Housing Quality and Tenure Choice in Bogota

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Abstract

Empirical housing articles have been scarce in developing countries. It results paradoxical given that homeownership and housing quality have continuously been included at the top of the developing countries political agendas. The present paper provides elements that explain the own/rent decision and the quality dwelling choice in the context of a developing country. The article follows a reduced-form approach that allows us to characterize some critical facts of the housing market equilibrium in the city of Bogota. We show that the tenure choice decision can be largely explained by the price of renting relative to owning and the permanent income. We find evidence that the poorer households delay home purchasing in contrast to the wealthier households, and the workers with unstable labor income are less likely to become homeowners. Furthermore, we estimate price and income elasticities coefficients that quantify the households' dwelling quality response to price and income variation. Thus, a 1% increase in prices reduces the average dwelling quality in 0.16% for the homeowners and 0.25% for the renters, whereas a 1% increase in permanent income increases the average dwelling quality in 0.08% both for homeowners and renters.

Keywords: Colombia, Housing demand, Real estate economics

JEL Classification: C21, C31, R21, R32,

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1 Introduction

The housing purchase decision is equal to any other durable good. It involves an intertemporal stock accumulation decision with a corresponding flow of services derived by the consumption of the stock. Nonetheless, in reality, housing differs from others durable goods in a variety of aspects, such as indivisibility, non-tradability of dividends, transaction costs, collateral constraints (Iacovello, and Pavan, 2013), the own-rent decision, quality heterogeneity (Landvoigt, Piazzesi, and Schneider, 2015) , among others. These multifold features of housing have motivated empirically and theoretical housing research, which aims to explain individual or aggregate housing decisions taking into account the distinctive features that housing possess.

As stated above, housing choices have many dimensions and features that are usually analyzed with large multidimensional structural models, mainly in the macroeconomic literature (Piazzesi, and Schneide,r 2016). In this article, we abstract from distinct critical elements of housing theory such as financial frictions, price uncertainty, or dwelling searching. Instead, we propose an empirical model for the own-rent decision (tenure choice) and the dwelling quality choice which takes into account some other critical features of housing demand.[1] Our model defines housing sub-markets within a metropolitan area delimited by administrative boundaries. This, variation allows us to explore observed equilibrium facts in the metropolitan area housing market and to obtain an estimation of the tenure choice and housing quality choice response to the sub-markets price variation.

The empirical model relies on household survey micro-data, which allow us to make use of cross-sectional variation to bring insights on dimensions of household heterogeneity that significantly explains tenure choice and the housing quality choice. The data is taken from 2011, 2014 and 2017 version of the "Encuesta Multipropósito" (Henceforth EM), a Colombian household survey that aims to measure life quality, socio-economic characteristics of the household, and the urban conditions. It is collected every three years and is mainly focused in the city of Bogota, where it serves as one of the primary sources of information for the local administration.[2]

In the empirical exercise, we consider some theoretical fundamentals behind the tenure choice and the quality decision that are presented in pioneering theoretical housing articles. For instance, Henderson et al. (1983) highlight the importance of the income profile in the tenure choice decision. Intuitively, people with income streams tilted toward the future are relatively more likely to rent than people with expected low income. Thereby, we incorporate in the empirical specification a permanent income variable that serves as a proxy for the single income stream, which is mainly explained by age and human capital variables (see, Belsky, 2006). Besides, in order to fully characterize the income profile for each individual, the employment

[1] The literature has referred to housing demand as the flow of services derived for owing or renting a specific stock of housing. In this article, we refer indistinguishably to this flow of services as housing demand or housing quality choice; both terms refer to the intensive margin decision of housing.

[2] Bogota is Colombia's capital city. It is a large and heterogeneous city. it has almost 8 million people and is considered one of the biggest city in America.

contract-type is included in the empirical model. We hypothesize that fixed term and verbal employment type of contract might lead to a lower homeownership probability[3].

Apart from the income profile, it has been remarked in the housing literature the influence of transaction costs in tenure choice (Goodman, 2003; Haurin, and Gill, 2002; O' Sullivan, 2007). Intuitively, moving is costly, hence when income, prices or preferences change, households do not adjust housing consumption immediately (O' Sullivan 2007), or in other words, people are far from their optimal housing consumption decision. We tackle down the move/stay decision by restricting the sample to households that have recently made the tenure choice decision and therefore are making more marginal decisions (see, Haurin, Hendershott, and Wachter, 1989).

In the strand of quantitative housing models, it has been critical to include the life-cycle profile as a fundamental component that explains tenure choice and the housing quality choice. For instance, in Attanasio et al. (2012), young individuals delay purchasing their first home when incomes are low or uncertain, and higher prices lead a household to downsize, rather than stop being homeowners. Further, in Yang (2009), borrowing constraints are critical in explaining the housing stock for the young and transaction costs are essential in explaining the housing stock for the older. Both articles highlight the role of the life-cycle vis-à-vis transaction costs and borrowing constraints for a better explanation of housing patterns. In our empirical exercise, we cannot observe credit constraints for the household; nonetheless, we include the age of the household head, marital status, and the number of children as an approximation for life-cycle effects.

Regarding the empirical methodology, we closely follow Belsky (2006), Blackley (1986), Goodman (1978, 1982, 1988) and more recently Ioannides (2003), Sieg et al. (2002), and Zabel (2004). The methodology relies on constructing constant-quality price indexes by using techniques based on hedonic pricing and in the same manner, construct a variable that proxies housing quality choice. Once both variables and the permanent income are constructed a regression of the quality variable on the price and income variable gives the estimated price and income elasticities, which measures to what extent the household response to a change in income and prices. These articles exploit metropolitan statistical area (MSA) variation in their identification strategy, where each MSA represents a distinct housing market.

Empirical housing demand literature in developing countries have been scarce[4]. Malpezzi et al. (1985) estimate income elasticities for eight developing countries using national household surveys. Their estimated income elasticities lie between 0.3 and 0.6 among renters and 0.4 and 0.8 among homeowners; in the Colombian case, it is 0.66 for renters and 0.75 for homeowners using individual data. Also, more recently Fontela et al. (2009) estimate housing demand in Mexico using cross-city price variation for 21 metropolitan areas.

[3]The proposed mechanism, is twofold. Firstly, in Colombia's loan requirements, it is needed to signal a constant income flow. Secondly, people might be averse to make a dwelling when having high-income uncertainty

[4]In the literature housing demand refers to the flow of services derived from expenditure on housing. In this article, we indistinguishably call it housing quality choice

They estimate a price elasticity of -0.3 and an income elasticity of 0.8.

Finally, in the Colombian case, Arbelaez et al. (2011) (to the best of our knowledge) is the only article that estimates tenure choice and housing quality choice in Colombia. They use cross-city variation and two waves (2003, 2009) of the "Encuesta Nacional de Calidad de Vida" a nationally representative survey in Colombia. Their estimated price elasticity is -0.61 and -0.64 for renters and homeowners, respectively. Furthermore, their estimated permanent income elasticity is 0.51 and 0.40 for renters and homeowners, respectively. Our methodology is very close to Arbelaez et al. (2011); however, we identify the price elasticities relying on within market time variation in contrast to Arbelaez et al. (2011). Besides, we test the effect of the labor contract type on tenure choice, as well as the tenure choice average marginal effects of permanent income relative price of renting vs. owning and age.

The contribution of the paper is twofold. First, quality-adjusted price indexes are constructed from hedonic regressions for Bogota. Second, we estimate income and price elasticities for the housing quality choice and the tenure choice response for changes in income and relative price (Renting vs. owning). The income and price elasticities are essential elements in any fiscal incidence analysis that incorporates behavioral responses, and it allows the computation of the buyer response whenever a subsidy or a tax are imposed (Lustig, 2018). Furthermore, a broader knowledge of variables that describe the tenure choice and the housing quality decision can be valuable for the housing policymakers in the country.

