	0.119	0.324
Garbage collector in neighborhood	12,771	0.030	0.172
Market places in neighborhood	12,771	0.070	0.255
Airport in neighborhood	12,771	0.037	0.188
Terminals of ground transportation in neighborhood	12,771	0.033	0.178
House close to open sewers	12,771	0.103	0.304
House close to high tension lines of electricity transmission	12,771	0.018	0.132
You feel safe in your neighborhood	12,771	0.680	0.466
Provision of water is inside the house	12,771	0.973	0.163
The kitchen is a individual room	12,771	0.960	0.195
Shower bath	12,771	0.974	0.160
House*	12,771	0.378	0.485
Walls material is any of: Brick, block, stone, polished wood	12,771	0.978	0.146
Floor material is any of: Marmol, parque, lacquered wood	12,771	0.084	0.277
Floor material is Carpet	12,771	0.133	0.339
Floor material is any of: Floor tile, vinyl, tablet, wood	12,771	0.595	0.491
Floor material is any of: Coarse wood, table, plank	12,771	0.054	0.227
Floor material is any of: Cement, gravilla, earth, sand	12,771	0.134	0.341
House with Toilet connected to the public sewerage	12,771	0.989	0.103
House with potable water service	12,771	0.985	0.120
Number of infantile shelters ♣	12,771	0.070	0.352
Number of asylums ♣	12,771	0.140	0.456
Number of convents ♣	12,771	0.260	0.888
Objects theft rate ♣	12,861	0.869	6.088
Assaults rate ♣	12,861	3.24	22.13
Residential and commercial assault rate ♣	12,861	2.99	9.23
Cars theft rate ♣	12,861	2.48	12.53
Crime rate ♣	12,120	0.538	0.668
Land use ♣	12,861	0.002	0.017
Attacks of FARC, ELN or other groups** ♣	12,871	0.232	0.422
Share of women heads of households ♣	12,861	0.275	0.051

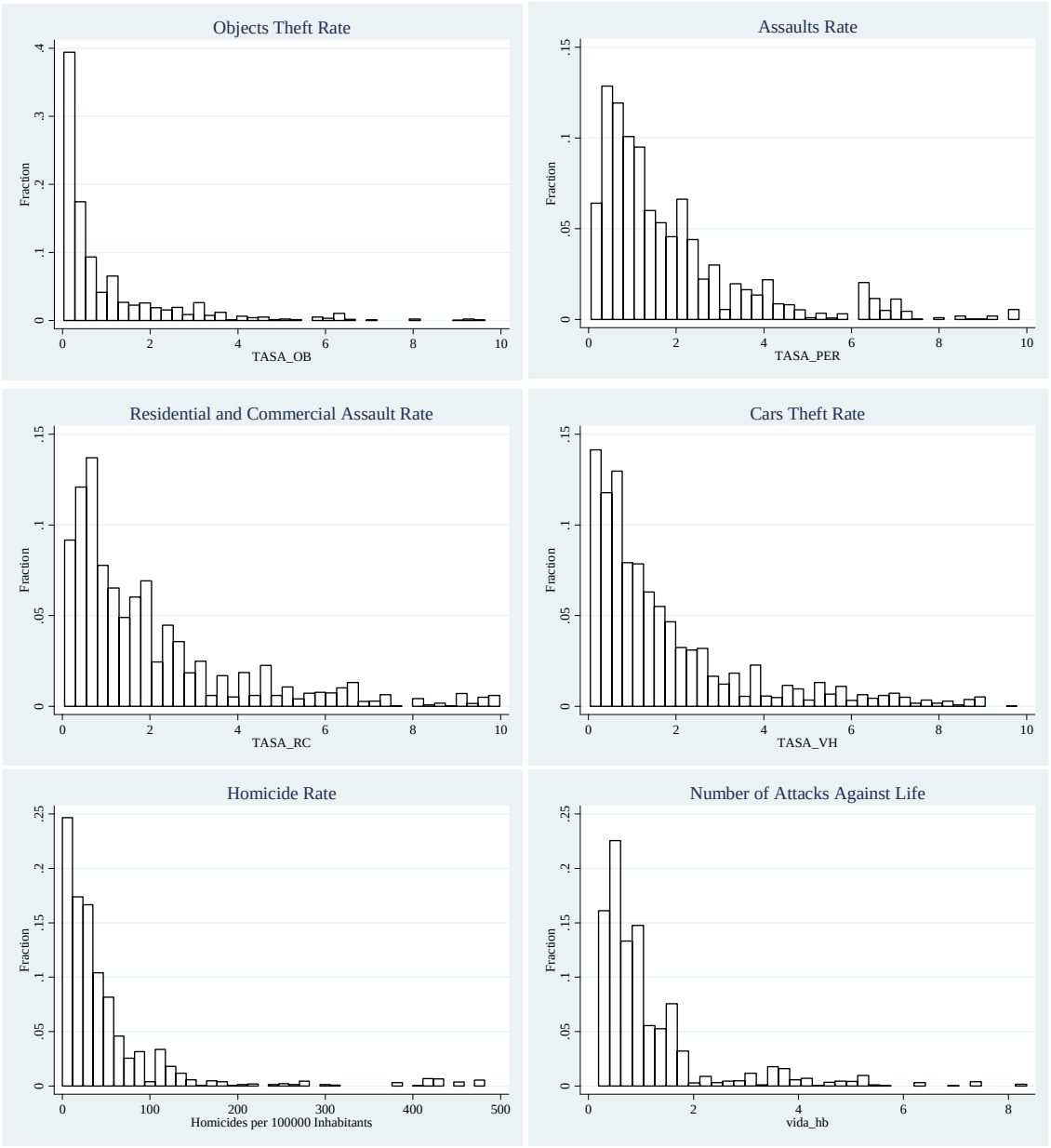
Table 1. Descriptive Statistics (Continuation)

Variable		N	Mean	Std. Dev.
Labor force Unemployment rate	♣	12,871	3.89	1.01
Illiteracy rate	♣	12,861	0.030	0.021
Average education	♣	12,861	8.365	1.896
Index of Quality of Life***	♣	12,871	82.12	7.09
Gini of education	♣	12,861	0.051	0.013
Number of CAIS****	♣	12,861	0.474	9.894
Number of medical centers	♣	12,861	0.281	1.476
Number of private hospitals	♣	12,861	0.243	1.384
Number of police headquarters	♣	12,861	0.241	17.64
Number of local security funds	♣	12,861	6.95	60.45
Number of public hospitals	♣	12,861	0.572	19.630
Number of religious centers	♣	12,861	1.12	3.45
Number of social welfare centers	♣	12,861	2.30	7.39
Number of cultural centers	♣	12,861	2.91	11.48
Number of prisons	♣	12,861	0.032	0.966
Number of attacks against life	♣	12,861	0.844	18.082
Number of attacks against wealth	♣	12,861	1.30	22.17
Number of bars	♣	12,861	1.179	18.727
Number of brothels	♣	12,861	0.630	17.689
Number of casinos/places for bets	♣	12,861	0.288	17.659
Number of places selling drugs/narcotics	♣	12,861	0.879	20.300
Number of people 0-4 years old	♣	12,771	1,183	980
Number of people 5-9 years old	♣	12,771	1,156	929
Number of people 10-14 years old	♣	12,771	1,168	910
Number of people 15-19 years old	♣	12,771	1,092	793
Number of people 20-24 years old	♣	12,771	1,211	890
Number of people 25-29 years old	♣	12,771	1,217	898
Number of people 30-34 years old	♣	12,771	1,132	814
Number of people 35-39 years old	♣	12,771	898	638
Number of people 40-44 years old	♣	12,771	696	499
Number of people 45-49 years old	♣	12,771	506	352
Number of people 50-54 years old	♣	12,771	413	270
Number of people 55-59 years old	♣	12,771	299	186
Number of people 60 + years old	♣	12,771	700	415
Unsatisfied Basic Needs (NBI): Dependency	♣	12,771	37.01	43.36
NBI: Accumulation	♣	12,771	418.35	410.15
NBI: Dropouts	♣	12,771	6.04	9.18
NBI: Public utility services	♣	12,771	37.71	76.72
NBI: Housing in	♣	12,771	69.09	97.20
NBI: NBI in Municipality where were born	♣	12,871	26.86	17.34
NBI: NBI in Municipality where were born	♣	12,871	0.097	0.296
Born in urban area		12,771	0.753	0.431
Share of women in household		12,771	0.535	0.268
Household with children		12,771	0.716	0.451
Age of mother minus age of oldest children		12,771	17.13	12.77
Logarithm of rent values		12,669	12.44	0.771
logarithm of cadastral house values		8,879	17.48	0.777
logarithm of cadastral or reported house values		10,845	17.50	0.792

Sources: *Encuesta de Calidad de Vida* 2003, Real State Appraisal of Bogotá, National Police-DIJIN 2000, Paz Pública (2000). Colombian 1993 Population Census.

[*] Dummy variable equal to one if house, 0 otherwise (apartment, etc.). [**] 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. [***] A-Theoretical estimation of QoL (See methodology in DNP, 1997). [****] *Centros de Atención Inmediata*, CAIS: Centers of Immediate -Police- Attention. [♣] At the census sector level.

