Credit Access and Housing Quality

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Abstract

Would widespread credit access improve housing quality in developing countries? Using data from Mexico, we find a large and significant effect of credit access. Access to mortgage loans for households in the lowest-income decile is equivalent to raising their income to the middle-income decile in terms of improvement in housing quality. This correlation falls for high-income households. We present a heterogeneous-agent model with a discrete housing choice and borrowing constraint to match our empirical facts. In this model, low-income households are differentially affected by limited access to credit as they are more financially constrained. We use this model to study the effect of credit provision and find that overall housing quality can be improved by 10 percent if all households in Mexico are given access to mortgage loans.

Keywords: Housing Quality, Heterogeneous Agents, Borrowing Constraint

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1 Introduction

Housing quality is a focus of governments in developing countries. Even though the homeownership rate is often much higher in developing countries than in developed countries, many households live in dwellings with poor conditions (Bradley and Putnick (2012)). For example, the homeownership rate in Mexico is nearly 80% but many homes lack basic facilities such as electricity, lights and toilets.

One possible explanation is that households in developing countries have limited access to mortgage finance, which effectively bars low-liquidity households from acquiring more expensive homes with adequate quality or remodelling their current property. In the case of Mexico, most households do not have access to any mortgage loan facilities. In addition to low banking services penetration, public access to subsidized mortgages is available only for formal workers, who make up less than half of the working population.

In this paper, we study the housing market in Mexico to understand what providing credit access can do to improve housing quality. We argue that providing mortgage loan opportunities can have a huge impact on the housing quality. Using survey data, we construct an index to measure the quality of dwellings in Mexico. We find that income and credit access, measured by the accessibility to government's home loan program, are positively correlated to the housing quality index. In particular, a household in the lowest-income decile with credit access lives in a dwelling with quality comparable to a household in the middle-income decile without credit access. The quality difference between with and without credit access vanishes for high-income households. These findings are robust to alternative definitions of the housing quality index and characteristics of households. The results suggest that households are potentially bound by financial constraints on housing spending. Low-income households, who often have less liquid assets, require external financing for any substantial housing spending. Conversely, high-income households, who likely have more liquid assets, could afford large purchases without relying on housing loans.

If widespread credit access is provided to households and the supply of high-quality homes is inelastic, the price of high-quality homes may increase as suggested in Kaplan *et al.* (2020), voiding any effect on the overall housing quality. Thus, it is important to understand how households improve their housing quality. We document that households often improve their home through remodeling funded by housing loans. Using loan-level data, we find that housing loans initiated by low-income households are almost exclusively used for remodeling. This suggests that the supply of low- to mid-quality homes may be more elastic than high-quality homes because of the remodeling channel.

We use a model with different housing-quality types and borrowing constraints to rationalize our empirical findings. Households with a low-quality house may choose to remodel and improve to a mid-quality home or purchase a high-quality home. Low-income households do not remodel or purchase high-quality homes because the down payment is either infeasible for them, or its disruption for non-housing consumption is too large. Introducing credit helps overcome these problems and potentially makes households choose to remodel to a mid-quality house or purchase a new high-quality home.

We extend this idea to a quantitative heterogenous-agent model with discrete housing choices to analyze the potential effect of relaxing mortgage credit conditions. Households who have access to the government's home loan program in Mexico are likely to be formal workers. We model the labor market dynamics with an exogenous Markov process jointly on formality of employment and income states. Formal workers can remodel or purchase homes with home loans, while informal workers do not have access to home loans. We calibrate the debt-to-income and loan-to-value conditions of the home loans for both home purchases and remodeling using loan-level data on housing loans originated through banks.

We model the housing as discrete choices with a quality ladder. Motivated by our findings on remodeling, we consider three types of housing: low, mid, and high-quality. We assume a flexible supply of mid-quality homes as households can improve a low-quality house to a mid-quality house through remodeling. The supply of high-quality home is assumed to be fixed to account for the fact that high-quality homes are more difficult to develop, as they often require real estate developers to construct.

We compute a policy counterfactual where all households are given equal access to credit with the same debt-to-income or loan-to-value constraint, while still allowing for heterogeneity in the income process for formal and informal workers. We find an overall 10% increase in the share of households living in mid-quality housing. The improvement is mostly concentrated in the low-to-mid-income households. Under the fixed supply of high-quality homes, these households will choose to remodel and improve their homes to mid-quality homes. This is because, under the current calibration, these households are the marginal households that are close to being able to remodel their homes.

Moreover, we find a redistributive effect where housing-quality distribution becomes more homogeneous across wealth groups. Lower-wealth individuals own a higher share of mid and high-quality homes relative to the baseline economy. As people have more access to credit and the supply of high-quality homes is fixed, the price of high-quality homes soar. This increases the home equity for high-quality homeowners. Thus, they choose to sell and move to lower quality houses. As most of these homeowners were originally high-wealth individuals, home-quality distribution becomes more homogeneous across wealth.

Literature Our paper is related to the literature on financial constraints in developing countries. Many papers have shown that financial constraints can lead to a misallocation of resources and thus losses in productivity (Moll (2014)). Our paper is similar to Manysheva (2022) which emphasizes using micro-data to discipline a heterogeneous agents model to answer development economics questions.

This paper is also related to the long literature on credit and housing. A large part of the literature has focused on how credit affects housing in developed countries such as the US. Most of these papers find important effects on prices and quantities, as in Greenwald and Guren, Buera and Moll (2015), Iacoviello (2005). However, the effect of credit on housing has not been widely studied in developing economies. Moreover, to the best of our knowledge, we are the first ones to study the effects of credit on housing quality choice in this setup.

On the technical side, we apply techniques in discrete choice Iskhakov *et al.* (2017) to study the housing market with rich heterogeneity on the household side. This framework has started to gain popularity and has been used in a number of applications such as in Mongey and Waugh (2024), Ales and Sleet (2022) and others. We use then use these techniques along those in Auclert *et al.*

(2021) to solve general equilibrium properties. We contribute to this recent literature by applying this framework to housing decisions and exogenous borrowing constraints.

The paper proceeds as follows. Section 2 and 3 discuss housing data in Mexico and empirical findings. Section 4 discusses the remodeling channel. Section 5 presents a simple model to explain how financial constraints explain our findings. Section 6 describes our quantitative model and counterfactual exercise. Section 7 concludes.

2 Data

We first describe the data source for our empirical analysis. The cross-sectional relationship between housing quality and access to credit is analyzed using the 2020 National Housing Survey (ENVI). To further investigate the mechanism, we use the home loan data from National Banking and Securities Commission (CNBV). Finally, we also use the National Occupation and Employment Survey (ENOE) to calibrate the income dynamics of workers in Mexico.

2.1 Measuring Housing Quality

National Housing Survey (ENVI) is a public dataset put together by the Mexican National Institute of Statistics (INEGI). The survey includes sections on housing, financial and sociodemographic characteristics at the housing, household and individual level from 55,147 representative housing units. For each housing unit, we obtain information including quality, value, and rental value, as well as sociodemographic information of the head of the unit (type of ownership, formal or informal type of income, access to credit, age, education level) and unit inhabitants.

INEGI randomly selects housing units from a master list of units to survey. Every five quarters, INEGI updates the master list to reflect changes in streets and their property density. This is to ensure that the survey continuously reflects the geostatistical changes in the country. One concern with this survey is that it may not cover informal dwellings that are in rural areas, where poor housing quality is a dire issue. In ENVI, roughly 55% of the housing units were not built by professional builders, which are often of poor quality. Even though we may not cover some low-quality housing units with the survey, the survey still covers a large portion of housing units that are of poor quality, which policymakers may want to target.

To construct our housing quality index, we consider all the housing quality questions in ENVI, which inquiry different dimensions of the dwellings, such as the materials of the walls, the availability of in-house toilets, and the presence of electric light. The complete list of questions is available in Appendix (C). We convert the responses to these questions into binary variables -

high-quality or low-quality. For individual i and quality question q, the raw response is given by

$$\widehat{\text{quality}}_{i,q} = I(Reponse_{i,q} = Good)$$

We then standardize $widehat$quality$_{i,q}$ to obtain quality$_{i,q}$, such that for each quality question q, their mean response is zero and their standard deviation is one. This ensures that the overall quality index is not driven by one or very few specific quality questions. Finally, we aggregate the standardized quality questions using weights w_q to obtain the overall quality index quality$_i$ for each housing unit i.

$$\text{quality}_i = \sum_q w_q \text{quality}_{i,q}$$

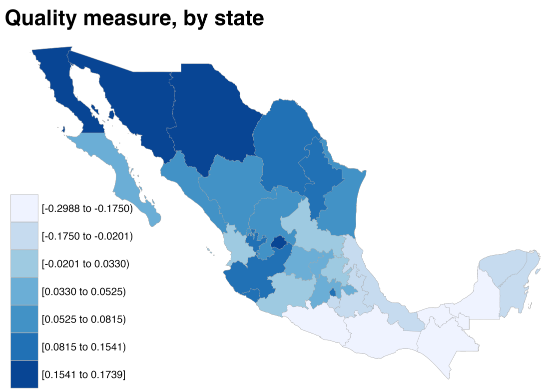
We explored multiple methods to obtain the weights w_q. All results in our main analysis are based on equal weights. We also used weights from the American Housing Survey (AHS) as well as the weights of the first component of a principal component analysis, that was commonly used in index construction. The results were similar across all methods.

2.2 Home Loan Data

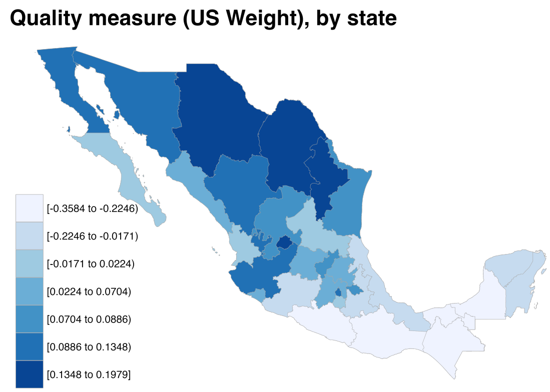
To complement the household credit access information from the ENVI, we incorporate the National Banking and Securities Commission (CNBV) regulatory data on banking access and usage at the state level.

Based on the ENVI 2020 section on housing issues, we present an index to measure housing quality. The index is based on the American Housing Survey (AHS) 2013 Housing Quality Index methodology, incorporating additional quality dimensions not considered for the US housing market but relevant for the Mexican housing market.