The empirical model indicates the probability of owning increase 0.17 percent points with an increase in the relative price of renting vs owning. In the same manner, the probability of owning increase 0.173 percent points with a change in permanent income. Our results also indicate that people in Bogota are more likely to purchase a dwelling when being married at the age of 30 but less likely to own when the individual has a fixed-term or a verbal employment contract. Also, the average marginal effect across age and income quintiles shows that the poorer people are most likely to purchase a dwelling at the age of 40 while the wealthier population are most likely to purchase a dwelling at the age of 25.

Furthermore, the results indicate that the localities of Bosa and Usme, appear as the more likely places to become a homeowner, while la Candelaria and Chapinero are the less likely localities to become a homeowner. Finally, concerning the housing quality choice, our empirical model reveals a price elasticity of -0.167 and -0.32 for homeowner and renters, respectively. Furthermore, we find an income elasticity of 0.08 for homeowners and renters.

The rest of the article is organized as follows, in section two we present the estimation methodology for housing prices and housing quality, in section three we describe data and provide summary statistics for the sample, section four presents the tenure choice estimation, section five contains the housing quality choice estimation, section six discuss results, and finally we conclude and discuss some caveats and extensions.

2 Hedonic price estimation

In reality, housing prices are not observable. When people buy or rent dwellings, they pay the price for a bundle of dwellings attributes, neighborhood amenities, and public goods level that provides a flow of utility to the household. The election of a given bundle "size" is what we identify as the housing quality choice; therefore the observed housing expenditures is the interaction of the chosen bundle and its price. If we take housing expenditure (buying value or rent payment) from the data as a proxy for the price, it necessarily will confound with quality. Hence in order to correct that, the following methodology consists on the construction of a price index that does not confound with quality. Besides the procedure allow us to derive an expression for housing quality (that do not confound with prices).

In order to illustrate the structure behind the separability of price and quality, we exhibit Sieg et al. (2002) model.[5]Suppose households receive utility from the consumption of a composite private good b and the consumption of an heterogeneous housing good $h(z)$, which is a function of two characteristics z_1 and z_2, that may be dwelling characteristics like the number of rooms, the quality of the dwelling, or amenities such as the proximity to a green zone or the quality of public space zones. Households only differ in income y and are able to purchase characteristics z_1 and z_2 at prices q_1 and q_2 respectively.[6] Also for expositional simplicity we select a Cobb-Douglas specification for preferences $U(b, h(z))$ and housing quality $h(z)$.

The household solves:

$$max_{\{z_1,z_2,b\}} \quad U(b, h(z)) = h(z)^d b^{1-d}$$

s.t

$$b + q_1 z_1 + q_2 z_2 = y \tag{1}$$

$$h = z_1^a z_2^{1-a} \tag{2}$$

The indirect utility function and the optimal demands are then given by

$$V = d^d (1-d)^{1-d} (A q_1^{-a} q_2^{-(1-a)})^d y \tag{3}$$

$$z_1^* = \frac{day}{q_1} \tag{4}$$

$$z_2^* = \frac{d(1-a)y}{q_2} \tag{5}$$

[5]In contrast to the CES specification in Sieg et al. (2002), for simplicity we specify a Cobb-Douglas. It does not disturb the main separability result

[6]We allow z to be either dwelling attributes or neighborhood amenities

Where $A = a^{-a}(1-a)^{a-1}$.Defining the index price function as $p = Aq_1^a q_2^{a-1}$, then the indirect utility function of a household is given by equation (6); as expected it negatively depends on the price index and positively depends on income.

$$V = d^d(1-d)^{1-d}(p)^{-d}y \tag{6}$$

In order to find an expression for $h(z)$, we compute (2) from (4) and (5) in order to obtain

$$[\frac{day}{q_1}]^a][\frac{d(1-a)y}{q_2}]^{1-a} = z_1^{*a} z_2^{*1-a}$$

rearranging gives

$$(da^a d(1-a)^{1-a})y = q_1^a q_2^{a-1} z_1^{*a} z_2^{*1-a} \tag{7}$$

The right-hand side in equation (7) is the price index multiplied by the housing quality index, and the left-hand side is the required housing expenditure to purchase it. We denote housing expenditure as e, the housing price index as p, and the housing quality index as $h(z)$. Lastly, we replace them in equation (7) in order to obtain:

$$e = h(z)p \tag{8}$$

Taking logarithms in (7) and (8) yields

$$ln(e) = ln(p) + aln(z_1) + (1-a)ln(z_2) \tag{9}$$

Suppose we observe e and z_1 for household j at sub-market m at year t but not z_2. Hence, we obtain the linear regression model:

$$lne_{jmt} = lnp_{0mt} + lnz_{1jmt} + \epsilon_{jmt} \tag{10}$$

Where $\epsilon_{jmt} = (1-a)ln(z_{2jmt})$ are the non-observable attributes of the regression model. Finally, splitting the vector of observable attributes z_1 as a union of one vector of dwelling attributes (s) and one vector of amenities (n), and specifying a distinct equation for homeowners and renters, we obtain the following empirical equations

$$\ln e_{jmt}^{ho} = a_{0mt}^{ho} + a_{1t}^{ho}\boldsymbol{s}_{jmt} + a_{2t}^{ho}\boldsymbol{n}_{jmt} + \epsilon_{jmt}^{ho} \;\; m = 1.....M \tag{11}$$

$$\ln e_{jmt}^{re} = a_{0mt}^{re} + a_{1t}^{re}\boldsymbol{s}_{jmt} + a_{2t}^{re}\boldsymbol{n}_{jmt} + \epsilon_{jmt}^{re} \;\; m = 1.....M \tag{12}$$

Where e_{jmt} is housing expenditure for household j at sub-market m at year t; s_{jmt} is a vector of dwelling attributes, n_{jmt} is a vector of neighborhood amenities and the intercept term a_{0mt} is a component of

expenditure that is constant across all houses in sub-market m (lnp_{0mt} in the structural model). Furthermore, we specify a hedonic equation for each tenure status (re, ho), where housing expenditure (e_{jmt}) is the dwelling purchase value in the homeowner's equation, and the monthly rent payment in the renter's hedonic equation.

Under the hedonic theory each coefficient of the hedonic functions represents the equilibrium price for each attribute. Therefore the housing expenditure for household j at market m at year t, is decomposed as the sum of the base value for all houses in the market m plus the cross product of attributes prices and the chosen bundle of them. Once the hedonic equations are estimated we proceed with $h(z)$ and p identification as follows

$$\hat{e}^{ho}_{jmt} = \hat{\alpha^{ho}_{0t}} \exp\left(\hat{a}^{ho}_{0mt} + \hat{a}^{ho}_{1t}\boldsymbol{s}_{jmt} + \hat{a}^{ho}_{2t}\boldsymbol{n}_{jmt}\right) \tag{13}$$

$$\hat{e}^{re}_{jmt} = \hat{\alpha^{re}_{0t}} \exp\left(\hat{a}^{re}_{0mt} + \hat{a}^{re}_{1t}\boldsymbol{s}_{jmt} + \hat{a}^{re}_{2t}\boldsymbol{n}_{jmt}\right) \tag{14}$$

where (13) and (14) are the prediction equations for (11) and (12) respectively.[7]. Thereby, we define $h(z)$ and p as

$$\hat{e}^{ho}_{jmt} = \underbrace{exp(\hat{a}^{ho}_{0mt})}_{p^{ho}_{mt}} \underbrace{\alpha^{ho}_{0t} exp(\hat{a}^{ho}_{1t}\boldsymbol{s}_{jmt} + \hat{a}^{ho}_{2t}\boldsymbol{n}_{jmt})}_{h^{ho}_{jmt}} \tag{15}$$

$$\hat{e}^{re}_{jmt} = \underbrace{exp(\hat{a}^{re}_{0mt})}_{p^{re}_{mt}} \underbrace{\alpha^{re}_{0t} exp(\hat{a}^{re}_{1t}\boldsymbol{s}_{jmt} + \hat{a}^{re}_{2t}\boldsymbol{n}_{jmt})}_{h^{re}_{jmt}} \tag{16}$$

Equation (15) and equation (16) are the empirical versions for equation (8). We see from both equations that either p^{re}_{mt} and p^{ho}_{mt} are the estimated housing price index that do not depend on the chosen quality ($\boldsymbol{s}_{jmt}$, $\boldsymbol{n}_{jmt}$). Thus, variation in the house price index will be a result of a_{0mt} variation over time. This price