Figure 1. Distribution of Variables Related to Crime by Census Sector. Bogotá



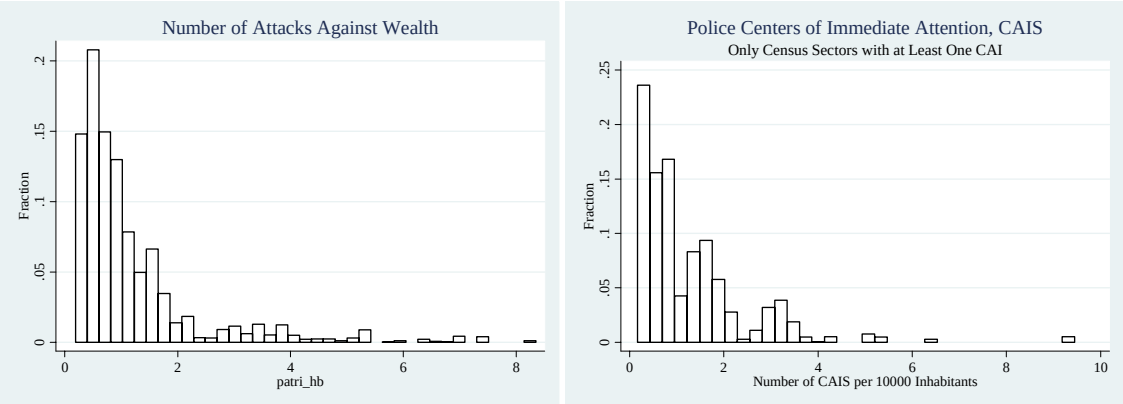
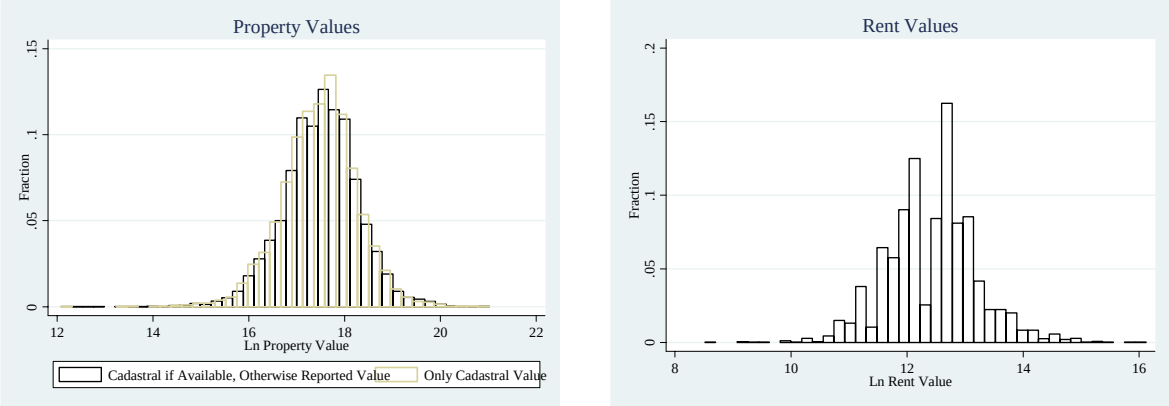


Figure 2. Property and Rent Values

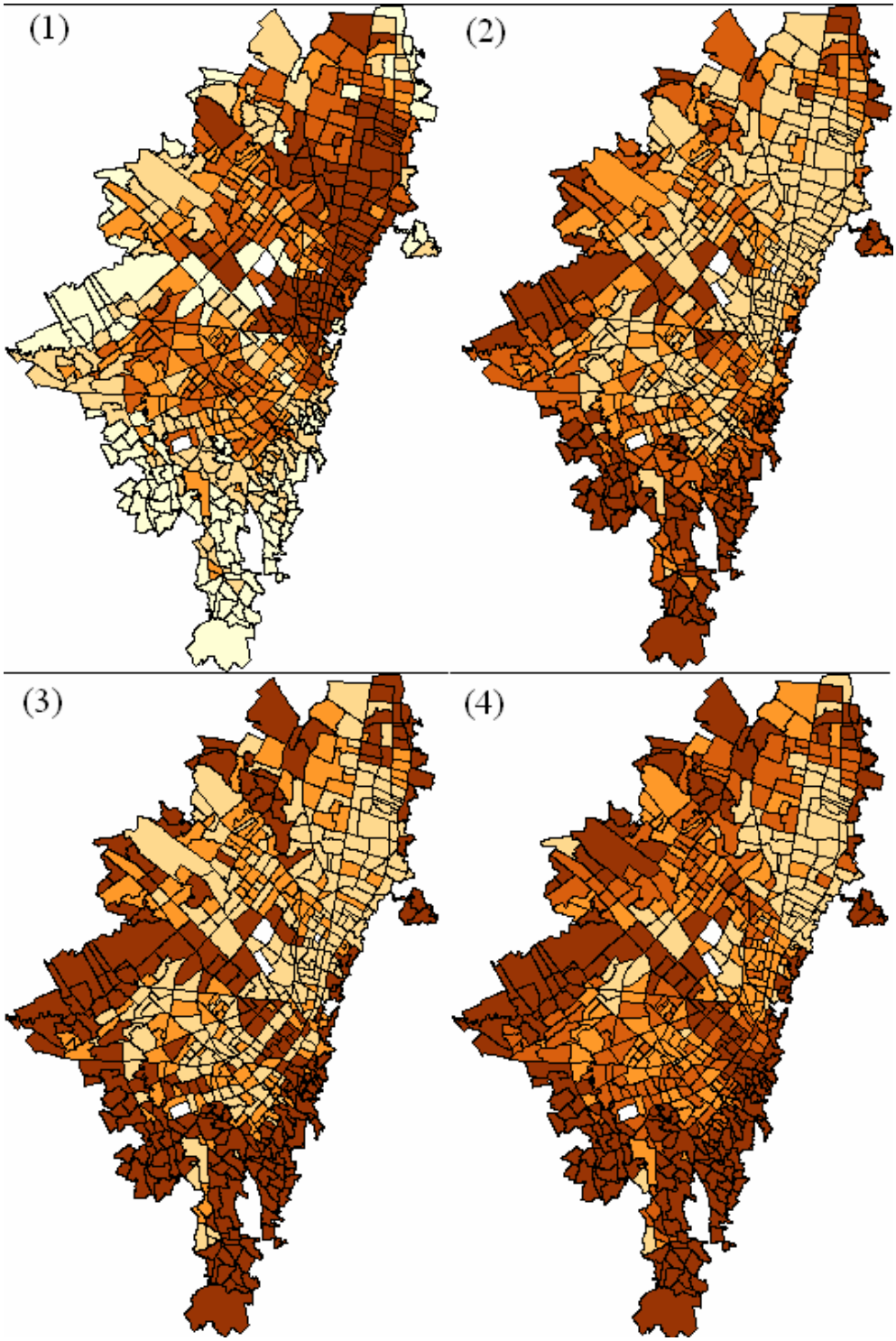


To complement the description of the quality of life in different places of the city that can be inferred from map 2, Map 4 shows quintiles of some indicators of quality of life: a Colombian index of quality of life, ICV, Unsatisfied Basic Needs, NBI, Misery, and the Gini coefficient of education, which measures the inequality in the distribution of the years of education in each census sector.[9] ICV, NBI and Misery indexes are highly correlated (the former positively, the other two negatively) to the socioeconomic strata. On the other hand, inequality in the distribution of education is higher in the poorest neighborhoods, which suffer as well of higher rates of some of our crime variables like homicide rates, attacks from guerrilla and other groups, and attacks against life (See map 5).[10]

[9] See details of the definition of the ICV in DNP (1997). The NBI measures the share of households in a specific census sector that has at least one basic need unsatisfied (basic needs: (i) adequate houses, (ii) basic public utility services (water, sewerage and electricity), accumulation in household, economic dependency, dropouts. Based on the NBI, the Misery Index is estimated, which counts the share of households with at least two unsatisfied basic needs.

[10] See Fajnzylber, Lederman and Loayza (1998, 2000, 2002a, 2002b) who find a positive relation between income inequality and the homicide and robbery rates. A review of this regularity for Latin American and Caribbean Countries can be found in Heinemann and Verner (2006). For the Colombian case, Sánchez and Núñez (2000) that find inequality in land distribution is positively related to the homicide rate, although it explains just a small part of the cross sectional variation in the homicide rate.

Map 4. Quality of Life and Inequality Indicators.[11]