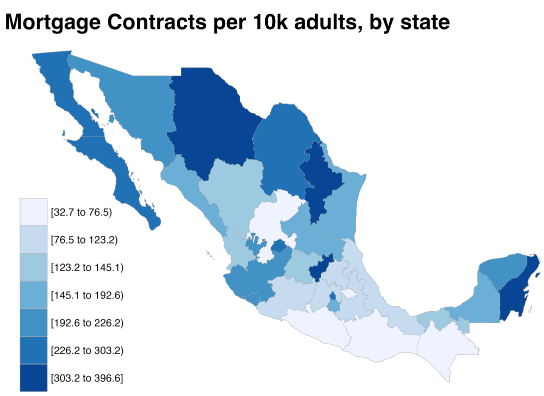
Figure 1 displays the three main variables of our study as a state level heat map. Figure 1a and Figure 1b display two measures of housing quality: the average unweighted aggregate of all quality issues a housing unit presents (full list of quality issues considered is available in C) and our AHS index equivalent of housing quality issues. Both indices are highly correlated at the



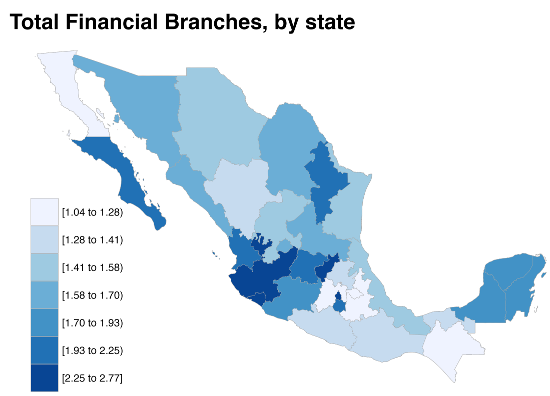
(a) Average unweighted quality index



(b) Average weighted quality index



(c) Mortgage contracts per 10k adults



(d) Total financial branches

Figure 1: State level aggregates of quality index, number of mortgages and banking access

state level, but throughout the paper we mainly refer to the AHS equivalent index. Figure 1c and Figure 1d display the banking usage and access variables we consider: total mortgage contracts and banking branches at the state level. We note that, while banking usage and quality seem to have a stronger link, the relationship between housing quality and access to credit is not as evident. We study the disproportionate effects access to credit has on housing quality outcomes, incoporating sociodemographic information as well as state level controls.

2.3 Loans from Private Institutions

To further understand the mechanism behind this correlation, we use additional loan-level microdata from CNBV. This dataset contains all mortgage loans originated by private institutions (e.g. commercial banks, rather than government institutions) since 2019. It includes granular data on loan type (home purchase, remodeling, etc.), loan amount, borrower monthly income, interest rates, home value, loan maturity, among others.

This dataset allows us to further understand what type of loans predominate different income levels. This will be key to identifying the remodeling channel, in which lower-income households use credit mainly for remodeling purposes as opposed to higher income households that use them for home purchasing.

Moreover, we can extract the type of borrowing constraint for each type of loan and income level. Debt-to-income (DTI) and loan-to-value (LTV) constraints are common throughout the dataset. As discussed in section (4), remodeling loans are predominantly DTI loans whereas home-purchase loans are mainly LTV loans. This will become relevant when calibrating the quantitative model, as the type of housing will determine the type of borrowing constraint.

2.4 Labor and Income

For our model calibration, we incorporate information on Mexican workers' labor and income based on information from the National Survey on Occupation and Employment (ENOE). Among other things, this survey contains information on income level, employment and formality status at the monthly and quarterly levels. It is the main dataset used to measure employment outcomes in Mexico and has been widely used in the literature and has been available since 2005.

This survey allows us to classify workers by source of income, in particular displaying enough information to separate workers into formal and informal, which we use to assess workers' access to the government's subsidized lending. We will be able to calibrate workers' income and credit access process in the quantitative model and replicate the empirical data using this survey.

3 Credit and Housing Quality in Data

We present three facts regarding credit access and housing quality: 1) the quality of dwellings is increasing in income, 2) the quality of dwellings is positively correlated to credit access, and 3) the correlation of quality and credit access dissipates for high-income households. This confirms our hypothesis that low-income households encounter credit constraints which limits them from purchasing high-quality housing.

We measure credit access in terms of access to government-originated mortgage loans, INFONAVIT or FOVISSSTE.[1] Both of them are government programs that offer housing loans, which can be used towards property acquisition or remodeling. Access to such loans is linked to the formality of employment.[2] Formal workers pay income tax and receive social security benefits while informal workers do not.[3]

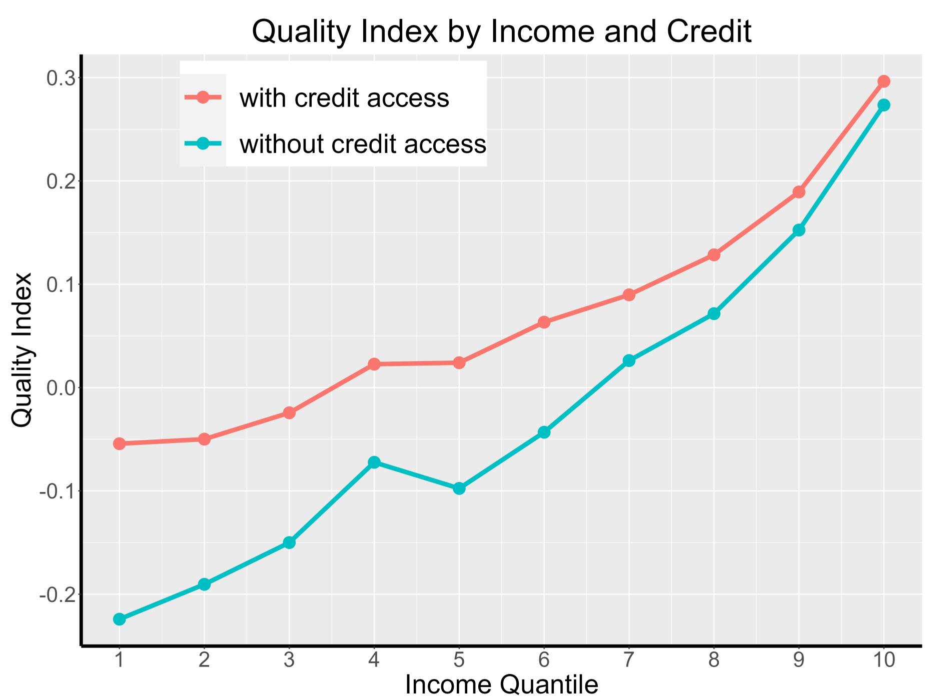


Figure 2: Average housing quality by credit access and income groups

[1]An alternative measures in the literature is the use of banking services in the area. However, in the context of Mexico, both formal and informal workers are present in the same area. The use of banking services in an area is too granular that an important variation in credit access will be omitted

[2]Low-income borrowers may be eligible for interest rate subsidies. We do not consider the subsidy in our empirical analysis. However, it is possible to consider it in our quantitative framework.

[3]Informal workers include those working for a formal or informal business, and the self-employed. The formality is often chosen by the employers instead of the employees.

At first glance, we find that the quality of dwellings is increasing in income and credit access. Figure (2) shows the quality index of dwellings increases in income and there is a significant difference between the quality of dwellings for those with and without credit access. One may be concerned that since our measure of credit access is highly correlated formality of employment, the correlation observed may reflect characteristics beyond access to credit, such as education, age or whether the household is located in an urban area. To address them, we move on to the regression analysis.

To uncover the relationship between credit access and housing quality, we regress the quality of the housing y_i to the individual credit access

$$\text{quality}_i = \beta_0 + \beta_1 \times \log(\text{income})_i + \beta_2 \times \text{credit access}_i + z_i'\gamma + \epsilon_i \tag{1}$$

quality_i is the quality index of the dwelling occupied by individual i. credit access_i is a binary variable of whether the household is eligible for INFONAVIT or FOVISSSTE, which are two government programs that offer housing credit. β_1 captures the correlation between credit access and the quality of housing. z_i' is a collection of control variables which includes age, education level, and whether the household is in an urban area. We also included state fixed-effects to account for potential unobservable geographical factors.

Table 1: Quality Index and Credit Access

	Quality Index	
	baseline	with state controls
	(1)	(2)
log(Income)	0.067*** (0.001)	0.049*** (0.001)
Age	0.001*** (0.0001)	0.001*** (0.0001)
Credit Access	0.091*** (0.002)	0.043*** (0.002)
College Educ	0.144*** (0.003)	0.148*** (0.002)
Urban		0.109*** (0.002)
Observations	73,167	73,167
R^2	0.228	0.353
Note:		*p<0.1; **p<0.05; ***p<0.01

The effect of income is captured by β_1 and the effect of credit access is captured by β_2. Table (1) shows a positive correlation between credit access and income to housing quality. Access to credit is associated with a 0.043 points increase in the quality index. To gauge the potential importance of this channel, we can compare it with the correlation between income and quality. For a 100 percent increase in income, it is associated with a 0.049 points increase in the quality index. Therefore, giving access to credit is comparable to an 87 percent increase in income at improving the quality of the dwellings.

To uncover the heterogeneous effect of credit access for different income groups, we regress the quality of the dwellings to the interaction between income quantiles and credit access.

$$\begin{aligned} \text{quality}_i =& \beta_0 + \sum_{g=1}^{10} \beta_{1g} \times I(i \in \text{Income Quantile g}) \\ &+ \sum_{g=1}^{10} \beta_{2g} \times I(i \in \text{Income Quantile g}) \times \text{credit access}_i + m_i'\gamma + \epsilon_i \end{aligned} \tag{2}$$

β_{2g} captures the effect of credit for households in the income quantile g. m_i is the collection of control variables, which includes age, education level and whether the household is in an urban area.