[7] α_{0t} is an adjustment factor that comes from predicting e when $ln(e)$ is the dependent variable. For instance, suppose the dependent variable is $log(y)$, and the original model is

$$log(y) = \beta_0 + \beta 1 x_1 ... + \beta k x_k + u$$

Then the predicted value of modified y equals

$$E(y|x) = E(exp(u))E(exp(\beta_0 + \beta_1 x_1 ... + \beta_k x_k))$$

$$E(y|x) = E(exp(u))exp(\beta_0 + \beta_1 x_1 ... + \beta_k x_k)$$

$$E(y|x) = \alpha_0 exp(\beta_0 + \beta_1 x_1 ... + \beta_k x_k)$$

Following the procedure in Wooldridge (2015) we replace the population expectation with a sample average

$$\hat{\alpha}_0 = n^{-1}\sum_{i=1}^{n} exp(\hat{u}_i)$$

variation arises because of households' living preferences, because of supply and demand interactions, or due to variation in the intensity of public goods provision. Similarly, h^{re}_{jmt} and h^{ho}_{jmt} are the estimated housing quality chosen by the household; they not depend on the housing price index, and their variation depends on the household's housing bundle election.

Besides, as we are interested in the tenure choice response to the variation of the relative price of renting vs. owning we construct the following relative price index.

$$r_{mt} = \frac{p^{re}_{mt}}{p^{ho}_{mt}} \tag{17}$$

3 Data description

The data used in this paper comes from "Encuesta Multipropósito" (EM) a Colombian household survey which aims to measure individual life quality, socio-economic characteristics, and critical urban conditions. It has detailed information on social security, government programs participation, individual health outcomes, and household expenditure. For our propose, socioeconomic variables allow us to track observed heterogeneity among homeowners and renters, and the housing questionnaires allow us to construct a price and quality index with hedonic pricing techniques. We make use of the following set of variables:

- Dwellings' attributes: number of rooms, number of toilets, number of floors, dwelling in the residential complex, ventilation problems, cracks on the walls (or ceiling), pipelines failures, leaks, among others.

- Neighborhood and location characteristics: Air and noise pollution, proximity to non-residential places (factories, dumpsters, bus station, electric power plant, bus station, slaughterhouse), insecurity, bad smells, visual pollution, public space quality, and walking travel time to various places (public transport, green areas, pharmacy, supermarket, workplace).

- Demographics and income: Household size, gender, education level, number of children, age, marital status, labor status, migration, occupation, government benefits, labor income, rents, pension, subsidies, and transfers.

- Tenure status: Whether renting or owning, the dwelling value, the rent payment, and the tenure length.

According to the survey questionnaire, we define homeowners as the households that have paid their dwelling or are currently paying it. Further, the renters are the households that respond to rent or lease the dwelling. We drop from the sample other types of tenure distinct from homeowning and renting which includes usufruction and adverse possession.[8]

The EM contains information on 37 municipalities; however, we restrict the sample to the city of Bogota. There, housing sub-markets are defined according to 19 localities, which are the main interjurisdictional

[8] Adverse possession refers to tenants that do not have a legal title

administrative entities in the city; The smallest locality the "Candelaria" has 22,041 resident people while the largest locality "Suba" has 1'348.372 resident people.[9] Each locality has a local government that is responsible for enforcing construction laws, noise control obligations, maintenance of secondary roads, monitoring the public services and provision of public goods according to the allocated budget.

It has been recognized that within MSA housing price variation is not enough to identify quality responses to prices, in contrast to inter-MSA variation methodologies (Zabel, 2004). Thereby, we exploit time variation of the three EM waves (2011, 2014, 2017), which allows the implementation of market fixed effects, and consequently control for by idiosyncratic components at the market level that persists in time and are correlated with the variable of interest.[10]

Finally, we provide a brief description of the sample. The three EM waves contain housing data only for households that purchased the dwelling five years or less before the interview (2006-2011 for the first wave, 2009-2014 for the second wave and 2012-2017 for the third wave). It restricts the sample size of each wave considerably; nonetheless, as we explained above restricting the sample to more marginal buyers is a recurrent method to exclude homeowner "stayers" in the estimates (for the "stayers" discussion see Goodman, 2003). Furthermore, in order to avoid renter "stayers," we keep renters that report not having lived in the dwelling interview five years ago.

Table 1 contains the main household characteristics of the empirical exercise. The set includes variables that control for essential observed heterogeneity that influence tenure choice and the housing quality decision such as marriage market outcomes, fertility decisions, human capital investment, labor market outcomes, and government transfers (Dietz, and Haurin, 2003).

Table 1 contains the mean and standard deviation for the pooled data of 2011, 2014, and 2017 waves. The table reveals how different are renters from homeowners in the sample.[11] Homeowners are in average older and more educated than renters due to a higher proportion of superior education among the homeowners. Also, the homeowners report being less participant of government benefits in contrast to the renters who have higher health-care and education subsidies. Regarding the family structure, we see that homeowners are more likely to be married (40% vs. 19%). Surprisingly, Table 1 shows, there is no observable difference between homeowners and renters about having at least one children and on the total number of children below 17 years old.

Table 6, Table 7, and Table 8 show the EM summary statistics for the dwelling attributes and neighborhood amenities variables that are used in estimating equation (9) and (10). In 2011, 2014 and 2017 the

[9]Source: Secretaria de habitat

[10]The EM is collected every three years. Also, all the nominal variables (rent payments, dwelling values, income) are deflated using the national consumer price index.

[11]According to the survey questionnaire, we define homeowners as the households that have paid their dwelling or are currently paying it. Further, the renters are the households that respond to rent or lease the dwelling. We drop from the sample other types of tenure distinct from homeowning and renting.

Table 1: Households' summary statistics

	Homeowners		Renters	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**
Household head				
Gender	0.73	0.54	0.78	0.58
Age	46.62	13.12	38.53	12.85
None education	0.00	0.05	0.00	0.07
Primary education	0.05	0.21	0.07	0.26
Secondary education	0.23	0.42	0.40	0.49
Technical education	0.13	0.34	0.17	0.37
University education	0.34	0.47	0.25	0.43
Pos-graduate education	0.25	0.43	0.11	0.31
Non-married couple	0.25	0.43	0.35	0.48
Widowed	0.05	0.22	0.03	0.17
Divorced	0.12	0.32	0.13	0.33
Single	0.19	0.39	0.30	0.46
Married	0.40	0.49	0.19	0.39
Household characteristics				
At least one child	0.44	0.50	0.44	0.50
Single household	0.14	0.35	0.20	0.40
Parent household	0.14	0.35	0.13	0.33
Other households	0.28	0.45	0.23	0.42
No. Children under 17 years	0.67	0.88	0.70	0.94
Household size	3.01	1.40	2.86	1.49
Health government program	0.17	0.38	0.29	0.45
Education government program	0.03	0.16	0.05	0.23
Study at public school	0.19	0.40	0.25	0.43

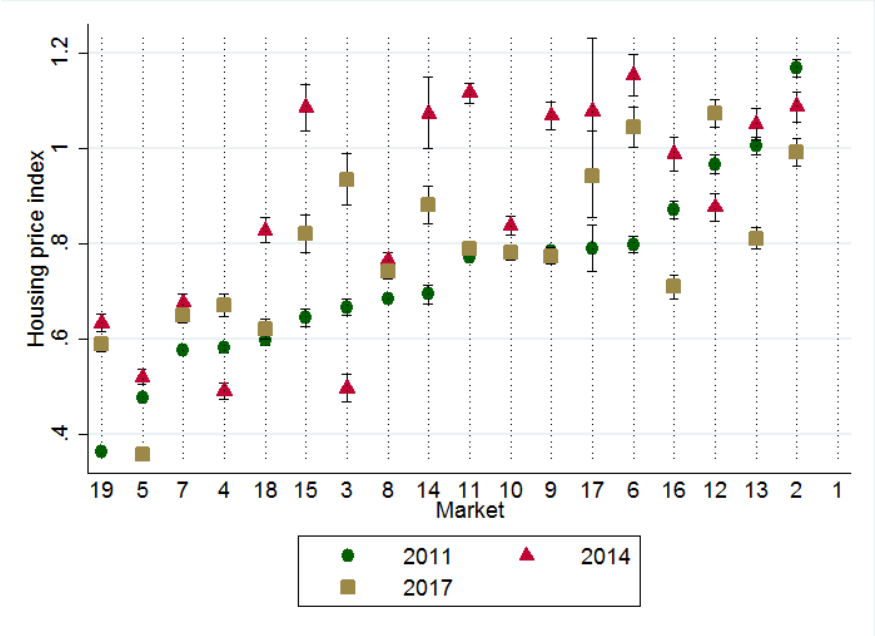
Source: ME 2011,2014 and 2017. Authors calculations.

homeowners live at bigger houses; the tables show that in average homeowners have dwellings with higher number of rooms, number of toilets, and dwelling with a garage. Furthermore, homeowners live closer to a police station, closer to green zones and far from drug dealing areas.