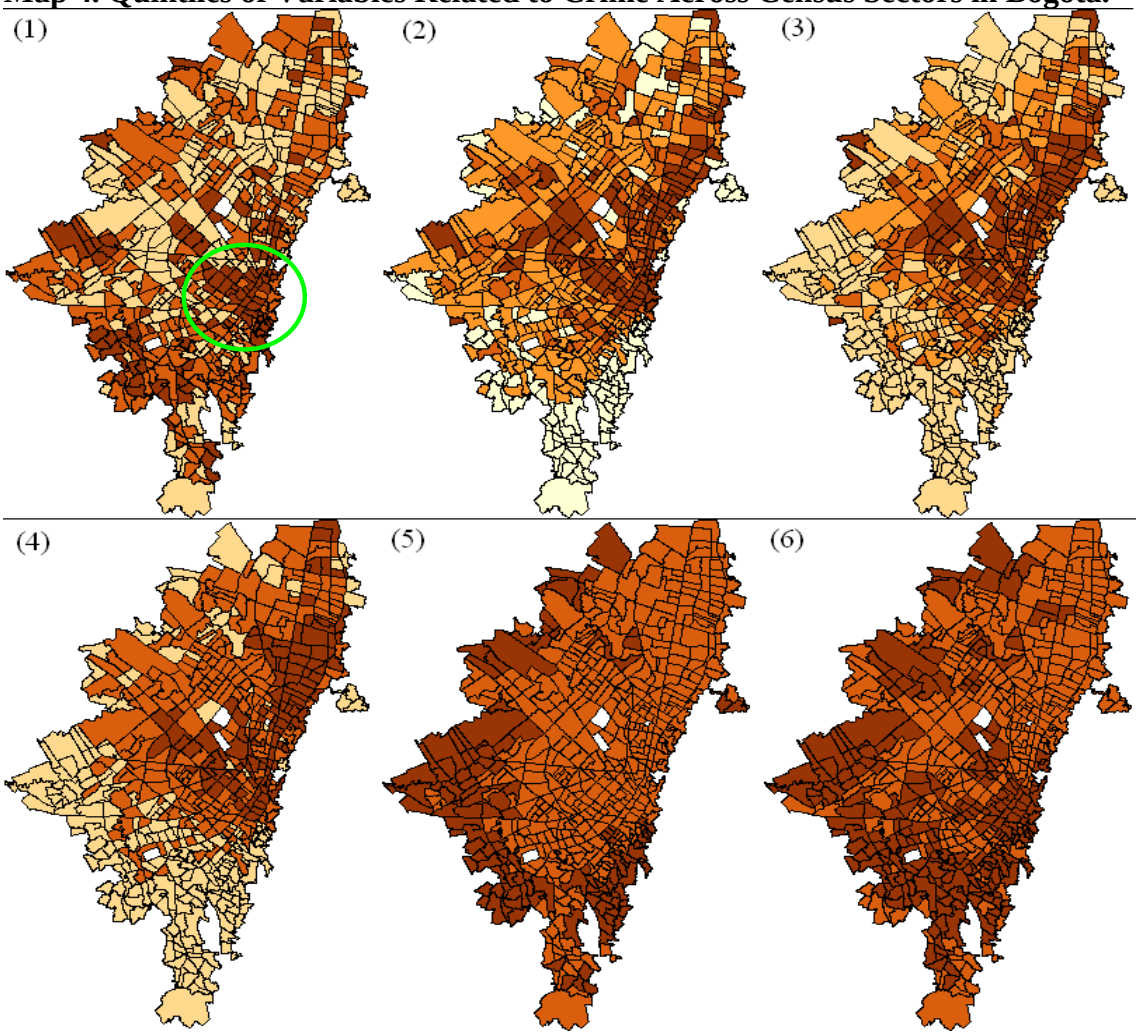


The darkest tones correspond to the highest quintiles. See sources in table 1.
(1) ICV, (2) NBI, (3) Misery, (4) Gini coefficient of the years of education

[11] Source: Medina et. al. (2007)

Now let us illustrate graphically the spatial correlation between quality of life and crime variables. Map 5 illustrates the spatial patterns of crime variables at the census sector level. The circled area in the upper left map, which includes downtown Bogotá, is one with the highest homicide rates of the city. Comparing maps 2 and 4, with map 5, it becomes clear that the highest assault, car and objects theft rates, take place in the highest stratum neighborhoods. On the contrary, homicides, FARC attacks, and attacks against life, are more likely in the periphery of the city, which is much poorer. Downtown Bogotá has as well a high rate of attacks against life. Spatial correlations suggested by these data are consistent with the results found by Gaviria and Velez (2001)

Map 4. Quintiles of Variables Related to Crime Across Census Sectors in Bogotá.[12]



The darkest tones correspond to the highest quintiles. See sources in table 1.
(1) Homicides rates, (2) Assaults rates, (3) Cars theft rate, (4) Objects theft rate, (5) FARC attacks, (6) Number of attacks against life.

3.2 Empirical Analysis

[12] Source: Medina et. al. (2007)

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

In this section we estimate the amount household would be willing to pay to avoid crime. We estimate a hedonic regression model of the logarithm of house valuation, and rental prices, on a battery of household and amenities variables, of the form

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

Where P_{ij} is either the value of the house (cadastral or reported by household) or rent (reported by household), H_i is a vector of household i variables, and A_j is a vector of amenities in census sector j. The idea is that the price households pay for their houses is compensated for what they get in house characteristics and amenities, amenities including access and quality of public goods and services (roads, parks and other green space, good weather, transport, security, etc.). In equilibrium, amenities would be capitalized into house values and rents.[13]

Table 2 presents the results of estimating this equation using different sources for the dependent variable. First, we present the results of using as our dependent variable the cadastral value of houses for those houses we have it available, and the amount reported by the household for those we do not have cadastral values, adding up to 10,290 households. The following panel presents the results of estimating the hedonic regression with only those households for which we have the cadastral values, namely 8,435 households. Finally, the last panel reports the results obtained from estimating the model with the rental values, available for 12,024 households. Each panel contains both OLS and 2SLS results. For all regressions we estimate robust standard errors correcting for clustering at the census sector level.

We focus first on the OLS estimates. Overall, the estimates found present intuitive signs. As it is shown, the value/rent of houses increases for houses located in better socioeconomic strata, for houses with better characteristics, such as their number of rooms, of bathrooms, if the house has piped gas, garden, garage, kitchen in an individual room, better floor materials, if there are parks in their neighborhood, and there are no open sewers, no garbage collectors, and house with potable water. Note that in the first panel, where we use cadastral values for those houses we have it available, and reported values for those we do not have the cadastral ones, we include a dummy variable equal to one if the house value is the cadastral and zero otherwise. The coefficient of this variable implies that cadastral values are on average 10.6% lower than the commercial values reported by households in the survey.

Regarding the variables related to crime, the objects theft rate is negatively related to house value, but its sign is only statistically significant for rent values. Attacks against life are as well negatively related to house values, although in that case, the sign is significant only for house values. The variable attacks by FARC, ELN, and other groups, is weakly negatively related to house rent. On the other hand, the assaults, residential and commercial assaults, cars thefts and crime rates, are unrelated to house values. Finally, the attacks against wealth are positively related to house values.

[13] See Rosen (1971, 1974, 2002), Blomquist et. al. (1982), Roback (1982, 1988), and Gyourko et. al. (1999) among others.

Although we would expect all crime related variables to be negatively related to house values and rents, there are several sources of endogeneity that would be preventing us from getting the expected results. On the one hand, if places where crimes are more likely to happen are the better neighborhoods, omitted characteristics of the neighborhoods might be positively correlated to these crimes, for example, cars theft, which would overestimate the coefficients of interest. On the other hand, some crimes like homicides, might take place more often in poor neighborhoods because the richest are more like to count with much better security, which should be already capitalized in house values and rents.

To minimize the omitted variable bias problem, we estimate again equation (1) interacting variables included in table 2 with the socioeconomic strata.[14] Results for the crime related variables are presented in table 3.

According to the previous results, households who report feeling safe in their neighborhoods pay less rent for their houses, a result that weakly follows for house values in strata 5, once we include interactions. Nonetheless, this result might be driven by differences in perceptions between the richest and the poorest: if the richest live in safer neighborhoods and yet they do not feel as safe as the poorest, the coefficient would be capturing more these differences in perceptions than the capitalization of security.

Once we include the interactions with socioeconomic strata, the objects theft rate reveal a pattern of negative capitalization as we move towards the higher strata. Other variables like assaults, residential and commercial assaults, crime rates, attacks by FARC, ELN, and other groups, and attacks against wealth, show no relation to house or rent values. Actually, cars theft and crime rates become positive and significant when interacted with stratum 6. The variable attacks against life keep registering a negative relation to house values and rents.

The variable number of Centers of Immediate Attention, CAIS, which appeared only positively related to house rents, become positively and significantly related to house values when interacted with the highest socioeconomic strata, and only weakly positively related to house rents.

Instrumenting the Crime Rate

In this section we try to identify the capitalization effect of the crime rate on house values and rents, by using an instrumental variable approach. The goal is to use a variable related to the decision the households make of living in a neighborhood of a determined crime rate, while at the same time not affecting the value or rent of the house.

[14] The variables “Cadastral”, “You feel safe in Neighborhood”, “Land use”, “Attacks of FARC, ELN, or other groups”, “Number of medical centers”, “Number of medical centers”, “Number of private hospitals”, “Number of police headquarters”, “Number of local security funds”, “Number of public hospitals”, “Number of religious centers”, “Number of social welfare centers”, “Number of cultural centers”, “Number of prisons”, “Number of attacks against life”, “Number of attacks against wealth”, “Number of bars”, “Number of brothels”, “Number of casinos/places for bets”, “Number of places selling drugs/narcotics”, “Number of people by age range”, and the dummy variables of father’s and mother’s education levels and their interactions, are not interacted with the socioeconomic strata.

We use as instrument a proxy for the household having a teenage mother as household head, or spouse of household head, and build our instrument based on the following rationale: (i) children of teenage mothers are more likely to become criminals, (ii) since teenage mothers are more likely to come originally from low socioeconomic status, SES, end up in low SES, they are as well more likely to end up living spatially segregated in neighborhoods with high crime, and specifically, with high homicide, rates, and (iii) whether a house is inhabited by a teenage mother or not, is not related to the value of the house where she lives. If this rationale was true, then we could be sure our instrument to be related to crime but not to house value or rent.

The first component of our reasoning, namely that children of teenage mothers are more likely to become criminals is supported by several studies. For example, Krug et. al. (2002) enumerated among the *Relationship Factors* associated to violence in youths, the influence of families. Among the factors associated to the influence of families, they enumerate parental conflict in early childhood and poor attachment between parents and children. They also include as factors of risk a large number of children in the family, **a mother who had her first child at an early age**, and a low level of family cohesion.[15] Furthermore, teenage mothers are likely to be characterized by an environment that includes these factors altogether. In addition, in developing countries like Colombia, teenage childbearing is more likely to happen among the poorest population, and keep teen mothers in a poverty trap.[16] This in turn, adds another risk factor enumerated by Krug et. al. (2002): low socioeconomic status.

On the other hand, Donohue and Levitt (2000) provide direct evidence for the United States that children being born out of unwanted pregnancies are more likely to become criminals, and in particular, homicides, and Hunt (2003) provides evidence, as well for the United States, that children of teenagers are more likely to commit assaults later in their lives.

If children from teenage mothers are more likely to become criminals, and their households are more likely to belong ex ante, and end up belonging to the lowest socioeconomic status, then it seems reasonable to expect them to end up relatively sorted into neighborhoods where youth are more likely to be criminals, influenced, by the way, by their communities (another risk factor according to Krug et. al. 2002), and thus, more likely to inhabit a neighborhood with high crime, and in particular, homicide rates.

To provide empirical evidence of households with teen mothers sorting, and in particular, sorting in places with higher homicides rates, let us analyze map 5, which illustrates the spatial distribution in Bogotá of adolescent pregnancy by block, and homicide rate by census sector.[17] In both maps, the darkest colors represent the highest figures of the variables analyzed, and are located in similar areas of the city.

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[15] Other studies supporting the relationship between teenage motherhood and their children's likelihood to commit crime in the future are Farrington (1998), Morash (1989), and Nagin (1997).