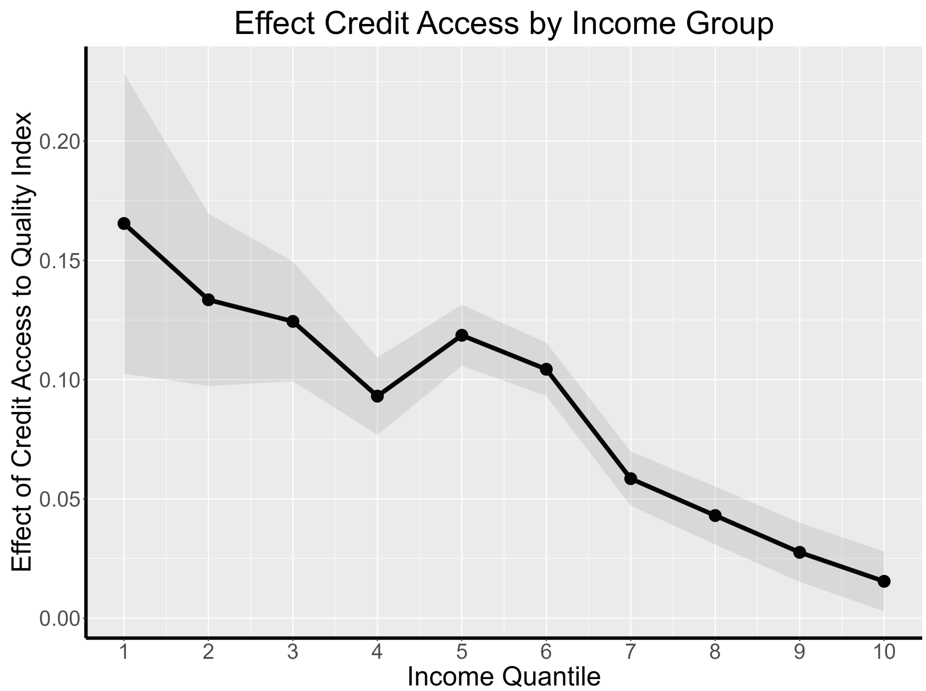


Figure 3: Effect of Credit Access by Income Group

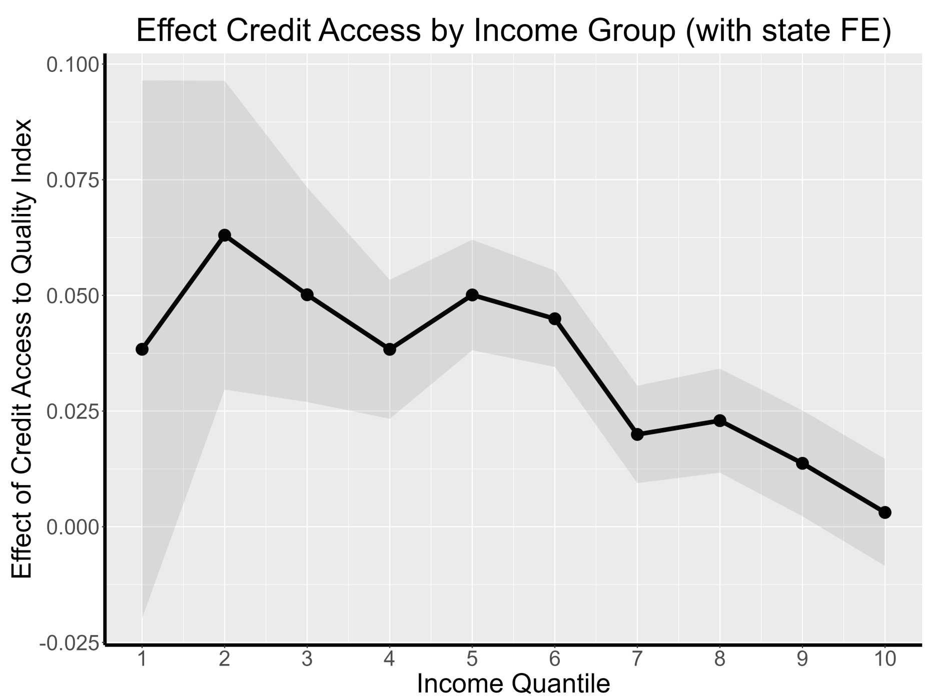


Figure 4: Effect of Credit Access by Income Group with state fixed effects

Figure (3) and (4) show that the effect of credit access decreases with income. In both specifications, the highest-income group benefitted very little from access to credit while the low and middle-income groups benefitted the most from credit access. Credit access varies largely by state. The additional fixed effects in Figure (4) potentially mute some variations in the credit access, making the error bands wider.

These three facts support the idea that many low-income households are constrained by limited access to credit. This suggests that a model of credit constraint may explain the pattern in the data.

4 How does home loans improve housing quality?

In this section, we explore how improvement of credit access can help improve housing quality. Home loans in Mexico are mainly used for home purchases and remodeling. Both of them allow households to move from low-quality homes to high-quality homes. It is important to distinguish between these two channels. Suppose only home purchase loans are available. Relaxing the borrowing constraint would increase the demand for high-quality housing without raising the supply of housing at each quality level. We find that in the context of Mexico, a significant portion of home loans are used for remodeling or renovation. This is particularly true for low-income households.

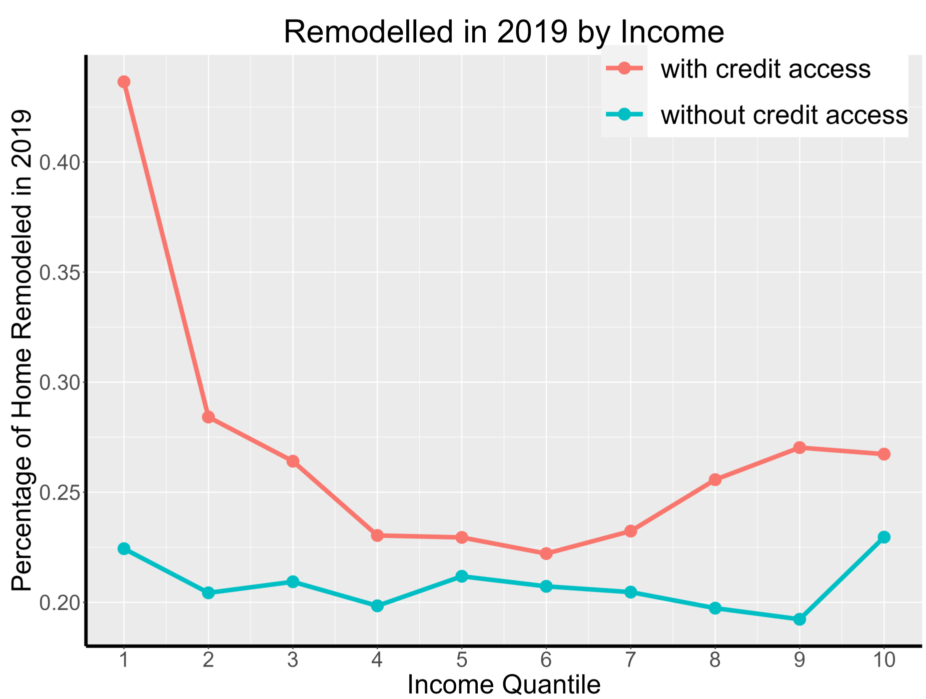


Figure 5: Share of home remodeled in 2019 by credit access and income

Figure (5) shows the share of households reported that some form of home remodeling was done in the previous year. Remodeling is common for Mexican households. More than 20% of households have remodeled their home in the previous year. There is a noticeable difference across income and access credit. Households with access credit are more likely to remodel their homes. The difference shrinks as income increases. As documented before, low-income households likely live in low-quality housing. Remodeling may have a higher marginal impact on low-quality homes. Thus, when low-income households are presented with housing loan opportunities, they are likely to remodel or renovate their homes.

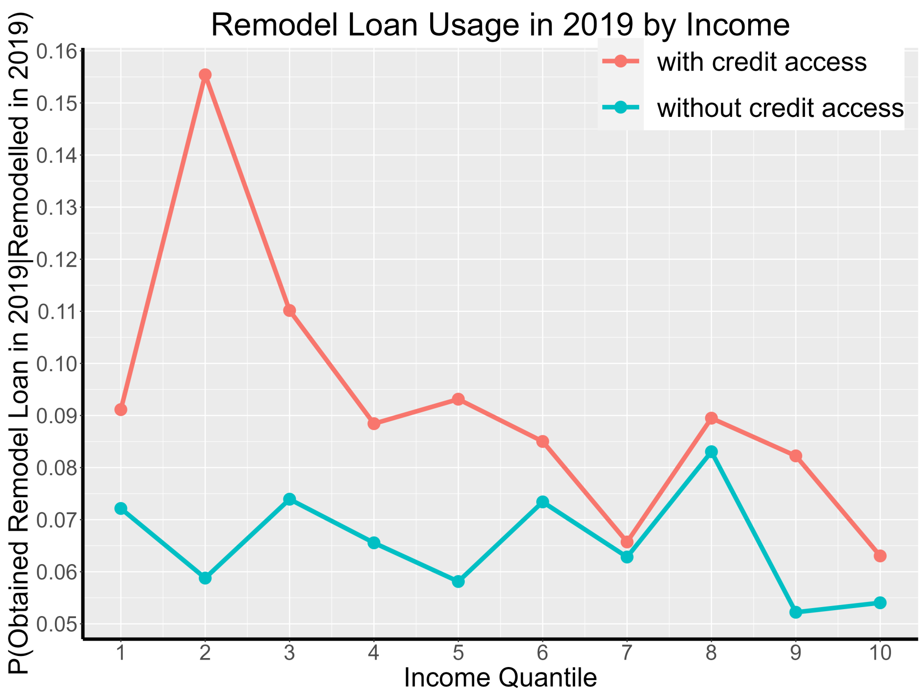


Figure 6: Share of remodeled homes financed by home loans

Figure (6) shows the percentage of households that used a remodeling loan to finance their remodeling work. On average, 8% of households obtained a loan for their renovation work in the previous year. The percentage is higher for low-income households who have more access to credit. Since we measure credit access using the formality of employment, households in the informal sector can still borrow through the bank. The difference reflects the effect of the public loan program to increase credit access.

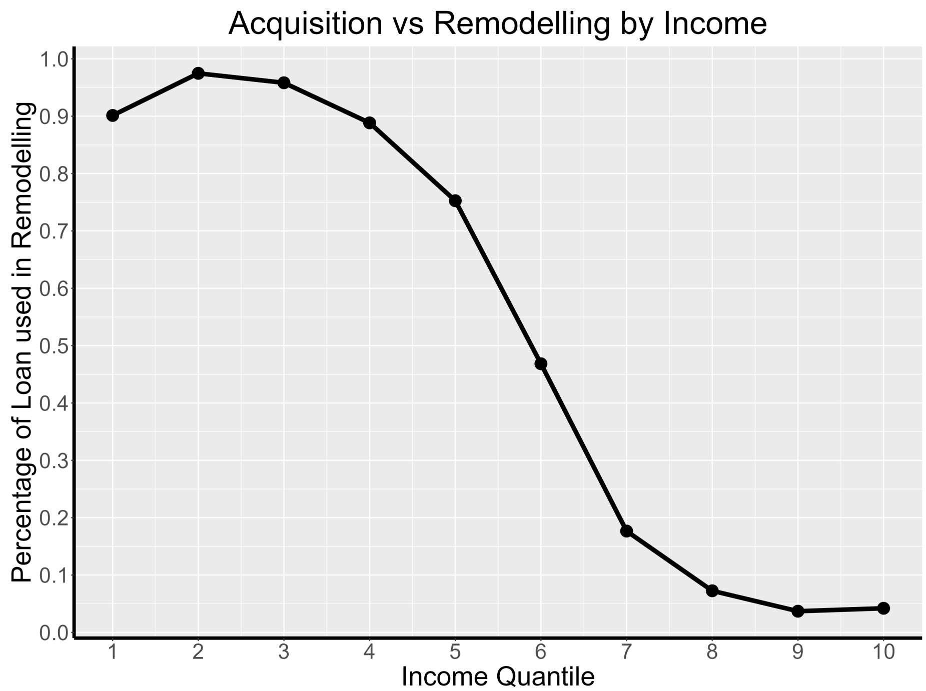


Figure 7: Share of home loans used for remodeling or acquisition

Finally, we complement the previous analysis with the data on home loans originating through private banks. Figure (7) shows the share of home loans used for remodeling by income groups. Low-income households almost exclusively use home loans for remodeling instead of acquisition. This share decreases as income increases. This is consistent with our hypothesis that the marginal benefit of upgrading a low-quality home may be higher than a high-quality home. While high-quality homes are available in the market, they may still be unaffordable for low-income households even with a mortgage loan. Thus, low-income households are more likely to use home loans for remodeling while the high-income households who may afford to acquire a high-quality home opt for acquisition loans.