Besides, the homeowners report to has less humidity in the dwelling, and less neighborhood negative externalities such as insecurity, bad smells, noise pollution, and public space deprivation. Either in dwelling attributes and neighborhood amenities, the homeowners report to demand higher housing quality. One of the reasons is that the people want higher quality when purchasing a dwelling because of the long-term scope of the decision and the higher cost associated with moving, in contrast to the rent decision.

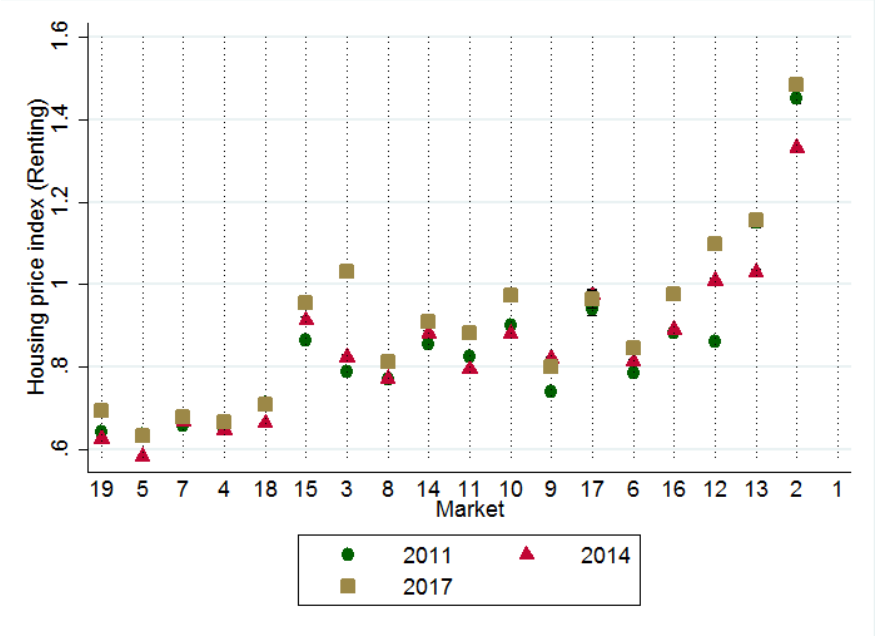
Tables 9, 10, and 11 in the appendix, show the hedonic regression estimates for homeowners and renters in 2011,2014 and 2017. According to the estimation results, the housing value (rent payment) is higher when

Figure 1: Homeowning housing price index



Source: EM 2011,2014,2017. Authors' calculations

Figure 2: Renting housing price index



Source: EM 2011,2014,2017. Authors' calculations

the dwelling is bigger, which is approximated by the number of toilets, the number of rooms, having a garage and having an elevator. Furthermore, insecurity in the neighborhood, and bad smells is negatively related to housing value and rent payment indistinctly in the three waves of the EM.

Regarding, noise pollution, drug dealing areas, and public space deprivation, the signs of these coefficients vary across the three waves, which may be a result of reverse causality, for instance, people choose to invade public space in highly income zones.[12] Furthermore, regarding the travel times variables, Table 9, Table 10 and Table 11 show that being apart from a police station negatively correlates with the housing value and rent payment.

Figure 1 and Figure 2 display the housing price index for home-owning and renting respectively. Taking into account the Table 5 market enumeration(in the appendix table), the figures show, Barrios Unidos Chapinero and Teusaquillo are the most expensive zones in Bogota while Usme and Ciudad Bolivar have the lower homeowning price index.

4 Tenure Choice

We incorporate a traditional microdata analysis of the probability of homeownership (McFadden, 1976). We specify a probit specification, where the estimated response probability can be derived from an underlying latent variable (y^*) that represent the difference between the indirect utility of being a homeowner (V^{HO}) and the indirect utility of being a renter (V^{RE}). Thus, we model the household observed decision (I) as a function of observed characteristics (x).

$$V^{HO} - V^{RE} = y^*$$

$$P(y^* > 0|\boldsymbol{x}) = P(I = 1|\boldsymbol{x}) = G(\beta_0 + \boldsymbol{x}\boldsymbol{\beta}) \tag{18}$$

Where $G(x)$ is the standard normal cumulative distribution function, and I is the observed household decision which equals 1 if the household owns the dwelling and 0 if the household rents the dwelling. The set of explanatory variables $\boldsymbol{x}$ contains: the relative price of renting vs. owning, the permanent income (See appendix A for the permanent income estimation procedure),the current income, the age of the head of the household (and its square), marital status, household type, being enrolled in the (subsidized) public health care system (Sisben), receive any kind of education subsidies,robes and crimes rate in each market, and the market and year fixed effect.

Table 2 exhibits the probit coefficient estimates for four distinct specifications, which differ in the inclusion of market fixed effects and the control variables. The inclusion of market fixed effects isolates between-market

[12]Besides the possible reverse causality issue, all the neighborhood variables are subjected to measure error due to self-reporting

variation and restricts the analysis to within-market differences through the three waves of the survey. Thus, it alleviates shortcomings from ex-ante unobserved heterogeneity in each market that may affect the consistency of the estimates; for example, the distribution of social housing among markets induces a level of homeownership, but at the same time it might distort the price of housing in each market, which exacerbates the omitted variable bias. Furthermore, the market fixed effect intrinsically justifies a market segmentation structure, where each market is independent of the others. The main caveat of the marked fixed effect is that it demands substantial variation in time to distinguish the variable of interest from the fixed effect, which in small spatial entities as the Bogota's localities is not quite large (Von Graevenitz, and Panduro, 2015). Even so, in the following of the article, we choose the model with market fixed effect, that according to Table 2 exhibits significant estimates either for income and the relative price of housing.

The post-estimates average marginal effects for the fixed effect market model are reported in Table 3 (column 1). According to our estimation results a continuous increment of the relative price of renting versus owning in average increase the probability of owning in almost 0.172 points, a continuous increment in the permanent income on average increase the probability of owning in 0.173 points and an increase in the current income increases the probability of owning by 0.046 points. The larger effect of permanent income in contrast to current income highlights the long-run nature of the household's tenure choice.

Table 2: Probit estimates

	(1)	(2)	(3)	(4)
Variables				
Log relative price (Rent/Own)	0.584***	0.420***	0.513***	0.0709
	(0.137)	(0.141)	(0.195)	(0.337)
Log permanent income	0.586***	0.670***	0.528***	0.541***
	(0.0551)	(0.0423)	(0.0596)	(0.0663)
Log current income	0.158***	0.185***	0.147***	0.123***
	(0.0281)	(0.0340)	(0.0239)	(0.0372)
2014	-0.337***	-0.397***	-0.242***	-0.387***
	(0.0527)	(0.0467)	(0.0672)	(0.0812)
2017	0.0524	0.0128	0.321***	0.146**
	(0.103)	(0.0612)	(0.0584)	(0.0675)
Observations	15,395	15,395	15,395	15,395
Locality FE	YES	YES	NO	NO
Controls	YES	NO	YES	NO

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

AME general model AME verbal contract AME fixed-term contract

Table 3: Average marginal effects: General model (column 1) Verbal-contract (column 2) Fixed-term contract (column 3).