[16] Flórez (2007)

[17] The pregnancy rate (percentage) by block is estimated with the New Sisben survey, which is a census of the poorest population in which key information is collected to build proxy-means test used to target social expending. In our database, we have somewhat more than two million people interviewed in Bogotá. Homicide rates at the census sector level are in deaths per 10 million inhabitants.

As our proxy variable for teenage mothers in household, we estimate de difference between the age of the spouse of the household (or head of household if woman) and her oldest children living in her household.

Map 5. Adolescent pregnancy rate by block (left), and homicide rate by census sector.[18]

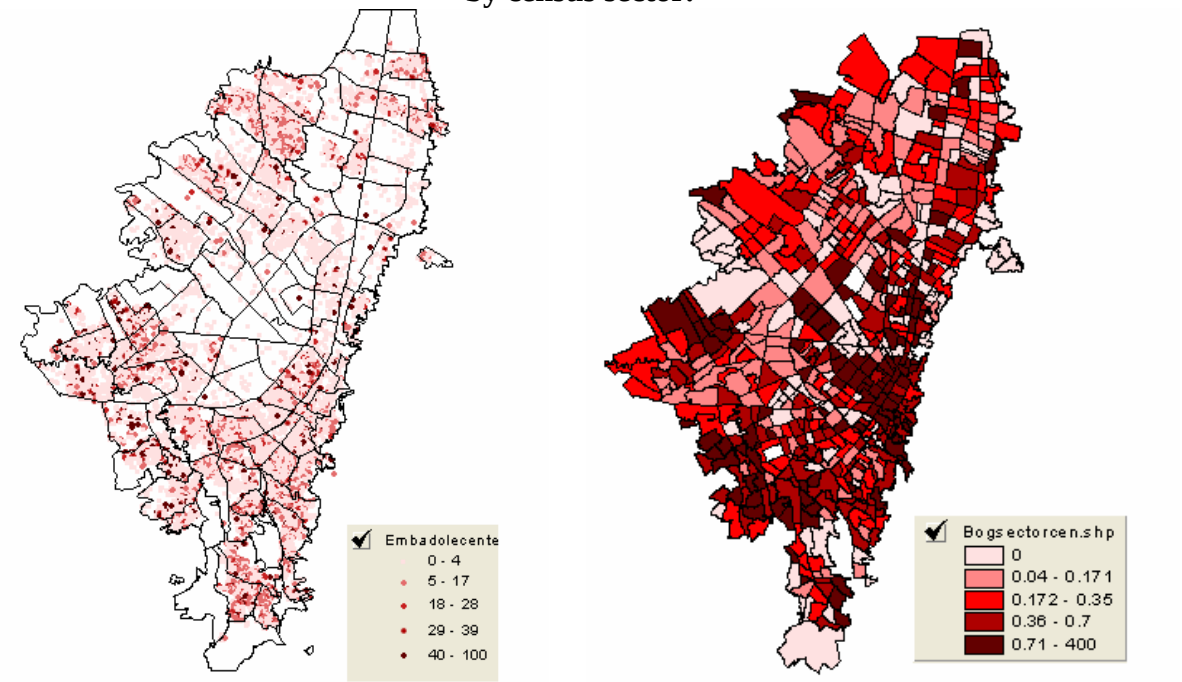


Figure 3. Proxy Variable for Teen Mother

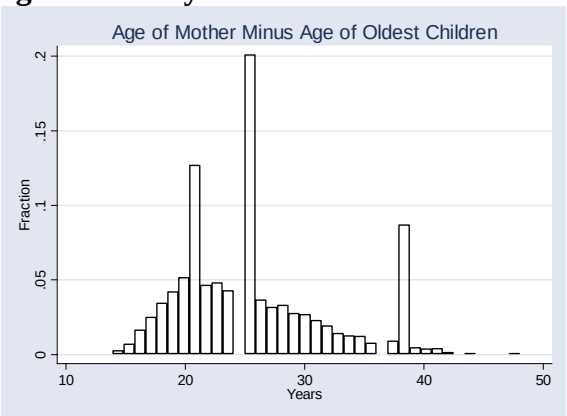


Figure 3 shows the distribution of our instrumental variable. Nearly 13% of households have a child that was born when his or her mother was between 13 and 19 years old.

To formalize the preliminary evidence presented in map 5, we use maps 6, 7 and 8, in which we illustrate the quintiles of the homicide rate, our instrument, and the rate of teenage mothers per census sector (the later estimates based on 1993 Population Census data). Since our instrument is negatively related to the rate of teenage mothers per census sector, results of these two variables are basically the opposite of each other. The almost perfect sorting of household according to our instrumental variable illustrated in map 6 is astonishing.

[18] Source: Medina et. al. (2007)

Map 7 shows the results of getting local Moran I_i estimates by census sector for the variables shown in map 6.[19] To illustrate how to read the map, let us take as example the case of the homicide rate. Red census sectors would imply the existence of a cluster of census sectors with high homicide rates, dark blue census sectors, the existence of a cluster of census sectors with low homicide rates, light blue census sectors, the existence of a census sector with low homicide rate surrounded by sectors with high homicide rates, and orange census sectors, a census sector with high homicide rates surrounded by sectors with low homicide rates. For the homicide rates, we compare the homicide rates at each census sector with those of its neighbors and the neighbors of its neighbors.[20]

According to map 7, there are only a few clusters with high homicides rates in the city, some of them located downtown Bogotá (the circled area). On the other hand, there is a wide area in the north of the city which registers a very low homicide rate. With respect to the cluster map of our instrument and the rate of teenage mothers, it confirms empirically that the southern part of the city if characterized for clusters of women having their children much younger, and by high rates of teenage mothers, while the opposite happens on the northeastern area of the city.

Map 6. Quintiles of key variables at the census sector level. Bogotá

[19] The **local Moran index** is used to identify spatial clusters and it is defined as

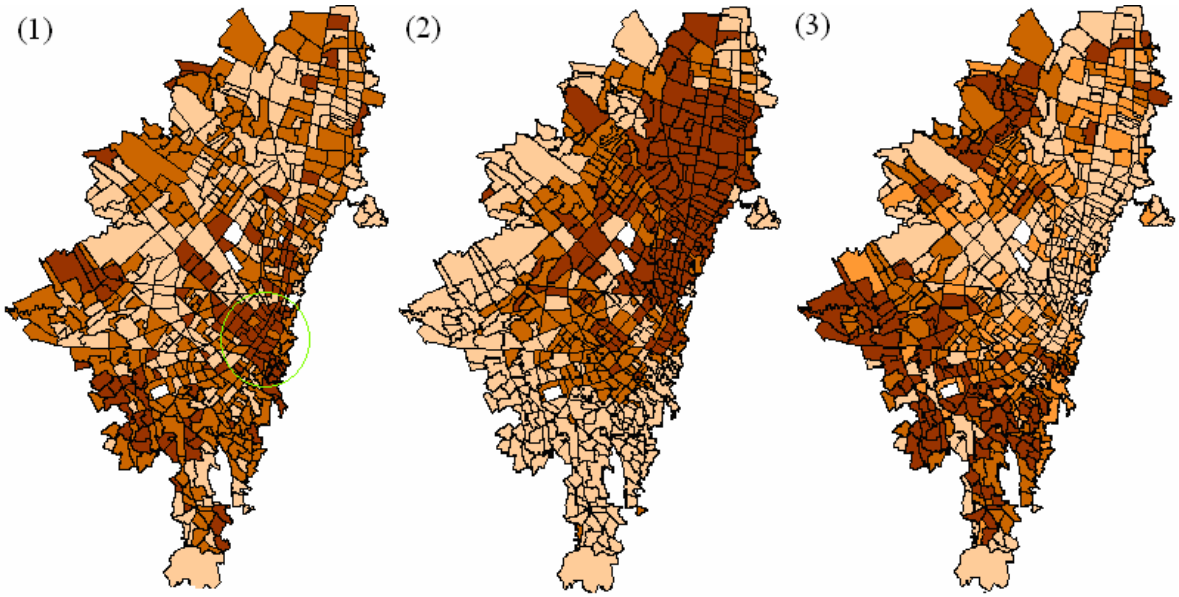
$$I_i = \frac{Z_i}{\sum_i Z_i^2 / N} \sum_{j \in j_i} W_{ij} Z_i$$

Where $Z=[I-E(I)]/[V(I)]1/2 \sim N(0,1)$, and is the **Moran index**

$$I = \frac{N}{S_0} \frac{\sum_{ij}^{N} W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{N}(x_i - \bar{x})}$$

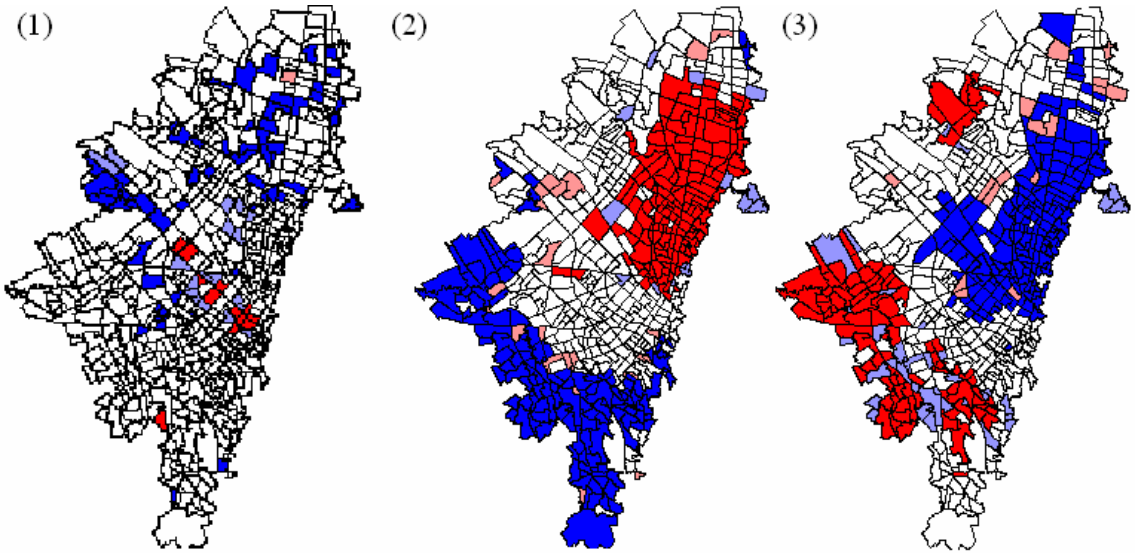
where x_i is the variable of interest on which we are interested to test spatial correlation, W_{ij} is a matrix of weights, and $S_0 = \sum_i \sum_j W_{ij}$. Matrix W will be defined depending of the variable of interest, using immediate neighbors with their respective neighbors. Positive (negative) values of the I_i index imply the existence of similar (different) values of the phenomenon of interest around area i.