The evidence suggests that credit access seems to have a large effect on housing quality and remodeling seems to be an important feature in the Mexican housing market. Connecting to the GE implication discussion at the beginning of this section, our finding suggests that the supply of low-quality to mid-quality housing is flexible because of the remodeling channels. This suggests that a policy of widespread credit access can have a large effect on housing quality even in the GE context.

5 Simple Model

We consider a two-period consumption-savings problem with discrete housing choice. This model highlights why limited credit access might deter households from acquiring high-quality housing.

At the beginning of period 1, people start with low-quality housing. They have to choose whether to keep their low-quality housing unit (L), remodel and upgrade to a mid-quality housing unit (M) or sell and purchase a high-quality housing unit (H). The latter is more expensive, provides a higher utility and is more capable of being mortgaged.

Households have exogenous access to credit through parameter θ, subject to a loan-to-value (LTV) or debt-to-income (DTI) constraint. People that stay in the existing low-quality house may borrow against their income in a standard DTI constraint, whereas people that either remodel or purchase a new home will be able to borrow against the value of their new home, i.e. they will be subject to a LTV constraint.

Households will choose discretely between the three options by maximizing their utility:

$$V(\bar{\theta}) = \max(V^L(\bar{\theta}), V^M(\bar{\theta}), V^H(\bar{\theta}))$$

We can see each value function and study the optimal choice for $i \in \{L, M, H\}$.

$$\begin{aligned} V^i(\bar{\theta}) = \max_{c_1,c_2,a} & \log(c_1) + \beta \log(c_2) + \psi \log(h^i) \\ \text{s.t } & c_1 + a + P(h^i) = y + P(h^L) \\ & c_2 = y + (1 + r)a \\ & a \geq -\bar{\theta}\mu(h^i) \end{aligned}$$

Where c_j represents consumption in period j, a represents savings, β the discount factor and ψ represents the marginal utility from housing. $P(h^i)$ represents the of house h^i, which increases with housing quality. We assume that households can remodel their houses at a cost κ, where $\kappa \equiv P(h^M) - P(h^L)$. Finally, $\mu(h^i)$ represents the borrowing constraint, which takes the following form:

$$\mu(h') \equiv \begin{cases} p(h') & \text{if } h' = h^i, i \in \{M, H\} \\ \frac{\phi y}{1+r} & \text{if } h' = h^L \end{cases}$$

Where θ represents the usual LTV constraint (e.g. $\theta = 0.8$), whereas ϕ is just a scaling parameter so that $\theta \cdot \phi = \theta^{DTI}$, where θ^{DTI} represents the usual debt-to-income ratio (e.g. 0.1 in our data). For simplicity, we further assume $1 = \beta(1+r)$. We can now see the value function for each case:

1. Keep low quality house

$$V^L(\bar{\theta}) = (1+\beta)\log(y) + \psi \log(h^L)$$

2. Remodel and improve housing quality at a cost

$$V^M(\bar{\theta}) = \begin{cases} \log\left(y - \kappa + \bar{\theta}P(h^M)\right) + \beta \log\left(y - (1+r)\bar{\theta}P(h^M)\right) + \psi \log(h^M) & \text{if} \quad \bar{\theta}P(h^M) \leq \frac{\beta}{1+\beta}\kappa \\ (1+\beta)\log(y - \kappa/(1+\beta)) + \psi \log(h^M) & \text{if} \quad \bar{\theta}P(h^M) > \frac{\beta}{1+\beta}\kappa \end{cases}$$

3. Selling low quality house and buying high quality Let us define $\Delta(P) \equiv P(h^H) - P(h^L)$. Then the value function is then given by:

$$V^H(\bar{\theta}) = \begin{cases} \log\left(y - \Delta(P) + \bar{\theta}P(h^H)\right) + \beta \log\left(y - (1+r)\bar{\theta}P(h^H)\right) + \psi \log(h^H) & \text{if} \quad \bar{\theta}P(h^H) \leq \frac{\beta}{1+\beta}\Delta(P) \\ (1+\beta)\log(y - \Delta(P)/(1+\beta)) + \psi \log(h^H) & \text{if} \quad \bar{\theta}P(h^H) > \frac{\beta}{1+\beta}\Delta(P) \end{cases}$$

5.1 How does credit affect housing choices?

How does the provision of credit affect the housing choice? We model credit access using $\bar{\theta}$. In particular, we want to understand how changing $\bar{\theta}$ affects the decision between choosing $i = L$, $i = M$ or $i = H$.

Focusing on the remodeling problem, as the borrowing constraint is binding for $\bar{\theta} \leq \frac{\beta}{1+\beta}\frac{\kappa}{P(h^M)}$, it can be shown that $\frac{dV^M(\bar{\theta})}{d\bar{\theta}} > 0$ if $\bar{\theta} \leq \frac{\beta}{1+\beta}\frac{\kappa}{P(h^M)}$. Similarly, $\frac{dV^H(\bar{\theta})}{d\bar{\theta}} > 0$ $\bar{\theta} < \frac{\beta}{1+\beta}\frac{\Delta(P)}{P(h^H)}$. But as $\bar{\theta}$ increases, the borrowing constraint ceases to be binding for each case. Thus, an additional relaxation of credit does not affect the housing choice. $\frac{dV^M(\bar{\theta})}{d\bar{\theta}} = 0$ if $\bar{\theta} > \frac{\beta}{1+\beta}\frac{\kappa}{P(h^M)}$ and $\frac{dV^H(\bar{\theta})}{d\bar{\theta}} = 0$

if $\bar{\theta} > \frac{\beta}{1+\beta}\frac{\Delta(P)}{P(h^H)}$. This means that households are more likely to choose either mid or high-quality housing when $\bar{\theta}$ increases rather than staying at their current low-quality house.

Intuitively, relaxing the borrowing constraint encourages households to purchase high-quality homes for two reasons. First, increasing $\bar{\theta}$ makes mid and high-quality housing more feasible. Households may not be able to afford the full moving price κ or $\Delta(P)$ in the first period. Second, increasing $\bar{\theta}$ makes consumption smoothing possible. As households receive a constant stream of income and have to pay for the home purchase in the first period, it would require them to borrow in the first period to achieve consumption smoothing.

We perform a comparative statics exercise to understand how the effect of $\bar{\theta}$ depends on the parameters. Five possible outcomes may happen when $\bar{\theta}$ increases.

5.1.1 Case 1: Always Low-quality

If $(1+\beta)\log(y-\kappa/(1+\beta))+\psi\log(h^M) < (1+\beta)\log(y)+\psi\log(h^L)$ and $(1+\beta)\log(y-\Delta(P)/(1+\beta))+\psi\log(h^H) < (1+\beta)\log(y)+\psi\log(h^L)$, regardless of what $\bar{\theta}$ is, households would always pick the low-quality housing. This may happen if the moving cost is too high compared to the additional utility benefit. This also happens when income is low since the marginal utility consumption is high for low-income households, the marginal cost of remodeling and switching to a mid-quality house is therefore higher.

5.1.2 Case 2: Always mid-quality

If $\log(y-\kappa)+\beta\log(y)+\psi\log(h^M) > (1+\beta)\log(y)+\psi\log(h^L)$ and $\log(y-\kappa)+\beta\log(y)+\psi\log(h^M) > (1+\beta)\log(y-\Delta(P)/(1+\beta))+\psi\log(h^H)$, households would always choose to remodel and convert their low-quality house to mid-quality housing. The first term in the first equation is the value of remodeling the house with the least generous credit condition. The first inequality means that households are willing to remodel their homes even when there is no mortgage loan available. The second equation implies that the utility of remodeling a house with no mortgage loan available is higher than switching to a high-quality house even with the best credit conditions. This happens when y is high enough such that the utility cost of paying more for housing is lower if the marginal utility of consumption is low and low enough such that the opposite is true for paying more for a higher quality house. Another way to see it is that the marginal gain from improving the home to mid-quality is high enough to sustain the monetary costs but the gain from moving to a high-quality house is not as big as the monetary costs.

5.1.3 Case 3: Always high-quality

If $\log(y-\Delta(P))+\beta\log(y)+\psi\log(h^H) > (1+\beta)\log(y)+\psi\log(h^L)$ and $\log(y-\Delta(P))+\beta\log(y)+\psi\log(h^H) > (1+\beta)\log(y-\kappa/(1+\beta))+\psi\log(h^M)$, households would always choose to purchase a high-quality house. These households will have higher utility from moving to a high-quality house with the least possible credit condition. Similar to the previous case, this happens whenever the utility gain from moving to high-quality is high enough to sustain the economic cost, even in the most adverse credit condition.

5.1.4 Case 4: Mid-quality housing if $\bar{\theta}$ is high enough

If $\log(y-\kappa)+\beta\log(y)+\psi\log(h^M) \leq (1+\beta)\log(y)+\psi\log(h^L) \leq (1+\beta)\log(y-\Delta/(1+\beta))+\psi\log(h^H) \leq (1+\beta)\log(y-\kappa/(1+\beta))+\psi\log(h^M)$ or $\log(y-\kappa)+\beta\log(y)+\psi\log(h^M) \leq (1+\beta)\log(y-\Delta/(1+\beta))+\psi\log(h^H) \leq (1+\beta)\log(y)+\psi\log(h^L) \leq (1+\beta)\log(y-\kappa/(1+\beta))+\psi\log(h^M)$, by the intermediate value theorem, there exists a θ^* such that if $\bar{\theta} > \theta^*$, the households would choose mid-quality housing over the low and high-quality ones. Those households are the marginal households that are primarily benefitted under a policy of credit relaxation. Households in this category have relatively high marginal utility of non-housing consumption so even though they can afford to purchase a mid-quality house, they have to sacrifice a lot of non-housing consumption to do so. The additional relaxation of credit allows them to remodel and improve their house to a mid-quality house without sacrificing too much non-housing consumption in the first period.