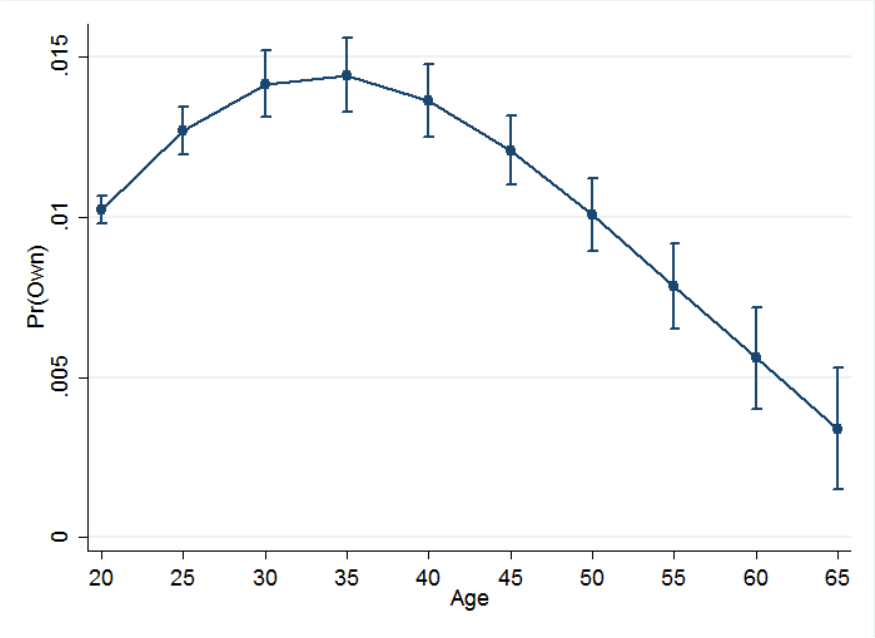
	(1)	(2)	(3)
	AME general model	AME verbal contract	AME fixed-term contract
Variables			
Log relative price (Rent/Own)	0.172***	0.171***	0.156***
	(0.0398)	(0.0432)	(0.0467)
Log permanent income	0.173***	0.168***	0.173***
	(0.0149)	(0.0185)	(0.0192)
Log current income	0.0467***	0.0589***	0.0581***
	(0.00800)	(0.0128)	(0.0136)
Age	0.0110***	0.0124***	0.0129***
	(0.000387)	(0.000780)	(0.000756)
Verbal contract		-0.0598***	
		(0.0187)	
Fixed-term contract			-0.0727***
			(0.0128)
2014	-0.0972***	-0.0831***	-0.0972***
	(0.0150)	(0.0227)	(0.0242)
2017	0.0160	0.0526	0.0416
	(0.0316)	(0.0385)	(0.0387)
Observations	15,395	8,707	7,897

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 3 illustrates the average marginal effect of the age of the household head. It shows that on average, the probability of being a homeowner reaches a peak at 30 years old for a sample of households that have recently purchased a dwelling. Thus, it is a novel description of who are the people that are buying houses in Bogota. Moreover, Figure 4, displays the average marginal effect by income quintile; As expected, more affluent households have a higher probability of owning a house as long as the average marginal effect of the more affluent households is higher in contrast to the more poor households average marginal effect. On the other side, Figure 4 shows, that the peak age shifts to the right when households get poorer; for the top income quintile it is 25 years old, and for the bottom, it is 40 years old. According to the housing literature (Attanasio, Botazzi, Low, and Nesheim, 2012; Blundell, 2012; Ortalo-Magne, and Rady, 2016), One possible explanation for the shift in the peak across income quintiles is a life-cycle pattern, where the poorer households need more time to save enough resources from fulfilling a down-payment requirement. Thereby, the lack of savings vehicles for the poorer households in conjunction with housing institutions such

Figure 3: Age average marginal effect



Source: EM 2011,2014,2017. Authors' calculations

as the down-payment requirement can delay dwelling purchasing for the poorer households.

4.1 Income profile

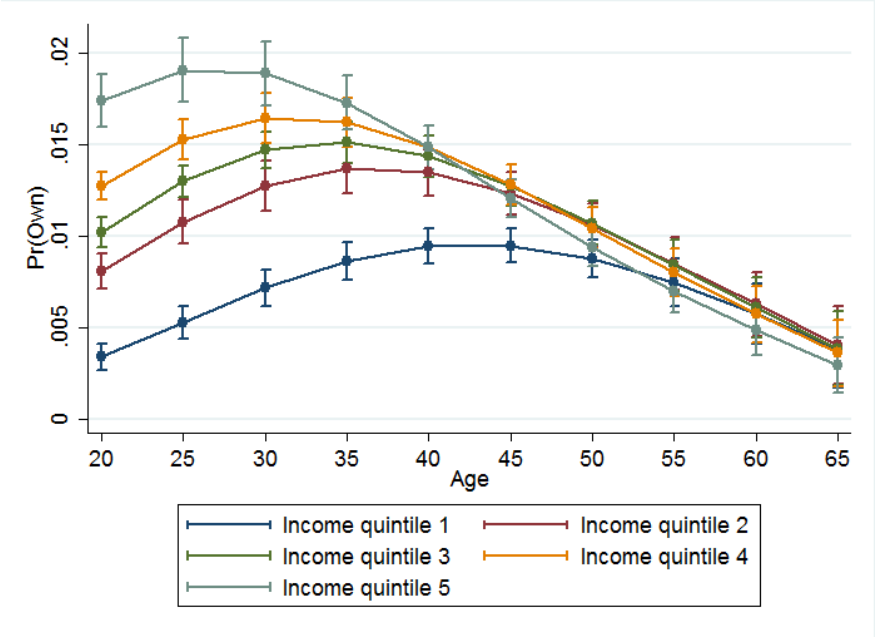
According to Robst et al. (1999) article, income uncertainty reduces the likelihood of individuals owning homes at a point in time. Intuitively, variation in earning and/or flows transitions to unemployment can caution the individuals to incur in a long-run contract such as a home purchase. Furthermore, in Colombia the bank requirements to ask a housing loan requires to signal a constant income flow, which in this context would generate a credit rationing for people with high-income risk. Along these lines, our interest in this section is to test the hypothesis that higher income risk leads to a lower homeownership probability.

The individual income variability is not observable in our cross-section data. There, we use as a proxy for income variability the type of contract for each worker.[13] We evaluate two proxies for income variability, the first one is the fixed-term contract vs. full-time permanent employment contract and the second is a verbal vs. a written contract. According to our hypothesis, we expect that either fixed-term and verbal contract negatively affect the homeownership likelihood.

Table 3 shows the average marginal effects of the probit model with the fixed-term dummy (column 1), and the average marginal effects when the verbal-contract dummy is included in the probit model (column

[13]Clearly our sample confines to household where the head is a salaried worker

Figure 4: Age average marginal effect by permanent income decile



Source: EM 2011,2014,2017. Authors' calculations

2). Both models confirm our hypothesis that having either a fixed-term or a verbal employment contract reduces the probability of homeownership. According to Table 4, having a fixed-term contract reduces the homeownership probability in 0.07 percent points. Similarly, having a verbal-contract reduces in average the probability of homeownership in 0.05 percent points.

5 Housing quality choice

The previous section focuses on the estimation of the tenure choice. we find some determinants that significantly explain the tenure choice decision such as the relative price of renting vs. owning, the permanent income, the age of the household head, the marital status, among others. Apart from the decision of being a homeowner or being a renter, the household also decides on the quality of the dwelling they are demanding. Thereby, conditional on tenure choice, the household selects a housing bundle according to their preferences, according to their income and according to the price of the housing bundle.

Our main goal is to measure to what extent the household quality choice responds to geographical price variation and to the household income. In this scenario, a downward sloping demand implies that on average and controlling for observable household characteristics, more housing services will be purchased in markets with a lower price of housing (Zabel, 2004). Furthermore, it is expected that higher income also leads to a higher level of housing quality.