[20] See Anselin (1988) and Moran P. (1948)



Quintiles: (1) homicide rate, (2) age difference: oldest children and mother, (3) rate of teenage mothers

Map 7. Clusters of key variables at the census sector level. Bogotá



Cluster: (1) homicide rate, (2) age difference: oldest children and mother, (3) rate of teenage mothers

Finally, map 8 shows that our instrument is negatively correlated to the homicide rate, in a statistically significant magnitude in the south and northeast of the city.[21] The same follows for the rate of teenage mothers. The last figure in map 8 illustrates the local spatial covariance between the homicide rates and the share of households with children in the

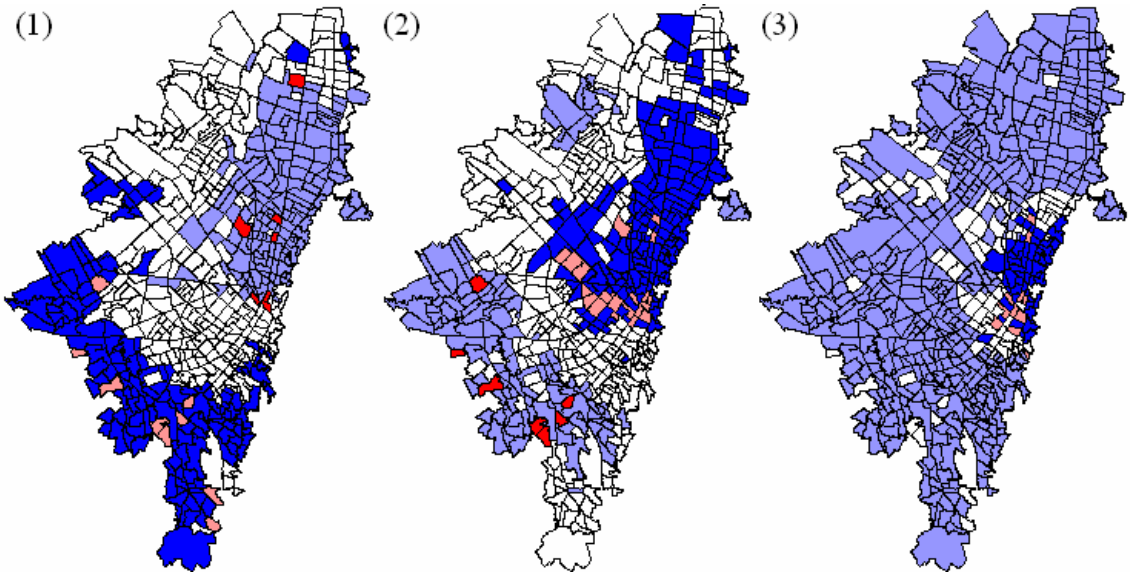
[21] The spatial autocovariance between variables x_{ci} and x_{cj}, is estimated with a formula of the form

$$\operatorname{cov}\left(x_{c_i}, x_{c_j}\right) = \hat{f}(h) = \sum_{i=1}^{N}\sum_{j=1}^{N} W\left[\frac{D_{ij}}{h}\right]\left(x_{c_i} - \bar{x}\right)\left(x_{c_j} - \bar{x}\right)$$

Where $\bar{x}$ is the sample mean of x, and $W(\cdot)$ is a kernel function normalized to sum one.

census sector. The aspect to highlight is that around downtown Bogotá, where there is a high homicide rate, lives a high share of households with no children.

Map 8. Spatial Covariances between key variables and the Homicide Rate at the census sector level. Bogotá



Cluster covariances: (1) homicide rate, age difference between oldest children and mother, (2) homicide rate, rate of teenage mothers, (3) homicide rate, children in household.

In sum, we found that in the case of Bogotá, our instrument is spatially negatively correlated to the homicide rate, as the rate of teenage mothers is positively correlated. Since households are amazingly segregated according to the age difference we use as instrument, we expect that variable to be a good determinant of the homicide rate at the census sector level. On the other hand, as that variable is not a house characteristic nor an amenity likely to be capitalized into house values or rents, we expect it not to be unrelated to them.

Table 2. Hedonic Regression for Bogotá

Variable	Homicide Rate		Ln house price [/1]				Ln house price [/2]				Ln house rent			
			OLS		2SLS		OLS		2SLS		OLS		2SLS	
	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*
Stratum 2	0.0461	0.53	0.1449	2.83	0.1419	2.58	0.1722	3.06	0.1721	2.84	0.0197	0.62	0.0342	1.01
Stratum 3	0.0826	0.70	0.3047	4.56	0.2980	4.08	0.3087	4.18	0.3061	3.80	0.1105	3.05	0.1362	3.25
Stratum 4	0.2040	1.24	0.3822	4.18	0.3630	3.16	0.3518	3.43	0.3411	2.65	0.2078	4.32	0.2711	3.81
Stratum 5	0.1735	0.91	0.4643	3.78	0.4469	3.22	0.3599	2.59	0.3481	2.22	0.4267	7.09	0.4803	6.45
Stratum 6	0.0469	0.20	0.6254	4.21	0.6206	4.12	0.5027	3.11	0.5011	3.05	0.7254	9.63	0.7390	9.70
Cadastral	0.0148	0.65	-0.1066	-5.00	-0.1078	-4.92	0.0000	0.00	0.0000	0.00	-0.0297	-2.67	-0.0251	-2.14
Number of rooms	-0.0013	-0.16	0.0116	1.67	0.0116	1.66	0.0083	1.13	0.0083	1.12	0.1395	24.80	0.1394	24.73
Number of bathrooms	0.0037	0.24	0.2011	12.83	0.2007	12.57	0.1968	11.66	0.1965	11.46	0.1290	11.63	0.1301	11.50
House with piped gas service	-0.0300	-1.00	-0.0046	-0.26	-0.0015	-0.08	-0.0047	-0.24	-0.0026	-0.11	0.0459	3.97	0.0363	2.41
House with telephone	-0.0541	-1.76	-0.1483	-4.89	-0.1430	-3.79	-0.1522	-4.79	-0.1494	-3.75	0.2016	11.35	0.1839	7.40
Good quality of electricity	0.0027	0.16	-0.0197	-1.00	-0.0197	-0.99	-0.0220	-0.97	-0.0224	-0.99	-0.0285	-1.96	-0.0277	-1.91
Good quality of garbage collection	0.0081	0.26	0.0371	1.95	0.0366	1.90	0.0320	1.70	0.0319	1.66	-0.0136	-0.96	-0.0111	-0.78
Water available 24 hrs a day	0.0098	0.21	0.1238	2.83	0.1218	2.78	0.1526	2.99	0.1512	2.92	0.0223	0.61	0.0255	0.69
Water available every day of the week	0.0126	0.16	0.0318	0.77	0.0311	0.76	0.0398	0.87	0.0401	0.89	-0.0065	-0.29	-0.0022	-0.10
Good quality of phone line	0.0074	0.49	0.0301	2.13	0.0292	2.03	0.0242	1.56	0.0236	1.50	0.0174	1.40	0.0199	1.55
House with garden	-0.0017	-0.07	0.1391	8.23	0.1389	8.23	0.1383	7.67	0.1381	7.67	-0.0055	-0.50	-0.0061	-0.55
House with court yard	-0.1146	-3.68	0.1441	3.77	0.1551	3.09	0.1610	3.61	0.1661	2.78	-0.0236	-0.81	-0.0598	-1.55
House with garage	-0.0546	-2.17	0.0742	3.84	0.0793	2.92	0.0681	3.38	0.0705	2.40	0.1023	7.11	0.0851	4.05
House with terrace	-0.0221	-0.90	0.1328	7.86	0.1352	7.20	0.1118	6.24	0.1134	5.54	0.0380	3.14	0.0311	2.27
Parks in neighborhood	0.0172	0.47	-0.1084	-3.54	-0.1107	-3.56	-0.1731	-4.75	-0.1763	-4.73	0.0284	1.56	0.0335	1.81
The house has suffered because of a natural disaster	-0.0836	-1.47	0.0916	1.92	0.0994	1.87	0.0293	0.57	0.0345	0.59	0.0180	0.56	-0.0080	-0.21
House in area vulnerable to natural disasters	0.1003	1.77	-0.1416	-3.39	-0.1514	-3.17	-0.1054	-2.49	-0.1122	-2.12	-0.0420	-1.41	-0.0107	-0.27
Factories in neighborhood	0.0548	0.54	0.0883	3.34	0.0822	2.76	0.0862	3.14	0.0821	2.62	0.0055	0.33	0.0230	1.05
Garbage collector in neighborhood	-0.0067	-0.11	-0.0488	-0.97	-0.0479	-0.94	-0.0695	-1.21	-0.0688	-1.18	0.0238	0.91	0.0217	0.82
Market places in neighborhood	-0.0758	-1.04	0.0136	0.36	0.0218	0.49	0.0024	0.06	0.0095	0.19	0.0225	0.93	-0.0010	-0.03
Airport in neighborhood	-0.1967	-2.52	-0.0485	-1.13	-0.0282	-0.36	-0.0609	-1.26	-0.0473	-0.54	0.0640	2.45	0.0023	0.04
Terminals of ground transportation in neighborhood	0.0012	0.02	-0.0103	-0.26	-0.0101	-0.26	-0.0708	-1.54	-0.0725	-1.58	0.0541	1.98	0.0546	2.00
House close to open sewers	-0.0642	-1.80	-0.0516	-2.01	-0.0455	-1.38	-0.0489	-1.67	-0.0452	-1.17	-0.0034	-0.21	-0.0234	-1.04
House close to high tension lines of electricity transmission	0.0069	0.09	0.0667	1.35	0.0667	1.35	0.0861	1.54	0.0871	1.56	-0.0222	-0.64	-0.0195	-0.56
You feel safe in your neighborhood	-0.0675	-4.44	-0.0076	-0.58	-0.0005	-0.02	-0.0119	-0.86	-0.0077	-0.27	-0.0189	-2.00	-0.0401	-1.93
Provision of water is inside the house	0.0367	0.68	0.0085	0.12	0.0033	0.05	0.0086	0.11	0.0049	0.06	0.2043	3.51	0.2159	3.62
The kitchen is a individual room	0.0561	0.92	0.1194	2.73	0.1123	2.24	0.1043	2.19	0.0991	1.82	0.1254	4.49	0.1444	4.36
Shower bath	-0.0551	-1.49	0.0318	0.63	0.0356	0.61	0.0107	0.20	0.0131	0.21	0.0921	2.29	0.0749	1.74
House[*]	0.0166	0.59	-0.1797	-8.23	-0.1808	-8.29	-0.1953	-8.36	-0.1958	-8.35	0.0583	4.46	0.0632	4.67