5.1.5 Case 5: Mid-quality housing if $\bar{\theta}$ is high enough

If $\log(y-\Delta(P))+\beta\log(y)+\psi\log(h^H) \leq (1+\beta)\log(y)+\psi\log(h^L) \leq (1+\beta)\log(y-\kappa/(1+\beta))+\psi\log(h^M) \leq (1+\beta)\log(y-\Delta/(1+\beta))+\psi\log(h^H)$ or $\log(y-\Delta)+\beta\log(y)+\psi\log(h^H) \leq (1+\beta)\log(y-\kappa/(1+\beta))+\psi\log(h^M) \leq (1+\beta)\log(y)+\psi\log(h^L) \leq (1+\beta)\log(y-\Delta/(1+\beta))+\psi\log(h^H)$, then again there is a θ^{**} such that if $\bar{\theta} > \theta^{**}$, the households would choose high-quality housing over the other types. This is a similar case as the one before.

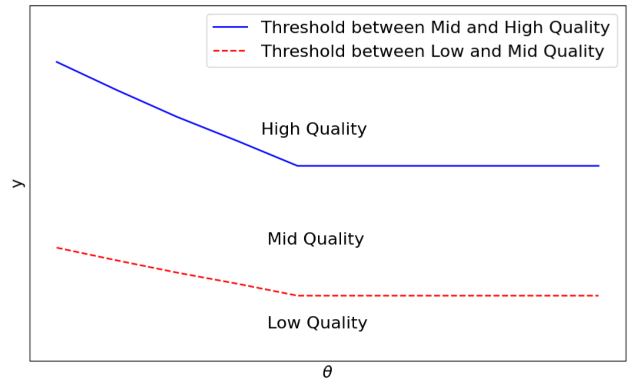


Figure 8: Optimal housing choice depending on y and $\bar{\theta}$

Figure (8) summarizes the theoretical results. Consistent with our empirical findings, high-income households opt for high-quality housing regardless of the credit condition. Middle- to high-income households choose high-quality houses when credit conditions are favorable enough and mid-quality when they are not. Mid-to-low income households choose mid-quality houses when credit conditions are good and low-quality when they don't have enough credit. Low-income households always choose low-quality houses.

6 Quantitative Exercise

We expand on our simple model presenting a quantitative exercise that introduces several sources of heterogeneity, stochastic shocks and distributional characteristics in order to provide answers to counterfactual exercises for the Mexican economy. In this model, consumers can choose three types of housing: low, mid and high quality, i.e. $h \in \{h^L, h^M, h^H\}$ every period. The model will feature home sales and purchases as well as home remodeling. Agents get an exogenous income $y(s)$ which follows an $AR(1)$ process with persistence ρ and standard deviation σ. Additionally, a fraction of people will be able to borrow a fraction of their income or home value whereas the rest will not have access to credit.

We will then use the model to ask a simple question: what would happen if everyone gains access to credit? In this counterfactual economy, the share of mid-quality houses would increase by more than 10% through remodeling. Moreover, there is a distributional effect where lower-wealth households will hold higher-quality houses than in the baseline economy. This comes at the expense of wealthier households, who will hold lower-quality houses in the counterfactual economy.

6.1 Model Overview

Agents choose consumption c, savings a' and housing h' to solve the following problem:

$$
\begin{aligned}
V(s,a,\theta,h) = \max_{c,a',h'} & u(c) + v(h') + \beta\mathbb{E}[V(s',a',\theta',h')|s,\theta] \\
\text{s.t. } & a' + c + \chi p(h') + I(h,h') = (1+r)a + y(s) + T \\
& a' \geq -\theta\mu(h',s)
\end{aligned}
$$

Where $v(h')$ is a flow consumption function from housing services. χ is a maintenance cost for housing and T represents government transfers. $p(h')$ represent price of house type h' and is an increasing function. θ represents the degree of access to credit for a given individual, while $\mu(h',s)$ is the borrowing constraint. This function will be defined in the next section (6.2) and can either be a loan-to-value or debt-to-income constraint. On the other hand. $I(h,h')$ represents the total cost of adjusting housing, to be explained in subsection 6.3. This will account for the possibility of purchasing a home or remodeling.

This is a discrete-continuous choice model, which can be challenging to solve computationally. If we were to use the endogenous grid method as in Carroll (2006), there could potentially be kinks in the value function, resulting in discontinuities in the policy functions.

Following Iskhakov *et al.* (2017), we solve this class of models by including taste shocks. These are additive choice-specific independent and identically distributed extreme value taste shocks that can be thought of as *unobserved state variables* or *random noise*. This is sufficient to smooth the value functions and eliminate any potential kinks, removing any discontinuities in the value functions.

Each housing option has its own taste shock $\sigma_\epsilon \epsilon_i$, and the problem becomes:

$$
\begin{aligned}
V(s,a,\theta,h,\epsilon) = \max_{c,a',h'} u(c) + v(h') + \left(\sigma_\epsilon \sum_i 1(h'=h_i)\epsilon_i\right) + \beta \mathbb{E}[V(s',a',\theta',h',\epsilon')|s,\theta] \\
\text{s.t. } a' + c + \chi p(h') + I(h,h') = (1+r)a + y(s) \\
a' \geq -\theta\mu(h',s)
\end{aligned}
$$

We are not able to derive a deterministic policy function for the discrete choice of housing but only the non-degenerate probability of choosing each of the potential options.

6.2 Access to Credit and Income Process

Access to credit is reflected through θ, which represents the exogenous degree of access to credit each agent has. We assume that people either have access to credit or not, i.e. $\theta \in \{0,1\}$. Access to credit can either be through a debt-to-income (DTI) or loan-to-value (LTV) constraint. Guided by empirical evidence, we will assume that people with low-quality houses can only borrow through a DTI constraint, whereas agents with mid or high-quality houses will be able to borrow using an LTV constraint. Intuitively, lenders will not take low-quality houses as collateral as they usually have low market value and are informally built, making it hard to verify their value. Instead, they will rely on DTI constraints, where the verification process is simpler and less risky.

The type of borrowing will be reflected by the function $\mu(h',s)$ given by:

$$\mu(h',s) \equiv \begin{cases} \theta^{LTV} p(h') & \text{if } h' = h^i, i \in \{2,3\} \\ \frac{\theta^{DTI} \hat{y}(s)}{1+r} & \text{if } h' = h^1 \end{cases}$$

Where $\hat{y}(s)$ represents *annual* income. It is important to make this distinction as the model will be calibrated using quarterly data. θ^{LTV} and θ^{DTI} represent the share of housing equity or annualized income the agent can borrow against, respectively.

On the other hand, access to credit is usually associated with job formality and is not a household fixed effect. This means that θ will change over time and will not be fixed. However, job formality is correlated with the income process. Higher-income households are more likely to be formal workers as well as formal workers are more likely to earn higher-income. The same thing happens for lower-income households and informal workers. To reflect this, we assume that access to credit θ and income process $y(s)$ are correlated with each other. Moreover, these variables follow a bivariate Markov process, where the current state (s, θ) is updated through a joint transition matrix π:

$$\pi = \begin{pmatrix} \pi_{(0,0)} & \pi_{(0,1)} \\ \pi_{(1,0)} & \pi_{(1,1)} \end{pmatrix}$$

Where $\pi_{(i,j)}$ is the transition matrix of income process conditional on $\theta = \theta^i$ and $\theta' = \theta^j$, with $i, j \in \{0, 1\}$. That is, assuming that $y(s)$ has n states (i.e. $y \in \{y^1, ..., y^n\}$), then $\pi_{(i,j)}$ is given by:

$$\pi_{(i,j)} = \begin{pmatrix} p_{i,j}^{1,1} & \dots & p_{i,j}^{1,n} \\ \vdots & \ddots & \vdots \\ p_{i,j}^{n,1} & \dots & p_{i,j}^{n,n} \end{pmatrix}$$

Where $p_{i,j}^{k,l}$ is the probability of going from state $(y = y^k, \theta = \theta^i)$ to state $(y' = y^l, \theta' = \theta^j)$. The joint bivariate process has stationary distribution Π such that $\pi\Pi = \pi$.

6.3 Home Purchases and Remodelling

The model allows for the possibility of remodeling a house. The data shows that remodeling is predominant among low-quality houses. We assume that people can move from low to mid-quality houses through remodeling and not by purchasing an existing home. This is embedded inside the adjustment cost function $I(h, h')$, given by:

$$I(h,h') \equiv \begin{cases} p(h') - (1-\ell)p(h) & \text{if } h' \neq h, h \neq h^L, h' \neq h^M \\ \kappa & \text{if } h = h^L, h' = h^M \\ 0 & \text{if } h' = h \end{cases}$$

This means that households will need to pay a liquidity cost ℓ if they want to move to another house, thus paying $p(h')$ and receiving $(1-\ell)p(h)$. However, note that if an agent starts with $h = h^L$ and decides to switch to $h = h^M$ then she will need to pay a remodeling cost $\kappa > 0$.

Up to a first-order, introducing remodeling will not have any effect as those agents will still need to pay a cost. Without remodeling they would still need to pay $p(h^M) - (1-\ell)p(h^L) > 0$. Apart from its qualitative importance, we introduce remodeling for a simple quantitative reason: general equilibrium. Remodeling will play a key role in the model as we will be able to fully isolate the effect of credit on the demand side by fixing the supply of houses. If we fix the supply of houses, people can still convert their low-quality homes to mid-quality through remodeling as it is the same physical house. This will be further discussed in section 6.5.

6.4 Calibration

We do the model calibration in two steps. First, we calibrate certain standard parameters consistent with the literature, such as the discount factor β. Second, we calibrate the remaining parameters in order to replicate some moments in the Mexican data.

We assume that $u(c) = \log(c)$ and $v(h) = \psi \log(h)$ where, $\psi > 0$. On the other hand, parameters such as the discount factor β and interest rates r.

In particular, income process y was calibrated to have a mean of 1 with three potential states $n_s = 3$ by using Rouwenhorst method of approximating stationary AR(1), following Kopecky and

Suen (2010).

We set $\theta^{LTV} = 0.8$ and $\theta^{DTI} = 0.1$ to replicate median values seen from the CNBV loan level data. Additionally, we calibrate the bivariate Markov process for (s, θ) using data from ENOE. We get the transition matrix π and stationary distribution Π in this step. [Add the ENOE]. Additionally, quarterly income process y was calibrated to have a mean of 1 with three potential states $n_s = 3$ by using Rouwenhorst method of approximating stationary AR(1), following Kopecky and Suen (2010).

Moreover, we calibrated the price of high-quality houses to target a fixed supply of high-quality houses equal to 25%. We let the combination of low and mid-quality houses to be equal to 75% without imposing a particular mix between both.