Table 1 in the data section shows the difference between homeowners and renters in the sample; homeowners are on average older, more educated, wealthier, and more prone to be married than renters. In addition to the hedonic price estimation section, Table 6, 7, and 8 (in the appendix table) show that renters and homeowners broadly differ in the selection of the housing bundle. Thus, the first step in the empirical modeling of housing quality choice is to model the sample selection that emerges from being a renter or a homeowner. The basic strategy to correct for sample selection consists of computing the inverse mills ratio from the tenure choice equation (Rosen, 1979) and include it in the housing quality choice model. The inverse mill ratio gives:

$$\lambda^{HO} = \frac{g(\hat{I})}{G(\hat{I})} \tag{19}$$

$$\lambda^{RE} = \frac{g(\hat{I})}{G(-\hat{I})} \tag{20}$$

Where λ^{HO} and λ^{HO} are the IMR for homeowners and renters respectively, $\hat{I}$ is the predicted value from equation (14), $g(x)$ is the ordinate of the standard normal distribution and $G(x)$ is the normal cumulative distribution. Both inverse Mills Ratios are included in the housing quality choice model, in order to improve the estimates as long as, some of the housing quality choice determinants may also affect the tenure choice decision, which may lead to inconsistent estimates without the sample bias correction. Thereby, we define the housing quality choice model:

$$log(h^i_{jmt}) = \beta_0 + \beta_1 log(p^i_{mt}) + \beta_2 log(y^c_{jmt}) + \beta_3 log(y^p_{jmt}) + \beta_4 Z_{jmt} + \sigma\lambda^i_{jmt} + \mu_{jmt} \tag{21}$$

$$for \quad i = renter, homeowner$$

Where h^i_{jmt} is housing quality defined in section 3.1 for tenure status i, household j, at locality m in time t. Further, p^i_{mt} is the housing price index defined in section 3.1, and y^c, and y^p correspond to the current and permanent income respectively. We specify the model in logs-logs in order to interpret coefficients β_1, β_2, and β_3 as price and income elasticities respectively. Moreover, Z is a vector of controls such as household size, the number of children under 17 years old, marital status, being a participant of education and health-care government programs, robes and crimes in each sub-market over time, and market and year fixed effect.

The results for housing quality estimation are reported in Table 4. The table illustrates two models for the homeowner's quality; the first one restricts the sample to the household's that report at most a one-year tenure length, and the second model is estimated in all the sample. The idea of restricting the sample to at most one-year tenure length is to achieve that the households effectively face the estimated price.[14] The price elasticity for the homeowners is -0.167 across all the sample and -0.325 in the restricted model;

[14]For instance, households at 2017 that report a tenure length of 3 years, have not directly face the 2017 price

results show that the estimated elasticity is greater whenever we restrict the sample to households that more directly face the estimated price. In the renter's case, the estimated elasticity is -0.25, which is higher than the homeowner's elasticity when all the sample is included.[15]

In the homeowner's case, the permanent and current income elasticities are 0.0805 and 0.0934, respectively. Both elasticities are statistically significant and reveal that the household takes into account either his current income and his potential income when choosing the dwelling quality. In the renter's case, the permanent and current income elasticities are significant (-0.089, -0.14 respectively) and the current income elasticity is larger than the permanent income elasticity. This reveals that the renters' short-run income weights greater in their quality selection decision.

Besides, either in the renters and in the homeowner's case the coefficient of the inverse mills ratio is significant and hence validates the sample censoring modeling. In the homeowner's case, the coefficient of the inverse mills ratio is significantly negative, which implies that unobserved factors that influence homeownership are associated with lower housing quality. In contrast, the inverse mills ratio in the renters housing quality estimation shows that unobserved factors that influence renting are positively correlated with the renters' dwellings quality.

In brief, section 4 and section 5 study which are the tenure choice and housing quality choice determinants. Firstly, section 4 reveals that the relative price of renting relative to owning, and the permanent income significantly increases the probability of homeownership, while the current income also shows to increases the probability of homeownership but in a lesser extent. Furthermore, in section 4 the estimated average marginal effects display that the probability of purchasing a house reaches a peak at the age of 25 for the wealthier households; reach a peak at the age of 40 for the poorer households, and reach a peak at the age of 30 for the average household. Moreover, in section 4 it is shown that household's head that has a labor verbal-contract (in contrast to a written contract), or a fixed-term contract (in contrast to verbal contract) are less likely to become homeowners. Secondly, this section presents the income and price elasticities estimation either for renters and homeowners. Both elasticities have the expected theoretical direction, and their magnitude gives insights on the size of the household's quality to changes on income and prices. In the next section, we further discuss the results.

6 Discussion

This section illustrates the incidence of income and prices in tenure choice and housing quality choice. We discuss the relevance of permanent income in the tenure choice, the possible effect of credit access and down-payment (which are omitted variables in our empirical exercise), and the results for the price elasticities in relation to the existing literature.

[15]It is not possible to perform the sensitivity length analysis with the renters across all the years.

Table 4: Housing quality estimation

	(1)	(2)	(3)
VARIABLES	Homeowners log quality I	Homeowners log quality II	Renters log quality
Log housing price	-0.325***	-0.167***	
	(0.122)	(0.0557)	
Log rent price			-0.250***
			(0.0960)
Log permanent income	0.0818***	0.0805***	0.0898***
	(0.0288)	(0.0131)	(0.0101)
Log current income	0.105***	0.0934***	0.144***
	(0.0191)	(0.0110)	(0.00764)
Inverse Mills ratio	-0.0984**	-0.132***	0.254***
	(0.0435)	(0.0254)	(0.0190)
2014	0.281***	0.201***	0.121***
	(0.0520)	(0.0242)	(0.0131)
2017	0.322***	0.474***	0.124***
	(0.0518)	(0.0243)	(0.0147)
Constant	13.02***	13.02***	6.563***
	(0.384)	(0.197)	(0.118)
Observations	1,164	5,632	9,763

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: ME 2011,2014, 2017. Authors calculations.

Our findings suggest that permanent income significantly contributes to the probability of being a homeowner. The estimation results of section 4 show that the average marginal effect of the permanent income is almost four times larger than the current income. The explanation is that the current income only accounts for the instantaneous income that the individual earns in a month, while the permanent income constitutes a measure of the individual capacity to generate income in the long run. This result links the individual productivity, vis-a-vis homeownership probability in an expected way, where the more educated and experienced workers, are wealthier and hence are able to purchase a dwelling.

However, some key element is absent from the analysis above. Why do individuals with lower expected productivity are less likely to purchase a dwelling? In a world with perfect credit-markets any individual that aims to purchase a dwelling will effectively do it by postponing consumption; even the poorest individuals,

will be able to afford a dwelling by a commitment to payments in time according to their productivity. In reality, credit markets are imperfect, and people can default their debt. Especially the lowest productivity individuals are more likely to default its payments as long as their capacity to generate income is close to nil. However, the banking system in the real world cannot directly observe individual productivity. That is the key element from the permanent income discussion. As the banking system cannot directly observe the individual productivity, it builds a proxy for individual productivity based on the available characteristic of the individual, such as education, age, and health condition, precisely the variables that we use to estimate the permanent income. Thus, we highlight that the permanent income variable that is estimated, can be understood as the primary signal for the banking system .[16]

Apart from signaling a capacity to generate income in time, the banking system requires a down-payment to request a loan for buying a house. [17] It exacerbates differences among individuals, as long as the poorer individuals, find more difficult to save for a down-payment in contrast to the wealthier individuals (Ortalo-Magne, and Rady, 2016). Below, we exhibit two facts of our results that allow us two discuss the behavior of individuals to the down-payment in Bogota:[18]

1) According to the estimation results, a 100% increase in permanent income only produces an 8% increase in housing quality both for renters and homeowners. The households slightly vary their chosen housing bundle by changes in permanent income.

2) According to Figure 4, the poorer households delay dwelling purchasing. Which according to the literature, we argue is a consequence of savings for a down-payment

We hypothesize that results in 1) and 2) are related in the following sense. As long as households slightly vary their chosen housing bundle by changes in permanent income, the poorer households that find difficult to afford a down payment, will prefer to save more and delay the home buying, instead of choosing a lower housing quality which would reduce the savings periods.