Table 2. Hedonic Regression for Bogotá (Continuation)

Variable		Homicide Rate		Ln house price /1				Ln house price /2				Ln house rent			
				OLS		2SLS		OLS		2SLS		OLS		2SLS	
		Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*
Walls material is any of: Brick, block, stone, polished wood		0,0599	1,07	0,1004	1,41	0,0925	1,27	0,0908	1,01	0,0841	0,92	0,1432	3,61	0,1626	3,82
Floor material is any of: Marmol, parque, lacquered wood															
Floor material is Carpet		0,0268	0,77	-0,2370	-7,68	-0,2408	-7,58	-0,2397	-6,57	-0,2427	-6,48	0,0097	0,49	0,0177	0,85
Floor material is any of: Floor tile, vinyl, tablet, wood		0,0330	0,86	-0,0290	-1,06	-0,0334	-1,12	-0,0134	-0,44	-0,0166	-0,50	-0,0167	-0,98	-0,0063	-0,33
Floor material is any of: Coarse wood, table, plank		0,1531	2,47	0,0487	1,21	0,0307	0,45	0,0638	1,47	0,0519	0,69	-0,0835	-3,07	-0,0355	-0,72
Floor material is any of: Cement, gravilla, earth, sand		-0,0218	-0,60	-0,2331	-5,99	-0,2318	-5,84	-0,2084	-4,84	-0,2078	-4,72	-0,1473	-5,65	-0,1538	-5,68
House with Toilet connected to the public sewerage		0,0886	0,69	-0,1361	-1,09	-0,1489	-1,16	-0,1925	-1,24	-0,2009	-1,26	0,0742	0,74	0,1015	0,99
House with potable water service		0,1759	1,22	0,2373	2,13	0,2212	1,72	0,3368	2,41	0,3253	2,06	-0,0368	-0,55	0,0188	0,22
Number of infantile shelters	♣	0,0073	0,12	-0,0594	-1,75	-0,0600	-1,76	-0,0994	-1,96	-0,0992	-1,97	0,0019	0,09	0,0042	0,21
Number of asylums	♣	-0,0107	-0,18	0,0009	0,03	0,0019	0,07	0,0116	0,37	0,0123	0,39	0,0209	1,25	0,0175	1,05
Number of convents	♣	-0,0459	-1,35	-0,0035	-0,25	0,0014	0,07	0,0072	0,40	0,0108	0,43	-0,0057	-0,78	-0,0201	-1,41
Objects theft rate	♣	-0,0991	-1,21	-0,0281	-1,37	-0,0182	-0,47	-0,0141	-0,66	-0,0081	-0,18	-0,0252	-3,10	-0,0562	-1,96
Assaults rate	♣	0,0913	3,95	-0,0053	-0,71	-0,0147	-0,46	-0,0035	-0,46	-0,0095	-0,27	0,0035	1,17	0,0322	1,29
Residential and commercial assault rate	♣	0,0693	1,51	0,0129	1,00	0,0062	0,24	0,0127	0,90	0,0089	0,30	0,0020	0,45	0,0236	1,20
Cars theft rate	♣	-0,0721	-2,75	-0,0017	-0,23	0,0056	0,21	-0,0064	-0,70	-0,0019	-0,06	0,0030	0,88	-0,0197	-0,99
Homicide rate (deaths per 10'000,000 people)	♣			-0,0470	-1,70	0,0555	0,17	-0,0411	-1,45	0,0224	0,06	-0,0115	-1,43	-0,3253	-1,18
Land use	♣	-0,5262	-0,44	-0,0725	-0,15	-0,0094	-0,02	-0,1376	-0,28	-0,0813	-0,16	-0,2480	-0,61	-0,4099	-0,95
Attacks of FARC, ELN or other groups**	♣	-0,0237	-0,31	-0,0461	-1,26	-0,0441	-1,15	-0,0366	-0,91	-0,0362	-0,87	-0,0324	-1,60	-0,0400	-1,91
Share of women heads of households	♣	-0,2071	-0,21	-2,2102	-5,45	-2,1998	-5,33	-2,4374	-5,40	-2,4475	-5,33	-0,1445	-0,60	-0,2130	-0,84
Labor force Unemployment rate	♣	0,0296	0,57	-0,1002	-4,75	-0,1037	-4,40	-0,1260	-5,84	-0,1288	-5,33	-0,0161	-1,61	-0,0069	-0,50
Illiteracy rate	♣	-5,7389	-1,80	0,0479	0,03	0,6566	0,27	-0,3278	-0,20	0,1107	0,04	1,2972	1,69	-0,5061	-0,29
Average education	♣	-0,3234	-2,73	-0,0380	-0,96	-0,0050	-0,04	-0,0497	-1,10	-0,0282	-0,21	0,0983	4,95	-0,0035	-0,04
Index of Quality of Life***	♣	0,0565	2,11	0,0442	4,75	0,0384	1,80	0,0440	4,14	0,0399	1,67	0,0076	1,42	0,0253	1,52
Gini of education	♣	11,0243	1,44	0,2304	0,09	-0,9956	-0,22	-1,8934	-0,63	-2,8396	-0,55	2,8591	1,70	6,3087	1,73
Number of CAIS****	♣	0,0065	0,14	0,0014	0,10	0,0004	0,03	0,0037	0,27	0,0028	0,20	0,0127	2,10	0,0147	2,30
Number of medical centers	♣	-0,0655	-2,95	-0,0109	-1,10	-0,0044	-0,18	-0,0131	-1,26	-0,0091	-0,34	-0,0037	-0,87	-0,0243	-1,35
Number of private hospitals	♣	0,0654	1,89	0,0048	0,30	-0,0017	-0,06	0,0114	0,58	0,0076	0,24	0,0092	1,53	0,0297	1,57
Number of police headquarters	♣	0,0688	0,58	0,0543	1,04	0,0481	0,91	0,0818	1,50	0,0778	1,40	0,0313	2,48	0,0529	2,36
Number of local security funds	♣	-0,0064	-1,80	0,0018	1,41	0,0025	1,06	0,0018	1,26	0,0022	0,81	0,0010	1,61	-0,0010	-0,53
Number of public hospitals	♣	0,0405	0,71	0,0008	0,06	-0,0036	-0,19	-0,0056	-0,41	-0,0093	-0,47	0,0016	0,20	0,0142	1,02
Number of religious centers	♣	0,0288	0,76	0,0171	1,56	0,0145	0,93	0,0195	1,65	0,0178	1,05	0,0021	0,45	0,0112	1,22
Number of social welfare centers	♣	0,0266	1,67	0,0084	1,41	0,0054	0,50	0,0110	1,55	0,0091	0,73	-0,0010	-0,40	0,0074	0,97
Number of cultural centers	♣	0,0124	1,47	0,0023	0,98	0,0009	0,20	0,0010	0,42	0,0002	0,04	0,0006	0,56	0,0045	1,26
Number of prisons	♣	0,2469	0,91	0,0203	0,51	-0,0079	-0,09	-0,0009	-0,02	-0,0201	-0,19	0,0168	0,73	0,0944	1,31
Number of attacks against life	♣	0,0425	0,80	-0,0460	-2,60	-0,0508	-2,24	-0,0606	-3,23	-0,0637	-2,61	-0,0067	-0,72	0,0068	0,45
Number of attacks against wealth	♣	0,0716	1,26	0,0344	2,14	0,0262	0,88	0,0314	1,82	0,0251	0,75	0,0092	1,04	0,0316	1,49
Number of bars	♣	0,0285	0,51	0,0148	0,84	0,0130	0,71	0,0161	0,91	0,0159	0,82	0,0180	2,29	0,0269	2,48

Table 2. Hedonic Regression for Bogotá (Continuation)