The rest of the parameters are related to housing and are used so that the steady state distribution replicates the following empirical findings:

- Housing quality is positively related with income
- Housing quality is positively related with access to credit
- Credit becomes less relevant for housing quality as income becomes larger

Our calibration is done in the following way:

Figure 9 shows the share of households that own high quality housing for different wealth groups (5 in total) in steady state. Each group contains the same mass of households over the asset space. It shows that the three facts mentioned above are satisfied under our calibration. Both for mid and high-quality homes curves have a positive slope, which implies that the share of households with higher quality housing increases as wealth increases, regardless of their access to credit situation. The opposite happens with low-quality houses. Secondly, households with access to credit have a higher share of mid and high quality housing than households without access to credit across wealth levels. Finally, the gap between both curves decreases as wealth increases.

Parameter	Name	Value
β	Discount factor	0.98
r	Interest rate	0.01
$\mathbb{E}(y)$	Expected income	1
ρ	Income process persistance	0.975
σ	Income process variance	0.7
ϕ	Housing utility parameter	0.1
h^H	Utility of high quality housing	14
h^M	Utility of high quality housing	13
h^L	Utility of low quality housing	3
$p(h^H)$	Price of high-quality housing	2.6
$p(h^M)$	Price of mid-quality housing	2.5
$p(h^L)$	Price of low-quality housing	1
θ^{LTV}	Loan-to-value constraint	0.8
θ^{DTI}	Debt-to-income constraint	0.1
χ	Maintenance cost	0.1
ℓ	Liquidity cost of selling a house	0.1
T	Government transfers	2.5

Table 2: Calibration of the quantitative model

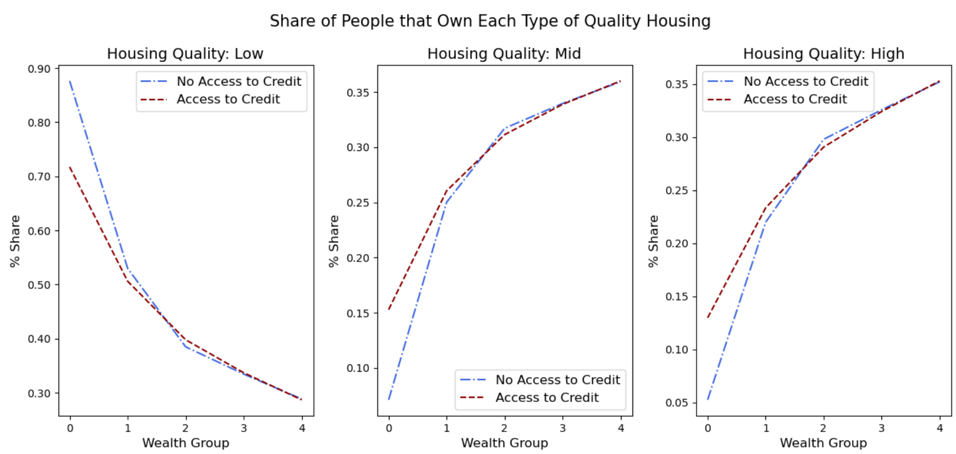


Figure 9: Steady State Share of Households that Own High Quality Housing

6.5 Main Results

We want to understand the role of credit in this economy. A simple way to do that is to ask the following question: what would happen if everyone had access to credit? That is, what would happen if there is a *credit shock* and now $\theta = 1$ for both formal and informal workers? In this counterfactual economy, informal workers will have the same access to credit than formal workers. However, they will still have a different income process than formal workers and thus we're only shutting down heterogeneity in terms of access to credit.

We want to isolate the effects of credit on the demand side of housing, while shutting down the supply side. To do so, we still assume a fixed supply of high-quality housing. There is also a fixed supply of low and mid-quality houses although the mix between both is fixed. The reason behind this is that people can always choose to remodel their low quality houses into mid-quality houses. This will not change the supply of houses since this remodeling is done in the same physical house. For this reason we calibrate high-quality house price in the counterfactual economy to still have a total share of 25% of total houses.

Introducing a credit shock to our baseline specification so that everyone has access to credit results in an increase of the share of mid-quality houses in the economy of more than 10%. In the counterfactual economy, the share of people that hold mid-quality houses increased from 26.8% to 29.9%, reducing the share of low-quality houses by the same amount. By assumption, the share of high-quality houses remains fixed.

Moreover, there is a redestribution effect as shown in Figure 10. This graph shows some interesting features by comparing the overall share of housing for each type by wealth level in the baseline and counterfactual economy. As a first point, we see that housing quality becomes more homogeneous across wealth levels. Introducing credit for everyone results in a redestributive effect of housing. Wealthier households hold a lower share of higher quality houses, whereas lower wealth households now hold more of these houses. We are by no means talking about welfare as part of the explanation behind this effect is that the price of high quality houses increases in order to still clear that market. So high-wealth individuals may still be better off my moving to lower quality houses as they would get more money from selling those houses. We are only interested in the positive effect of homeownership.

Overall, we can see that the absolute value of the slope of each curve reduces, which implies that wealth plays a less important role in this counterfactual economy. This is extremely intuitive as the possibility of loosing access to credit made wealth the main explanatory variable for homeownership type. People with lower wealth were less likely to buy a house even if they had access to credit since they could always move to an informal job, lose access to credit and not be able to repay their debt. Moreover, the importance of credit was directly related to wealth in the baseline economy. The largest gap between people with and without access to credit comes from people with low wealth. For these people, having access to credit may be the reason for having a higher quality house. People with low wealth and no access to credit chose to buy lower quality houses as they could not afford higher quality houses and would not be able to take any debt. In the counterfactual economy we see that the flattening of the curves across all house types implies a *credit shock* would result in a redistribution effect between wealth levels.

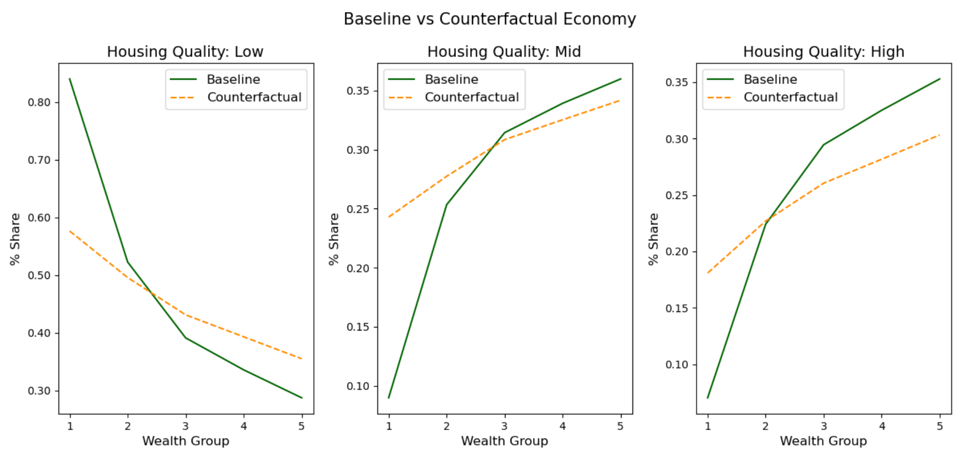


Figure 10: Total Share of Households that Own High Quality Housing for Baseline and Counterfactual Economies

7 Conclusion

We study the effect of credit access on housing quality in Mexico. We argue that this effect is potentially of a very large magnitude. Empirically, we find that access to mortgage loans is associated with residing in higher-quality homes, and its effect diminishes along different income levels. We show that a model with borrowing constraints can explain such a pattern and expand it to a quantitative heterogeneous-agent model with discrete housing choices. We find that providing mortgage loans to all households in Mexico can massively improve housing quality, especially for middle-income households.

The main finding may have broader implications for wealth inequality and the formality of employment. Many developing countries have a sizable population of informal workers who may have limited access to accumulate housing wealth. The financial constraint may broaden the wealth gap between the formal and informal workers. We leave this question for future research.

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A Solving the Simple Model

We will solve the model from section 5. Recall that the problem is

$$
\begin{aligned}
V^i(\bar{\theta}) = \max_{c_1,c_2,a} \log(c_1) + \beta \log(c_2) + \psi \log(h^i) \\
\text{s.t } c_1 + a + P(h^i) = y + P(h^L) \\
c_2 = y + (1+r)a \\
a \geq -\bar{\theta}\mu(h^i)
\end{aligned}
$$

Taking FOC we get:

$$
\begin{aligned}
c_1^{-1} &= \lambda_1 \\
\beta c_2^{-1} &= \lambda_2 \\
\lambda_1 &= (1+r)\lambda_2 + \eta
\end{aligned}
$$

Where λ_i represents the lagrange multiplier of the budget constraint in period $i \in \{1, 2\}$ and η is the multiplier for the liquidity constraint such that $\eta \geq 0$. Since we assume that $\beta(1 + r) = 1$, using the three equations above we get the Euler Equation specified below:

$$
c_1^{-1} = c_2^{-1} + \eta
$$

Let's first assume that the constraint is not binding and thus $\eta = 0$. In that case we have that $c_1 = c_2 = c$. Then

$$
\begin{aligned}
c &= y - a - (P(h^i) - P(h^L)) \\
c &= y + (1+r)a = y + \frac{a}{\beta}
\end{aligned}
$$

We can then solve for the value of a and c:

$$a = -\frac{1+\beta}{\beta}(P(h^i) - P(h^L)) \leq 0$$
$$c = y - \frac{(P(h^i) - P(h^L))}{1+\beta}$$

This way, the unconstrained value function will be equal to:

$$V^i(\bar{\theta}) = (1+\beta)\log\left(y - \frac{(P(h^i) - P(h^L))}{1+\beta}\right) + \psi\log(h^i)$$

Now, assume that the constraint is binding. Note that whenever $h = h^L$ then $a = 0$ and thus households will not borrow and thus the constraint will not be binding. Moreover, for people that move to $h = h^M$ or $h = h^H$ then $\mu(h^i) = P(h^i)$. Then we will have:

$$a = -\bar{\theta}\mu(h^i)$$
$$c_1 = y - (P(h^i) - P(h^L)) + \bar{\theta}P(h^i)$$
$$c_2 = y - (1+r)\bar{\theta}P(h^i)$$

In this case the value function would look like:

$$V^i(\bar{\theta}) = \log\left(y - (P(h^i) - P(h^L)) + \bar{\theta}P(h^i)\right) + \beta\log\left(y - (1+r)\bar{\theta}P(h^i)\right) + \psi\log(h^i)$$

We just need to see when will the constraints be binding. Recall that the constraint is binding if $a < -\bar{\theta}\mu(h^i)$. Then we have

$$
\begin{aligned}
a &< -\bar{\theta}\mu(h^i) \quad \Leftrightarrow \\
-\frac{1+\beta}{\beta}(P(h^i) - P(h^L)) &< -\bar{\theta}\mu(h^i) \quad \Leftrightarrow \\
\bar{\theta}\mu(h^i) &< \frac{1+\beta}{\beta}(P(h^i) - P(h^L))
\end{aligned}
$$

Then we can see each value function easily:

$$V^L(\bar{\theta}) = (1+\beta)\log(y) + \psi\log(h^L)$$

$$V^M(\bar{\theta}) = \begin{cases} \log\left(y - \kappa + \bar{\theta}P(h^M)\right) + \beta\log\left(y - (1+r)\bar{\theta}P(h^M)\right) + \psi\log(h^M) & \text{if} \quad \bar{\theta}P(h^M) \leq \frac{\beta}{1+\beta}\kappa \\ (1+\beta)\log(y - \kappa/(1+\beta)) + \psi\log(h^M) & \text{if} \quad \bar{\theta}P(h^M) > \frac{\beta}{1+\beta}\kappa \end{cases}$$

$$V^H(\bar{\theta}) = \begin{cases} \log\left(y - \Delta(P) + \bar{\theta}P(h^H)\right) + \beta\log\left(y - (1+r)\bar{\theta}P(h^H)\right) + \psi\log(h^H) & \text{if} \quad \bar{\theta}P(h^H) \leq \frac{\beta}{1+\beta}\Delta(P) \\ (1+\beta)\log(y - \Delta(P)/(1+\beta)) + \psi\log(h^H) & \text{if} \quad \bar{\theta}P(h^H) > \frac{\beta}{1+\beta}\Delta(P) \end{cases}$$

Where we defined $\Delta(P) \equiv P(h^H) - P(h^L)$ as before.