Finally, Section 5 exhibits that in the homeowners' case, the price elasticity is between 0.167 and 0.32 and in the homeowners' case the price elasticity is 0.25. Furthermore, the estimated permanent income elasticity is almost 0.08 both for homeowners and renters. Previous estimates of the price and income elasticities have tended to vary considerably because of distinct levels of aggregation, diversity of techniques, varying measures of income, the price of housing, and separate model specifications (Zabel, 2004). The articles that we closely follow in the construction of the housing prices, in the estimation of the permanent income and in the specification of housing demand (Arbelaez, Steiner, Becerra, and Wills, 2011;Fontela, and Gonzales, 2009; Goodman, 1998; Ioannides, and Zabel, 2003;Rosen, 1979) rely their identification strategy on between

[16]Thereby, the credit access is an unobserved variable in the probit estimates of section 4. Thus it positively biases the permanent income estimates as long as permanent income is positively correlated with credit access and credit access is positively correlated with homeownership

[17]In Colombia the down-payment is at most 30% of the market value of the house

[18]Similarly to the credit access, the down-payment is a non-observable variable in the empirical model, nonetheless in this section we disentangle facts that reveal its effects

city price variation.[19] Thereby, their elasticities are larger in contrast to our estimates as long as each market largely differs from each other. Nonetheless, in the between-city methodology the estimated coefficients are more exposed to unobserved factors (at the city level) that might bias the results.

Our specification controls for non-observed variables that do not vary in time, allowing for better control of the market unobserved heterogeneity. Nonetheless, it comes at the cost of a lack of variation in prices and income in order to identify price and income elasticities. Besides the model loses cross-market variation that might be valuable to interpret the households' housing choices, as in the case of Arbelaez et al. (2011) which exploit between city variation and consequently estimated higher price and income elasticities. Furthermore, our estimated elasticities might suffer from an omitted variable bias for unobserved factors at the market level that changes across time. In order to alleviate this potential bias, we include crimes and robbery rate in order to control for changes in each market (locality) throughout the three waves of the survey.

Conclusions

We propose an empirical model for the own-rent decision and the dwelling quality choice in Bogota. A two-stage procedure is specified in order to estimate the housing quality conditional on tenure choice. Furthermore, prices and housing quality are recovered from household survey data using hedonic pricing techniques for each sub-market (defined from administrative boundaries), and for each year (2011, 2014 and 2017). We find that the relative price of renting relative to owning significantly increases the probability of homeownership which is compatible with a model when households make the tenure choice decision comparing across the renting market and the owning market.

In addition, the tenure choice estimation results indicate permanent income significantly improves the probability of owning a dwelling, which is a result of the long-run nature of purchasing a dwelling in relation to the worker expected productivity. We hypothesize, permanent income is related to credit access, which is an omitted variable and hence positively biases the effect of a permanent income on tenure choice. In this regard, an obvious extension is to include credit access in the analysis, which would permit a broader analysis of homeownership determinants.

Moreover, the average marginal effect analysis shows that workers with verbal contracts (in contrast to written contract) and workers with fixed contracts (in contrast to long-term contracts) are less likely to become homeowners. Once controlling for income, we argue that income instability might restrict households to commit to a mortgage. Furthermore, the average marginal effect analysis, show that on average people are more likely to purchase a dwelling at the age of thirty, where at the case of the poorest people they are more likely to own at the forty years old. In relation to common results in the housing literature, we argue that the delay on home purchasing is a result of savings accumulation to afford a down-payment.

[19] None of the reviewed articles use market fixed effects in the estimation

The estimated price and income elasticities for the housing quality choice are statistically significant, but also lower in magnitude in contrast to existing articles on housing demand estimation. Nonetheless, the articles that we follow exploit city variation, which may result in a higher source of variation, but also more unobserved factors may come into play.

Finally, we remark some of the main caveats of the article. Firstly, the constructed price variable can be correlated with omitted variables, that vary in time in each sub-market such as possible supply effects or a shift in the intensity of public goods provision. Furthermore, the static setup of the empirical model misses essential properties of the housing literature such as the housing price uncertainty, and the investment motive of housing.

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Appendix A Permanent Income Estimation

Housing decisions have an underlying dynamic structure. People decide whether to own/rent and the level of quality according to the expectations of essential variables such as household income, and housing prices. The EM, does not contain any question regarding housing price expectations, therefore it is an omitted variable in the empirical exercise. However, it is possible to proxy future household income using current state variables. Following Belsky (2006), and Fontella et al. (2009), we use the household permanent income as a measure for the expected long-run average income. In order to estimate permanent income for each person, we consider the following regression

$$log(Y_{imt}) = \beta_0 + \beta_1 H_{imt} + \beta_2 Z_{imt} + \epsilon_{imt} \tag{22}$$

Where, Y_{imt} is current income for person i at locality m at year t, H_{imt} is a vector of human capital variables such as the education level, the father education and the health condition.[20]In addition, Z_{imt} is a

[20]we include Health condition as a set of dummy variables, that equals 1 whether person i have suffered chronic diseases

vector of control variables such as age (and its square), gender, and locality. Thereby, permanent income is the fitted value for equation (18)($\hat{Y}_{imt}$) ; intuitively, we fitted the part of the current income that is mainly explained by components that determine the long-run average income.

Appendix B Tables

Table 5: Households' summary statistics

		Sample Size			
Market number	Market	2011	2014	2017	Total
1	Usaquén	258	284	1,005	1,547
2	Chapinero	235	489	296	1,020
3	Santafé	213	190	355	758
4	San Cristóbal	214	189	385	788
5	Usme	271	305	428	1,004
6	Tunjuelito	316	271	270	857
7	Bosa	352	364	682	1,398
8	Kennedy	238	319	1,374	1,931
9	Fontibón	243	308	1,162	1,713
10	Engativá	211	284	718	1,213
11	Suba	308	347	1,525	2,180
12	Barrios Unidos	195	239	331	765
13	Teusaquillo	189	284	851	1,324
14	Los Mártires	201	285	281	767
15	Antonio Nariño	255	236	215	706
16	Puente Aranda	260	306	472	1,038
17	La Candelaria	157	209	111	477
18	Rafael Uribe	307	255	343	905
19	Ciudad Bolívar	216	258	710	1,184

Source: ME 2011,2014 and 2017. Authors calculations.

Table 6: Housing summary statistics 2011

	Homeowners		Renters	
Variables	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Tenure length:				
Less than 1 year	0.04	0.19		
1 years	0.16	0.37		
2 years	0.21	0.41		
3 years	0.20	0.40		
4 years	0.20	0.40		
5 years	0.19	0.39		
Residential complex	0.56	0.50	0.22	0.42
Elevator	0.25	0.43	0.07	0.26
Number of toilets	1.92	0.93	1.28	0.59
Garage	0.54	0.50	0.23	0.42
Building floors	4.46	3.55	3.18	2.26
Number of rooms	3.94	1.06	2.84	1.20
Humidity	0.23	0.42	0.31	0.46
Walking travel time to a police station:				
Less than 10 min	0.30	0.46	0.27	0.44
Between 10 and 20 min	0.37	0.48	0.35	0.48
20 min or more	0.33	0.47	0.38	0.49
Walking travel time to Green zones:				
Less than 10 min	0.80	0.40	0.70	0.46
Between 10 and 20 min	0.12	0.33	0.20	0.40
20 min or more	0.07	0.26	0.10	0.31
Dwelling close to:				
Drug dealing areas	0.19	0.39	0.25	0.43
Bad smells	0.32	0.47	0.36	0.48
Insecurity in the neighborhood	0.67	0.47	0.71	0.46
Noise	0.32	0.47	0.36	0.48
Public space deprivation	0.15	0.35	0.13	0.34

Source: ME 2011. Authors calculations.