Variable	Homicide Rate		Ln house price /1				Ln house price /2				Ln house rent			
			OLS		2SLS		OLS		2SLS		OLS		2SLS	
	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*
Number of brothels	♣ -0,1068	-1,98	0,0024	0,13	0,0133	0,35	0,0148	0,77	0,0215	0,50	-0,0179	-1,64	-0,0515	-1,70
Number of casinos/places for bets	♣ 0,0310	0,53	-0,0034	-0,18	-0,0080	-0,37	-0,0192	-1,02	-0,0232	-1,05	-0,0033	-0,30	0,0066	0,50
Number of places selling drugs/narcotics	♣ -0,0593	-1,15	-0,0198	-1,16	-0,0135	-0,53	-0,0207	-1,16	-0,0162	-0,58	-0,0002	-0,02	-0,0187	-1,02
Number of people 0-4 years old	♣ -0,0002	-0,52	0,0003	1,94	0,0004	1,91	0,0004	2,05	0,0004	1,98	0,0001	0,73	0,0000	0,02
Number of people 5-9 years old	♣ 0,0002	0,39	-0,0003	-1,40	-0,0004	-1,44	-0,0004	-1,53	-0,0004	-1,53	0,0000	0,06	0,0001	0,44
Number of people 10-14 years old	♣ -0,0012	-2,86	-0,0004	-1,73	-0,0002	-0,59	-0,0004	-1,85	-0,0003	-0,69	0,0000	-0,12	-0,0004	-1,13
Number of people 15-19 years old	♣ 0,0004	0,67	0,0000	-0,15	-0,0001	-0,28	0,0000	-0,15	-0,0001	-0,25	-0,0004	-2,68	-0,0003	-1,54
Number of people 20-24 years old	♣ 0,0000	0,07	-0,0001	-0,46	-0,0001	-0,45	-0,0001	-0,22	-0,0001	-0,21	0,0001	0,58	0,0001	0,67
Number of people 25-29 years old	♣ -0,0005	-1,21	-0,0001	-0,26	0,0000	-0,06	-0,0002	-0,64	-0,0001	-0,41	0,0000	0,43	-0,0001	-0,65
Number of people 30-34 years old	♣ 0,0004	1,00	0,0002	0,91	0,0002	0,61	0,0003	1,01	0,0002	0,72	-0,0001	-0,58	0,0001	0,44
Number of people 35-39 years old	♣ 0,0000	0,05	-0,0004	-1,62	-0,0004	-1,60	-0,0004	-1,50	-0,0004	-1,50	-0,0001	-1,03	-0,0001	-0,99
Number of people 40-44 years old	♣ 0,0010	1,23	0,0004	1,18	0,0003	0,58	0,0004	1,19	0,0003	0,65	0,0003	1,76	0,0006	1,79
Number of people 45-49 years old	♣ -0,0004	-0,44	0,0002	0,51	0,0002	0,59	0,0001	0,34	0,0002	0,42	0,0002	1,42	0,0001	0,59
Number of people 50-54 years old	♣ 0,0005	0,52	-0,0001	-0,19	-0,0001	-0,29	0,0000	-0,10	-0,0001	-0,17	0,0000	-0,02	0,0002	0,64
Number of people 55-59 years old	♣ 0,0005	0,54	-0,0003	-0,88	-0,0004	-0,94	-0,0002	-0,51	-0,0002	-0,52	-0,0001	-0,44	0,0001	0,20
Number of people 60 + years old	♣ -0,0004	-1,79	0,0005	5,08	0,0005	3,07	0,0005	4,35	0,0005	2,71	0,0001	2,21	0,0000	-0,12
Unsatisfied Basic Needs (NBI): Dependency	♣ -0,0008	-0,33	0,0012	0,94	0,0013	0,96	0,0013	0,96	0,0013	0,95	0,0010	1,79	0,0008	1,20
NBI: Accumulation	♣ 0,0007	2,27	0,0006	4,44	0,0006	2,11	0,0007	3,95	0,0006	1,98	0,0001	0,74	0,0003	1,35
NBI: Dropouts	♣ 0,0176	2,32	-0,0022	-0,77	-0,0039	-0,63	-0,0015	-0,50	-0,0025	-0,36	-0,0016	-1,07	0,0040	0,80
NBI: Public utility services	♣ 0,0006	1,79	-0,0002	-0,81	-0,0002	-0,77	0,0000	-0,14	-0,0001	-0,21	-0,0002	-1,68	0,0000	0,13
NBI: Housing in	♣ -0,0001	-0,14	0,0003	1,25	0,0003	1,26	0,0005	1,57	0,0005	1,57	-0,0001	-0,53	-0,0001	-0,70
NBI: NBI in Municipality where were born	♣ 0,0010	1,60	0,0008	1,85	0,0007	1,43	0,0011	2,24	0,0011	1,81	-0,0006	-2,07	-0,0003	-0,81
NBI: NBI in Municipality where were born	♣ 0,0353	1,74	0,0468	2,21	0,0431	1,87	0,0531	2,23	0,0507	1,97	0,0155	0,90	0,0260	1,31
Born in urban area	0,0219	1,22	-0,0078	-0,51	-0,0104	-0,61	-0,0067	-0,42	-0,0083	-0,45	-0,0056	-0,48	0,0016	0,12
Household with children	0,0673	2,60												
Age of mother minus age of oldest children	-0,0020	-2,52												
Constant	-2,5129	-1,32	14,2025	19,87	14,4826	13,33	14,4844	18,14	14,6996	12,12	9,3414	23,29	8,5617	10,37
Number of Observations	12.120		10.290		10.290		8.435		8.435		12.024		12.024	
R-squared	0,557		0,578		0,577		0,586		0,585		0,683		0,683	

All regressions include dummy variable of father's and mother's education levels and their interactions. *t* statistics computed based on robust standard errors corrected by clustering at the census sector level. 1/ Cadastral values if available, otherwise, the value reported by households surveyd. 2/ Only includes households for which cadastral values are available.

Sources: Encuesta de Calidad de Vida 2003, Real State Appraisal of Bogotá, National Police-DIJIN 2000, Paz Pública (2000). Colombian 1993 Population Census.

* Dummy variable equal to one if house, 0 otherwise (apartment, etc.). ** 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. *** A-Theoretical estimation of QoL (See methodology in DNP, 1997). **** *Centros de Atención Inmediata* , CAIS: Centers of Immediate -Police- Attention. ♣ At the census sector level.

Table 3 presents the results of instrumenting the homicide rate with the previously defined age difference, as well as a dummy variable equal to one if the household has at least one children living in the house, and zero otherwise. The first column presents the first stage results, in which we can see that our instruments are statistically significant, and the age difference has the expected negative sign.

Once we focus on the homicide rate, we find that while in the first regression (cadastral and reported house values) the coefficient of the interactions between the homicide rate and strata 3 and 6 were formerly positive, once we instrument, only the coefficients of the homicide rate and strata 5 and 6 become significant and negative. When we use only cadastral data, the interaction with socioeconomic strata which were not being statistically significant, become significant and negative for stratum 6, and weakly significant for stratum 5. Finally, result for rent values that in the case of the interaction with socioeconomic strata was positive and significant for stratum 6, becomes non significant.

The final 2SLS result implies an elasticity of 1%, or that if the homicide rate in stratum 6 is increased by one standard deviation, from a mean of 0.009 to 0.074 (that is, an increase to 7.3 times the mean), the values of the house would fall 7.2%. In the case of stratum 5, the elasticity of 2% would imply a fall of 2.4% in the value of the house.

On the other hand, the objects theft, assaults, and residential and commercial assaults rates, the attacks of guerilla groups, and the attacks against wealth are not significant. The cars theft rate becomes negative and significant only for its interaction with stratum 5. Finally, the attacks against life keep being negative and statistically significant.