A.1 Value Function and $\bar{\theta}$

Now we want to show that $\frac{dV^i(\bar{\theta})}{d\bar{\theta}} > 0$ if $\bar{\theta}\mu(h^i) < \frac{1+\beta}{\beta}(P(h^i) - P(h^L))$ for $i \in \{M, H\}$ as described in section 5.1. Recall that if $\bar{\theta}\mu(h^i) > \frac{1+\beta}{\beta}(P(h^i) - P(h^L))$ for $i \in \{M, H\}$ then

$$V^i(\bar{\theta}) = \log\left(y - (P(h^i) - P(h^L)) + \bar{\theta}P(h^i)\right) + \beta\log\left(y - (1+r)\bar{\theta}P(h^i)\right) + \psi\log(h^i)$$

Then, taking derivative with respect to $\bar{\theta}$ we get:

$$\frac{dV^i(\bar{\theta})}{d\bar{\theta}} = \frac{P(h^i)}{y - (P(h^i) - P(h^L)) + \bar{\theta}P(h^i)} + \frac{P(h^i)}{y - (1+r)\bar{\theta}P(h^i)} = \frac{P(h^i)}{c_1} + \frac{P(h^i)}{c_2} > 0$$

Where the inequality follows from the fact that

$$c_1 = y - (P(h^i) - P(h^L)) + \bar{\theta}P(h^i) < y - (1+r)\bar{\theta}P(h^i) = c_2 \quad \Leftrightarrow$$
$$\frac{1+\beta}{\beta}\bar{\theta}P(h^i) < (P(h^i) - P(h^L))$$

Which is true by assumption.

B Quantitative Model Derivations

B.1 Solving the Model

We will solve the model backwards in three recursive steps. These steps follow the methodology described in Iskhakov *et al.* (2017).

- Step 3: Solve the consumer model after choosing h'. That is, solve the model for each $h' \in \{h^L, h^M, h^H\}$, assuming it is a state variable.
- Step 2: Choose h' optimally. Given the type of taste shocks, we will only get the probability of choosing each h'.
- Step 1: Get the continuation value.

Step 3: Solving the model after choosing h'. If we assume h' has already been chosen, we get the following problem:

$$\mathcal{V}(s, a, \theta, h, h') = \max_{c,a'} u(c) + v(h') + W(s, a', \theta, h') \tag{3}$$
$$\text{s.t. } a' + c + \chi p(h') + I(h, h') = (1+r)a + y(s)$$
$$a' \geq -\theta\mu(h', s)$$

Where $W(s, a', \theta, h') \equiv \beta\mathbb{E}[V(s', a', \theta', h', \epsilon')|s, \theta]$ is the continuation value, which is computed in step 1. We can easily solve this model as it is a simple continuous choice model. We can use the endogenous grid method as in Carroll (2006) to solve the model. By solving the model we get value function $\mathcal{V}$, marginal value function $\mathcal{V}_a$ and policy functions $\hat{c}$ and $\hat{a}$ in the state space (s, a, θ, h, h').

Step 2: Choosing h' optimally. We follow the methodology described in Iskhakov *et al.* (2017). The problem of choosing h' is then simply to choose $h_i \in \{h^L, h^M, h^H\}$ from among the discrete set of choices to maximize:

$$V(s, a, \theta, h) = \mathbb{E}_\epsilon \left[\max_{h' \in \{h_i\}} \mathcal{V}(s, a, \theta, h, h') + v(h') + \left(\sigma_\epsilon \sum_i 1(h' = h_i)\epsilon_i \right) \right]$$

That is, to maximize our post-choice value function plus the value of housing itself and the taste shocks. This gives us logit choice probabilities $p(s, b, \theta, h, h')$ of each h'. Furthermore V can be obtained using the logsum formula, so that we have

$$V(s, a, \theta, h) = \sigma_\epsilon \log \left(\sum_i \exp \left(\frac{\mathcal{V}(s, a, \theta, h, h_i) + v(h_i)}{\sigma_\epsilon} \right) \right) \tag{4}$$

$$p(s, a, \theta, h, h_i) = \frac{\exp\left(\frac{\mathcal{V}(s,a,\theta,h,h_i)+v(h_i)}{\sigma_\epsilon}\right)}{\sum_j \exp\left(\frac{\mathcal{V}(s,a,\theta,h,h_j)+v(h_j))}{\sigma_\epsilon}\right)} \tag{5}$$

Additionally, for the endogenous grid point method, we'll also need to keep track of the marginal value function with respect to assets, V_a. This is given by simply taking the expectation of the marginal value function with respect to the probabilities. We can do exactly the same to get the policy functions in the original state space (s, a, θ, h).

$$V_a(s, a, \theta, h) = \sum_i p(s, a, \theta, h, h_i) \cdot \mathcal{V}_a(s, a, \theta, h, h_i)$$

$$c(s, a, \theta, h) = \sum_i p(s, a, \theta, h, h_i) \cdot \hat{c}(s, a, \theta, h, h_i)$$

$$a(s, a, \theta, h) = \sum_i p(s, a, \theta, h, h_i) \cdot \hat{a}(s, a, \theta, h, h_i)$$

Step 1: Get the continuation value. Now, we define the continuation value, the discounted expected utility $W(s, a', \theta, h')$ that enters into (3). We also need the discounted expected marginal utility $W_a(s, a', \theta, h')$ which is necessary to solve the problem via the endogenous grid method.

This is simply given by taking the discounted expectation of utility V and marginal utility V_a. It is worth noting that this expectation is taken over two state variables: s and θ.

$$W(s, a', \theta, h') = \beta \mathbb{E}_{s,\theta}[V(s', a', \theta', h')|s, \theta]$$
$$W_b(s, a', \theta, h') = \beta \mathbb{E}_{s,\theta}[V_b(s', a', \theta', h')|s, \theta]$$

Putting it all together. Now we can solve the problem recursively following these three steps. By making an educated guess of the value and marginal value functions, we implement steps 1 to 3 repeatedly until the policy and value functions converge.

B.2 Euler Equation

We derive the Euler equation now. Recall the original problem:

$$V(s, a, \theta, h, \epsilon) = \max_{c,a',h'} u(c) + v(h') + \left(\sigma_\epsilon \sum_i 1(h' = h_i)\epsilon_i\right) + \beta \mathbb{E}[V(s', a', \theta', h', \epsilon')|s, \theta] \tag{6}$$
$$\text{s.t. } a' + c + \chi p(h') + I(h, h') = (1 + r)a + y(s)$$
$$a' \geq -\theta\mu(h', s)$$

Recall that in step 2 of solving the model we found V in terms of $\mathcal{V}$. Then we can replace 4 in 3 and get the following expression.

$$\mathcal{V}(s, a, \theta, h, h'|h') = \max_{c,b'} u(c) + \beta \mathbb{E}\left[\sigma_\epsilon \log\left(\sum_i \exp\left(\frac{\mathcal{V}(s', a', \theta', h', h_i) + v(h_i))}{\sigma_\epsilon}\right)\right)|s, \theta, h'\right] \tag{7}$$
$$\text{s.t. } a' + c + \chi p(h') + I(h, h') = (1 + r)a + y(s)$$
$$a' \geq -\theta\mu(h', s)$$

Now let's take FOC for (6).

$$u'(c) = \lambda$$
$$\beta \mathbb{E}[V_b(s', a', \theta', h')|s, \theta, h'] = \lambda$$

Then we get

$$u'(c) = \beta \mathbb{E}[V_a(s', a', \theta', h')|s, \theta, h']$$

Now taking envelope condition for (6):

$$V_a(s, a, \theta, h, h'|h') = (1 + r)\lambda$$

Together with the FOC for consumption we get:

$$V_a(s, a, \theta, h, h'|h') = (1 + r)u'(c)$$

Now, if we take FOC with respect to (7) we get

$$u'(c) = \lambda$$

$$\beta \mathbb{E}\Bigg[\left(\sum_i \exp\left(\frac{\mathcal{V}(s', a', \theta', h', h_i|h_i) + v(h_i)}{\sigma_\epsilon} \right) \right)^{-1}$$

$$\cdot \left(\sum_i \exp\left(\frac{\mathcal{V}(s', a', \theta', h', h_i|h_i) + v(h_i)}{\sigma_\epsilon} \mathcal{V}_b(s', a', \theta', h', h_i|h_i) \right) \right) |s, \theta, h' \Bigg] = \lambda$$

We can simplify and get

$$\beta(1 + r)\mathbb{E}\left[\left(\sum_i p(s', a', \theta', h', h_i)u'(c') \right) |s, \theta, h' \right] = u'(c)$$

Assuming $c \equiv c(s, b, \theta, h, h')$ then the Euler equation becomes:

$$\beta(1 + r)\mathbb{E}\left[\left(\sum_i p(s', a', \theta', h', h_i)u'(c(s', a', \theta', h', h_i)) \right) |s, \theta \right] = u'(c(s, a, \theta, h, h'))$$

	Average	Std. Dev	Median	Min	Max
Issues	15.696	4.733	19.5	1	37
Issues HQ	16.143	2.281	16.5	1	19
Issues LQ	23.902	3.169	23.5	20	37
Income	3625.663	6147.54	1491	0	98000
Issues LI	21.793	4.47	22.5	4	37
Issues HI	17.938	4.003	17.5	1	35
Price to Income	552.99	1623.349	249.1135	0.222	Inf
Price	860067.1	1805670	495000	4	45000000
Issues LP	22.509	7.012	22.5	6	37
Issues HP	17.297	3.805	17.5	1	34