Table 7: Housing summary statistics 2014

	Homeowners		Renters	
Variables	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Tenure length:				
Less than 1 year	0.09	0.29		
1 years	0.13	0.34		
2 years	0.15	0.36		
3 years	0.16	0.37		
4 years	0.16	0.37		
5 years	0.14	0.35		
6 years	0.15	0.36		
Residential complex	0.51	0.50	0.23	0.42
Elevator	0.24	0.42	0.09	0.29
Number of toilets	1.89	0.94	1.29	0.57
Garage	0.54	0.50	0.22	0.42
Building floors	4.41	3.37	3.39	2.04
Number of rooms	3.83	1.19	2.84	1.12
Humidity	0.20	0.40	0.22	0.42
Walking travel time to a police station:				
Less than 10 min	0.33	0.47	0.33	0.47
Between 10 and 20 min	0.34	0.48	0.36	0.48
20 min or more	0.32	0.47	0.32	0.47
Walking travel time to Green zones:				
Less than 10 min	0.76	0.43	0.66	0.47
Between 10 and 20 min	0.15	0.36	0.21	0.41
20 min or more	0.09	0.28	0.13	0.34
Dwelling close to:				
Drug dealing areas	0.16	0.37	0.21	0.41
Bad smells	0.29	0.45	0.29	0.46
Insecurity in the neighborhood	0.61	0.49	0.63	0.48
Noise	0.29	0.45	0.35	0.48
Public space deprivation	0.18	0.38	0.16	0.37

Source: ME 2014. Authors calculations.

Table 8: Housing summary statistics 2017

	Homeowners		Renters	
Variables	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Tenure length:				
Less than 1 year	0.08	0.27		
1 years	0.14	0.35		
2 years	0.21	0.41		
3 years	0.18	0.38		
4 years	0.18	0.39		
5 years	0.21	0.41		
Residential complex	0.66	0.47	0.32	0.47
Elevator	0.31	0.46	0.16	0.37
Number of toilets	1.84	0.83	1.37	0.66
Garage	0.45	0.50	0.25	0.43
Building floors	5.61	4.31	4.19	3.34
Number of rooms	3.78	1.02	3.00	1.20
Humidity	0.16	0.36	0.19	0.39
Walking travel time to a police station	16.97	14.54	16.98	14.47
Walking travel time to Green zones	35.45	30.70	38.62	31.32
Dwelling close to:				
Drug dealing areas	0.16	0.37	0.22	0.41
Bad smells	0.26	0.44	0.29	0.45
Insecurity in the neighborhood	0.55	0.50	0.60	0.49
Noise	0.29	0.45	0.34	0.47
Public space deprivation	0.16	0.37	0.16	0.37

Source: ME 2017. Authors calculations.

Table 9: Hedonic estimates 2011

	(1)	(2)
Variables	Log rent payment	Log dwelling value
1 year length		-0.148***
		(0.00812)
2 year length		-0.206***
		(0.00797)
3 year length		-0.377***
		(0.00801)
4 year length		-0.406***
		(0.00800)
5 year length		-0.421***
		(0.00805)
Residential complex	0.0877***	0.0110***
	(0.00166)	(0.00332)
Elevator	0.129***	0.348***
	(0.00352)	(0.00562)
Number of toilets	0.160***	0.309***
	(0.00128)	(0.00224)
Garage	0.167***	0.157***
	(0.00161)	(0.00336)
Building floors	0.0162***	0.000847
	(0.000376)	(0.000627)
Number of rooms	0.195***	0.0448***
	(0.000562)	(0.00157)
Humidity	-0.0224***	-0.0160***
	(0.00121)	(0.00339)
Walking minutes to a police station:		
Between 10 and 20 minutes	-0.0466***	0.0423***
	(0.00145)	(0.00349)
20 minutes or more	-0.0810***	-0.0530***
	(0.00147)	(0.00367)
Walking minutes to green zones areas:		
Between 10 and 20 minutes	-0.0135***	-0.0415***
	(0.00146)	(0.00438)
20 minutes or more	-0.0183***	-0.116***
	(0.00191)	(0.00568)
Drug dealing zones	-0.00285**	-0.0175***
	(0.00138)	(0.00393)
Bad smell areas	-0.0332***	-0.0277***
	(0.00125)	(0.00338)
Insecurity	-0.0228***	-0.0371***
	(0.00133)	(0.00333)
Noise pollution	-0.00585***	-0.0249***
	(0.00120)	(0.00321)
Public space deprivation	0.0412***	0.0209***
	(0.00170)	(0.00425)
Observations	476,772	218,722
R^2	0.658	0.570
Market FE	YES	YES

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: ME 2011. Authors calculations.

Table 10: Hedonic estimates 2014

	(1)	(2)
Variables	Log rent payment	Log dwelling value
1 year length		0.130***
		(0.0106)
2 year length		-0.0656***
		(0.0104)
3 year length		-0.173***
		(0.0101)
4 year length		-0.143***
		(0.0103)
5 year length		-0.0807***
		(0.0104)
6 year length		-0.482***
		(0.0104)
Elevator	0.250***	0.221***
	(0.00305)	(0.0103)
Residential complex	0.107***	-0.0528***
	(0.00151)	(0.00610)
Number of toilets	0.182***	0.294***
	(0.00120)	(0.00380)
Garage	0.0698***	0.129***
	(0.00144)	(0.00571)
Building floors	0.0214***	0.0117***
	(0.000391)	(0.00121)
Number of rooms	0.171***	0.0595***
	(0.000524)	(0.00259)
Humidity	-0.0611***	-0.00132
	(0.00126)	(0.00635)
Walking minutes to a police station:		
Between 10 and 20 minutes	-0.0427***	-0.00588
	(0.00125)	(0.00617)
20 minutes or more	-0.0329***	0.0315***
	(0.00132)	(0.00646)
Walking minutes to green zones areas:		
Between 10 and 20 minutes	-0.0192***	-0.110***
	(0.00132)	(0.00707)
20 minutes or more	-0.0213***	-0.402***
	(0.00160)	(0.00936)
Drug dealing areas	-0.0333***	0.0879***
	(0.00133)	(0.00738)
Bad smells	-0.0240***	-0.0190***
	(0.00122)	(0.00591)
Insecurity in the neighborhood	-0.0117***	-0.177***
	(0.00117)	(0.00578)
Noise pollution	0.0228***	0.0699***
	(0.00114)	(0.00597)
Public space deprivation	0.0223***	0.0149**
	(0.00149)	(0.00697)
Observations	540,794	212,785
R^2	0.653	0.307
Market FE	YES	YES

YES

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: ME 2014. Authors calculations.

Table 11: Hedonic estimates 2017

	(1)	(2)
Variables	Log rent payment	Log dwelling value
1 year length		-0.0434***
		(0.00964)
2 year length		0.00673
		(0.00904)
3 year length		-0.0370***
		(0.00938)
4 year length		0.0124
		(0.00934)
5 year length		-0.140***
		(0.00915)
Residential complex	0.132***	-0.0391***
	(0.00197)	(0.00550)
Elevator	0.190***	0.162***
	(0.00357)	(0.00811)
Number of toilets	0.162***	0.259***
	(0.00148)	(0.00356)
Garage	0.0962***	0.210***
	(0.00209)	(0.00526)
Building floors	0.00706***	0.0102***
	(0.000366)	(0.000803)
Number of rooms	0.160***	0.0372***
	(0.000699)	(0.00237)
Humidity	-0.0499***	-0.0148**
	(0.00190)	(0.00643)
Walking minutes to a police station	-0.00298***	-0.00434***
	(5.37e-05)	(0.000179)
Walking minutes to a green zone area	-0.00110***	-0.000261***
	(8.11e-05)	(7.66e-05)
Drug dealing areas	-0.0547***	-0.0558***
	(0.00193)	(0.00660)
Bad smell areas	-0.0394***	-0.000189
	(0.00180)	(0.00579)
Insecurity	-0.0266***	-0.0743***
	(0.00170)	(0.00509)
Noise pollution	0.0254***	-0.0598***
	(0.00164)	(0.00521)
Public space deprivation	0.0155***	0.108***
	(0.00211)	(0.00624)
Observations	274,428	229,433
R^2	0.669	0.269
Market FE	YES	YES

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: ME 2017. Authors calculations.