Table 3. Hedonic Regression for Bogotá

Variable	Homicide Rate		Ln house price /1				Ln house price /2				Ln house rent			
			OLS		2SLS		OLS		2SLS		OLS		2SLS	
	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*
Cadastral value	0.0146	0.69	-0.1135	-5.54	-0.1147	-5.51					-0.0232	-2.15	-0.0221	-1.95
You feel safe in your neighborhood	-0.0250	-0.68	0.0541	1.21	0.0565	1.23	0.0433	0.87	0.0423	0.83	-0.0095	-0.35	-0.0130	-0.47
" * Stratum 2	-0.0277	-0.73	-0.0411	-0.80	-0.0361	-0.70	-0.0167	-0.30	-0.0177	-0.31	-0.0181	-0.54	-0.0215	-0.62
" * Stratum 3	-0.0398	-0.97	-0.0629	-1.32	-0.0686	-1.39	-0.0632	-1.20	-0.0780	-1.41	-0.0160	-0.53	-0.0186	-0.58
" * Stratum 4	-0.0022	-0.04	-0.0732	-1.48	-0.0749	-1.50	-0.0637	-1.15	-0.0714	-1.27	0.0256	0.67	0.0281	0.74
" * Stratum 5	0.0538	1.23	-0.1112	-1.57	-0.1088	-1.47	-0.1210	-1.77	-0.1122	-1.53	0.0382	0.82	0.0439	0.90
" * Stratum 6	0.0430	0.95	-0.0809	-0.91	-0.0618	-0.71	-0.0738	-1.12	-0.0510	-0.75	-0.0867	-1.50	-0.0755	-1.27
Objects theft rate ♣	-0.5349	-3.57	0.0891	1.02	0.0910	0.39	0.0669	0.69	-0.0311	-0.12	-0.0695	-1.77	-0.1229	-0.72
" * Stratum 2	0.5236	1.73	-0.0541	-0.34	-0.0744	-0.29	-0.0198	-0.12	0.0507	0.18	0.0202	0.31	0.0733	0.43
" * Stratum 3	0.4175	1.75	-0.0645	-0.72	-0.0738	-0.38	-0.0440	-0.44	0.0225	0.10	0.0545	1.36	0.0950	0.70
" * Stratum 4	0.5246	3.38	-0.1225	-1.36	-0.1245	-0.54	-0.1114	-1.13	-0.0083	-0.03	0.0677	1.56	0.1174	0.69
" * Stratum 5	0.5335	3.23	-0.1667	-1.56	-0.1688	-0.72	-0.1063	-0.93	-0.0058	-0.02	0.0608	1.15	0.1131	0.65
" * Stratum 6	0.4705	4.06	-0.1566	-1.72	-0.0905	-0.43	-0.0364	-0.32	0.0016	0.01	0.0074	0.16	0.0927	0.60
Assaults rate ♣	0.0332	1.65	-0.0174	-0.93	-0.0211	-0.93	-0.0120	-0.59	-0.0119	-0.47	0.0061	0.75	0.0102	0.74
" * Stratum 2	0.0141	0.23	0.0106	0.39	0.0025	0.09	-0.0006	-0.02	-0.0055	-0.20	0.0029	0.29	0.0066	0.53
" * Stratum 3	0.1020	2.70	-0.0135	-0.67	0.0006	0.01	-0.0196	-0.86	0.0173	0.34	-0.0111	-1.22	-0.0019	-0.06
" * Stratum 4	-0.0150	-0.45	0.0021	0.10	0.0069	0.33	-0.0188	-0.82	-0.0146	-0.63	-0.0119	-0.95	-0.0161	-1.18
" * Stratum 5	-0.0152	-0.45	0.0035	0.13	0.0079	0.33	0.0210	0.80	0.0280	1.09	0.0045	0.26	0.0000	0.00
" * Stratum 6	-0.0367	-1.28	0.0023	0.10	0.0109	0.41	0.0131	0.54	-0.0013	-0.04	-0.0033	-0.22	-0.0050	-0.23
Residential and commercial assault rate ♣	0.2908	5.96	0.0358	0.58	-0.0194	-0.13	0.0262	0.41	0.0210	0.13	-0.0093	-0.53	0.0253	0.27
" * Stratum 2	0.0164	0.16	0.0414	0.60	0.0134	0.13	0.0478	0.68	0.0217	0.20	0.0239	0.94	0.0372	0.91
" * Stratum 3	-0.2549	-3.18	-0.0275	-0.44	0.0297	0.22	-0.0094	-0.15	0.0060	0.04	0.0202	1.06	-0.0111	-0.13
" * Stratum 4	-0.2107	-4.12	0.0156	0.26	0.0706	0.59	0.0420	0.67	0.0700	0.54	0.0254	1.29	-0.0049	-0.07
" * Stratum 5	-0.2774	-5.14	0.0192	0.28	0.0775	0.54	0.0011	0.02	0.0109	0.07	-0.0052	-0.21	-0.0385	-0.42
" * Stratum 6	-0.2890	-4.29	-0.0487	-0.69	-0.1159	-0.76	-0.0803	-0.90	-0.0716	-0.42	0.0287	0.82	-0.0647	-0.63
Cars theft rate ♣	-0.0655	-3.14	-0.0006	-0.04	0.0202	0.54	0.0109	0.47	0.0225	0.56	0.0125	1.32	0.0036	0.15
" * Stratum 2	-0.1964	-2.94	-0.0398	-1.09	0.0060	0.07	-0.0453	-1.13	-0.0331	-0.35	-0.0184	-0.98	-0.0497	-0.77
" * Stratum 3	-0.0098	-0.27	0.0083	0.43	-0.0189	-0.68	-0.0083	-0.34	-0.0413	-1.44	-0.0084	-0.83	-0.0067	-0.46
" * Stratum 4	0.0229	0.72	-0.0003	-0.01	-0.0218	-0.76	-0.0042	-0.16	-0.0275	-0.91	-0.0155	-1.20	-0.0088	-0.52
" * Stratum 5	0.0048	0.08	-0.0094	-0.30	-0.0348	-1.05	-0.0437	-1.26	-0.0735	-2.08	-0.0028	-0.14	0.0017	0.08
" * Stratum 6	0.1320	2.77	**0.0602**	**2.12**	**0.1769**	**2.31**	0.0359	0.97	0.1053	1.29	-0.0334	-1.43	0.0422	0.77
Homicide rate ♣	0.0000	0.00	-0.1541	-2.57	0.0261	0.06	-0.1335	-1.93	-0.1050	-0.21	0.0061	0.20	-0.1157	-0.36
" * Stratum 2	0.0000	0.00	**0.1281**	**1.71**	0.1469	0.64	0.1141	1.34	0.1106	0.44	0.0160	0.47	-0.0054	-0.06
" * Stratum 3	0.0000	0.00	**0.1249**	**1.99**	-0.1129	-0.65	0.1084	1.53	-0.1752	-0.92	-0.0198	-0.63	0.0031	0.04
" * Stratum 4	0.0000	0.00	0.0452	0.47	-0.1160	-0.58	0.0422	0.40	-0.2800	-1.33	-0.0395	-0.76	0.0517	0.51
" * Stratum 5	0.0000	0.00	-0.1817	-0.85	-0.4501	-2.14	-0.1569	-0.76	-0.3674	-1.60	-0.0673	-0.37	-0.0956	-0.55
" * Stratum 6	0.0000	0.00	**0.7461**	**2.64**	-1.1070	-2.63	0.0634	0.19	-0.7913	-1.91	**0.9072**	**4.25**	0.2016	0.78
Attacks of FARC, ELN or other groups** ♣	-0.0443	-0.60	-0.0064	-0.19	-0.0027	-0.07	0.0175	0.46	0.0098	0.23	-0.0171	-0.85	-0.0213	-0.89
Number of CAIS****	0.0528	0.33	**-0.1519**	**-1.88**	-0.1384	-1.57	-0.1614	-1.42	-0.0931	-0.73	0.0093	0.18	0.0151	0.28
" * Stratum 2	0.0052	0.03	0.1831	2.06	0.1647	1.74	0.1965	1.61	0.1349	1.00	0.0204	0.38	0.0222	0.40
" * Stratum 3	-0.0588	-0.34	0.1732	2.12	0.1607	1.80	0.1784	1.56	0.1093	0.85	0.0024	0.04	-0.0042	-0.07
" * Stratum 4	-0.1729	-0.91	0.1726	1.94	0.1558	1.32	0.1852	1.53	0.0799	0.54	-0.0128	-0.22	-0.0235	-0.31
" * Stratum 5	-0.0201	-0.11	0.1765	1.83	0.1676	1.77	0.1629	1.29	0.0923	0.68	-0.0201	-0.33	-0.0136	-0.22
" * Stratum 6	-0.0615	-0.35	0.3128	3.46	0.3226	3.29	0.2461	1.79	0.1667	1.15	0.0995	1.61	0.1040	1.68
Number of police headquarters ♣	0.0661	0.61	0.0731	1.54	0.0793	1.51	0.0896	1.57	0.1153	1.85	0.0380	2.99	0.0363	1.43
Number of local security funds ♣	-0.0037	-1.05	0.0019	1.42	0.0016	0.85	0.0023	1.50	0.0013	0.60	0.0007	1.06	0.0003	0.19
Number of prisons ♣	0.2143	0.80	0.0230	0.82	0.0165	0.18	0.0246	0.73	0.0734	0.73	0.0060	0.28	0.0221	0.31
Number of attacks against life ♣	0.0041	0.08	-0.0332	-1.95	-0.0349	-2.02	-0.0569	-2.99	-0.0576	-2.98	-0.0076	-0.81	-0.0068	-0.73
Number of attacks against wealth ♣	0.0954	1.63	0.0195	1.20	0.0177	0.43	0.0294	1.62	0.0469	1.02	0.0031	0.37	0.0125	0.41
Number of bars ♣	-0.0093	-0.15	0.0070	0.45	0.0070	0.44	0.0043	0.26	0.0037	0.22	0.0143	1.77	0.0136	1.57
Number of brothels ♣	-0.0817	-1.57	0.0060	0.34	0.0069	0.20	0.0185	0.99	0.0013	0.03	-0.0117	-1.13	-0.0205	-0.78
Number of casinos/places for bets ♣	0.0431	0.70	0.0017	0.09	-0.0042	-0.17	-0.0149	-0.73	-0.0121	-0.45	-0.0061	-0.58	-0.0010	-0.07
Number of places selling drugs/narcotics ♣	-0.0512	-1.09	-0.0330	-2.00	-0.0366	-1.35	-0.0354	-2.03	-0.0487	-1.66	0.0002	0.02	-0.0046	-0.25
Household with children	0.0583	2.47												
Age of mother minus age of oldest children	-0.0017	-2.32												
Constant	4.9914	1.56	13.2273	7.40	12.5977	4.33	13.7531	5.92	14.2756	4.08	9.0278	7.60	9.6076	5.08
Number of Observations	12,120		10,290		10,290		8,435		8,435		12,024		12,024	
R-squared	0.6314		0.6361		0.6357		0.6508		0.6510		0.7017		0.7012	

All regressions include dummy variable of father's and mother's education levels and their iteractions. *t* statistics computed based on robust standard errors corrected by clustering at the census sector level. 1/ Cadastral values if available, otherwise, the value reported by households surveyd. 2/ Only includes households for which cadastral values are available.

Sources: Encuesta de Calidad de Vida 2003, Real State Appraisal of Bogotá, National Police-DIJIN 2000, Paz Pública (2000). Colombian 1993 Population Census.

* Dummy variable equal to one if house, 0 otherwise (apartment, etc.). ** Attack by guerrilla groups Fuerzas Armadas Revolucionarias de Colombia, FARC, *Ejército de Liberación Nacional*, ELN, or other groups. *** A-Theoretical estimation of QoL (See methodology in DNP, 1997). **** *Centros de Atención Inmediata*, CAIS: Centers of Immediate -Police- Attention. ♣ At the census sector level.

Conclusions

In this paper we use hedonic price models to estimate the value households are willing to pay to avoid crime, and in particular, high homicides rates, in Bogotá. We and find that households living in the highest socioeconomic stratum, stratum 6, are paying up to 7.2% of their house values to keep their average homicide rates and avoid increasing them in one standard deviation. On their part, households in strata 5, that with the next group of richest population in the city, would be paying up to 2.4% of their house values to keep their average homicide rates.

The result reveals the willingness to pay for security by households in Bogotá, and additionally, reveals that a supposed pure public good like security, ends up propitiating urban private markets that auction security. These markets imply different levels of access to public goods among the population, and actually, the exclusion of the poorest.

We find as well evidence of negative capitalization of the rate of attacks against life, and positive capitalization of the presence of police authority in the form of Centers of Immediate Attention, CAIS.

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