Table 3: Housing quality issues, select descriptive statistics for housing characterstics

Mnemonic	Variable	Question	Answers
P4_4	Good Wall	4.4 What material are most of the walls of this dwelling made of?	Waste material; Cardboard sheeting; Asbestos or metal sheeting; Reeds, bamboo or palms; Mud or bajareque; Wood; Adobe; Drywall, brick, block, stone, stone quarry, cement or concrete
P4_5	Good Roof	4.5 What material is most of the roof of this dwelling made of?	Waste material; Cardboard sheeting; Metal sheeting; Asbestos sheeting; Fiber cement sheeting; Palm or straw; Wood or shingles; Roof with joists; Tile; Concrete slab or joists with vaulting
P4_6	Good Floor	4.6 What material is most of the floor of this dwelling made of?	Soil; Cement or pavement; Wood, mosaic or other covering
P4_7_1	Roof Thermal Insulation	4.7 To avoid excess heat or cold, does this dwelling have any type of thermal insulation in ceilings?	Yes; No; Doesn't Know
P4_7_2	Wall Thermal Insulation	4.7 To avoid excess heat or cold, does this dwelling have any type of thermal insulation in walls?	Yes; No; Doesn't Know
P4_7_3	Window Thermal Insulation	4.7 To avoid excess heat or cold, does this dwelling have any type of thermal insulation in windows?	Yes; No; Doesn't Know
P4_8_1	Roof Noise Insulation	4.8 To reduce excess noise, does this dwelling have any type of insulation in ceilings?	Yes; No; Doesn't Know
P4_8_2	Wall Noise Insulation	4.8 To reduce excess noise, does this dwelling have any type of insulation in walls?	Yes; No; Doesn't Know
P4_8_3	Window Noise Insulation	4.8 To reduce excess noise, does this dwelling have any type of insulation in windows?	Yes; No; Doesn't Know
P4_8_4	Door Noise Insulation	4.8 To reduce excess noise, does this dwelling have any type of insulation in doors?	Yes; No; Doesn't Know
P4_9	Kitchen	4.9 Does this dwelling have a room for cooking?	Yes; No
P4_11	Toilet	4.11 Does this dwelling have an outhouse, toilet or sanitary toilet (latrine or black hole)?	Yes; No
P4_12	Flushing Water	4.12 Does the sanitary service…	have a direct water discharge? need water poured into it with a bucket? can't have water poured on it?
P4_13	Inhouse Water Supply	4.13 Do they get water from faucets or hoses that are...	inside the house? only in the yard or land? No piped water
P4_14	Safe Water	4.14 Does the piped water coming into your home come from....	from a public utility? from a well? from a pipe? from another house? from somewhere else?
P4_15	Public Drainage	4.15 Does this dwelling have drainage or sewage connected to...	the public network? a septic tank (biodigester)? a pipe leading to a ravine or crevice? a pipe leading to a river, lake or sea? No drainage? Not specified
P4_16	Electric Light	4.16 Is there electricity in this dwelling?	Yes; No
P4_17	Gas or Electric Cooking	4.17 In this household, the fuel they use most often to cook or heat food is....	gas? wood or coal? electricity? other fuel? No cooking? Not specified
P4_22_1	Washbowl	4.22 Is this dwelling equipped with a laundry room?	Yes; No
P4_22_2	Sink	4.22 Is this dwelling equipped with a sink or sink unit?	Yes; No
P4_22_3	Water Tank	4.22 Is this dwelling equipped with a water tank?	Yes; No
P4_22_4	Cistern	4.22 Is this dwelling equipped with a cistern?	Yes; No
P4_22_5	Boiler	4.22 Is this dwelling equipped with a water heater or boiler (gas, electric, wood)?	Yes; No
P4_22_6	Solar Heater	4.22 Is this dwelling equipped with a solar water heater?	Yes; No
P4_22_7	Stationary Gas Tank	4.22 Is this dwelling equipped with a stationary gas tank?	Yes; No
P4_22_8	AC	4.22 Is this dwelling equipped with air conditioning?	Yes; No
P4_22_9	Heater	4.22 Is this dwelling equipped with heating?	Yes; No
P4_23_1	Dining Room	4.23 Does this dwelling have a living/dining room?	Yes; No
P4_23_2	Garden	4.23 Does this dwelling have a garden?	Yes; No
P4_23_3	Patio	4.23 Does this dwelling have a patio?	Yes; No
P4_23_4	Laundry	4.23 Does this dwelling have a laundry room?	Yes; No
P4_23_5	TV Room	4.23 Does this dwelling have a television room or study?	Yes; No
P4_23_6	Garage	4.23 Does this dwelling have a garage or parking space?	Yes; No
P4_25_1	Cracks	4.25 Does this dwelling have problems with cracks or crazing in ceilings or walls?	Yes; No; Doesn't Know
P4_25_2	Window Damage	4.25 Does this dwelling have problems with buckling or warping of door or window frames?	Yes; No; Doesn't Know
P4_25_3	Floor Problems	4.25 Does this dwelling have problems with floor heaving or sagging?	Yes; No; Doesn't Know
P4_25_4	Leaking Problems	4.25 Does this dwelling have problems with dampness or water seepage in foundations, walls or roofs?	Yes; No; Doesn't Know
P4_25_5	Column Fractures	4.25 Does this dwelling have problems with cracking, buckling, or buckling of columns, beams, or girders?	Yes; No; Doesn't Know
P4_25_6	Electric Problems	4.25 Does this dwelling have problems with the electrical system (walls, ceilings, etc.)?	Yes; No; Doesn't Know
P4_25_7	Drainage Problems	4.25 Does this dwelling have problems with the water or sewage pipes inside the dwelling?	Yes; No; Doesn't Know
P4_26_1	Corridor Crackings	4.26 Does your building have problems such as cracks, fractures or dampness in hallways?	Yes; No; Doesn't Know
P4_26_2	Stair Crackings	4.26 Does your building have problems such as cracks, fractures, or dampness in stairways?	Yes; No; Doesn't Know
P4_26_3	Elevator Crackings	4.26 Does your building have problems such as cracks, fractures or dampness in elevators?	Yes; No; Doesn't Know

Table 4: ENIGH survey questions for our housing quality index

C Additional Information about the Data

C.1 Summary Statistics

C.2 Survey Questions

C.3 Weights on each question

D Additional Regression Results

E Sampling Method in ENVI

For all surveys originated by INEGI (including ENVI and ENOE), two updating mechanisms are used in order to continuously reflect geostatistical changes: a master sample list used and updated every five quarters in order to reflect changes in streets and their property density, and a frame-

PQI Component	Score (Weight)	MX Index Variable	Score (Weight)
Housing materials*			
		P4_4	10
		P4_5	10
		P4_6	10
Electricity problems			
1 Unit does not have electricity	10	P4_16	10
2 Unit has exposed wiring	4	P4_25_6	1
3 Unit does not have electric plugs in every room	3		
4 Each occurrence of a blown fuse or thrown circuit breakera	1		
Amenities*		P4_23_1	1
		P4_23_2	1
		P4_23_3	1
		P4_23_4	1
		P4_23_5	1
		P4_23_6	1
Heating problems			
5 Unit was uncomfortably cold for 24+ hours	4	P4_7_1	0.66
6 Each heating equipment breakdownb	2	P4_7_2	0.66
7 Unit cold due to utility interruption	2	P4_7_3	0.66
8 Unit cold due to inadequate heating capacity	2	P4_8_1	0.5
9 Unit cold due to inadequate insulation	2	P4_8_2	0.5
10 Unit cold due to other reason	2	P4_8_3	0.5
11 Main heating equipment is unvented kerosene heater(s)	4	P4_8_4	0.5
		P4_22_6	2
		P4_22_7	2
		P4_22_8	2
		P4_22_9	6
Inside structural or other problems			
12 Water leak in roof	2	P4_25_2	5
13 Water leak in wall or closed door/window	2	P4_25_3	2
14 Water leak in basement	2	P4_25_4	5
15 Water leak from other source	2	P4_25_5	2
16 Inside leak from leaking pipes	2	P4_25_7	2
17 Inside leak from plumbing fixtures	2	P4_26_1	2
18 Inside leak from other or unknown source	2	P4_26_2	2
19 Holes in the floor	2		
20 Open cracks wider than a dime	2		
21 Peeling paint larger than 8 by 11 inches	2		
22 Evidence of rodents	2		
Bathroom problems			
23 Unit does not have hot and cold running water OR Unit does not have a bathtub or shower OR Unit does not have a flush toilet	10	P4_11	6
24 Each breakdown leaving unit without a toilet for 6+ hoursc	2	P4_12	2
		P4_22_5	2
Kitchen problems			
25 Unit does not have a refrigerator OR Unit does not have a kitchen sink OR Unit does not have a cook stove or range	10	P4_9	10
		P4_17	2
Outside structural problems			
26 Windows broken	5	P4_25_1	5
27 Holes/cracks or crumbling in foundation	5		
28 Roof has holes	5		
29 Roof missing shingles/other roofing materials	5		
30 Outside walls missing siding/bricks/and so on	5		
31 Roof's surface sags or is uneven	5		
32 Outside walls slope/lean/slant/buckle	5		
Water and sewer problems			
33 Each time unit is completely without watere	2	P4_13	2
34 Each sewage disposal breakdownf	2	P4_14	2
		P4_15	2
		P4_22_1	2
		P4_22_2	2
		P4_22_3	2
		P4_22_4	2
Elevator problems			
35 No working elevator in building of four or more stories	4	P4_26_3	4
*: Categories Not included in AHS index			

Table 5: ENIGH and AHS index component equivalence

Table 6: Quality Index and Credit Access

	Quality Index (US Weighted)	
	baseline	with state controls
	(1)	(2)
log(Income)	0.068*** (0.001)	0.047*** (0.001)
Age	0.001*** (0.0001)	0.001*** (0.0001)
Credit Access	0.096*** (0.003)	0.044*** (0.003)
College Educ	0.119*** (0.003)	0.126*** (0.003)
Urban		0.111*** (0.003)
Observations	73,167	73,167
R^2	0.169	0.303
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 7: Quality Index and Credit Access

	Quality Index (First Principal Component)	
	baseline	with state controls
	(1)	(2)
log(Income)	0.563*** (0.006)	0.382*** (0.006)
Age	0.009*** (0.001)	0.009*** (0.0005)
Credit Access	0.861*** (0.017)	0.428*** (0.016)
College Educ	1.134*** (0.020)	1.152*** (0.017)
Urban		1.140*** (0.015)
Observations	73,167	73,167
R^2	0.274	0.451
Note:		*p<0.1; **p<0.05; ***p<0.01

work for areas of new growth updated quarterly in order to reflect new streets not reflected in the master sample list.