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An Approach for Housing Wealth Estimation: The Mexican Case*

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Abstract: Housing is the greatest asset held by most households, and it is an important determinant of their financing and consumption decisions. Despite the fact that measuring housing wealth is crucial for understanding households' economic behavior, this indicator is currently unavailable in Mexico due to the lack of data commonly required for its estimation. This paper proposes a more flexible methodology, based on the quantity times price approach and the perpetual inventory method, that eases data requirements while still meeting international guidelines. Our results suggest housing wealth in Mexico has followed an upward trend as percentage of GDP since 2005, reaching around 187% and 202% of GDP in 2020. In addition, our measure enables the calculation of other popular indicators concerning households, such as housing equity and household total net worth.
Keywords: Housing, household wealth, perpetual inventory method, quantity times price approach.
JEL Classification: G51, E21, E22, R2, R31, O18.

Resumen: La vivienda es el principal activo de la mayoría de los hogares y es un determinante importante de sus decisiones de financiamiento y consumo. A pesar de que la medición de la riqueza por vivienda es crucial para comprender el comportamiento económico de los hogares, este indicador no está disponible en México debido a la falta de datos comúnmente requeridos para su estimación. Este documento propone una metodología de cálculo más flexible, basada en el enfoque de cantidades por precios y el método de inventarios perpetuos, que relaja los requerimientos de información al tiempo que cumple con las directrices internacionales. Nuestros resultados sugieren que la riqueza por vivienda en México ha seguido una tendencia ascendente desde 2005, alcanzando niveles alrededor del 187% y 202% del PIB en 2020. Además, nuestra medida permite el cálculo de otros indicadores de los hogares, tales como el capital de vivienda y la riqueza neta total del sector.
Palabras Clave: Vivienda, riqueza de los hogares, método de inventarios perpetuos, enfoque de cantidades por precios.

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1 Introduction

Housing wealth, defined as the market value of all residential dwellings, plays an important role on consumption decisions through the so-called wealth effect, and on households' borrowing constraints for its role as collateral.[1] Moreover, the availability of this series can be useful for the construction of additional statistics on households, such as housing equity and household net worth. However, the heterogeneity of housing data available in each country has hindered the design of a standard methodology to calculate such indicator, so countries obtain their own estimations based on their available data. This issue, in turn, poses a great challenge for developing countries where housing data is scarce and usually private.

In Mexico, despite the important changes through which housing stock has gone since 1980, both in terms of the type of constructions (apartment buildings, duplex, etc.) and the quality of building materials (wood, concrete, etc.),[2] the evolution of housing wealth has not been formally measured yet, as some housing indicators used in other methodologies are unavailable or incomplete.[3] In this regard, the recently issued National Survey on Household Finances 2019 (hereafter ENFIH), conducted by Banco de México and INEGI, represents another instrument to measure housing wealth at a certain point in time. However, the ENFIH has two shortcomings for the purposes of this paper. On the one hand, the results are not available as time series. On the other hand, such kind of surveys are typically conducted to provide insight into the distributional aspects of the balance sheet of households.

This paper tackles the referred problem by proposing a more flexible approach to measure housing wealth in Mexico, mostly relying on aggregated data from the national accounts. Our methodology adapts both the *quantity times price* approach (Eurostat-OECD, 2015) and the *perpetual inventory method* (OECD, 2009), and is implemented following four main steps. First, we calculate the value of the capital stock of the residential structure. Second, we

[1] Several studies have tested the importance of housing wealth as a determinant of consumption and its use as collateral. For instance, Barrell et al. (2015) test the housing wealth effect on consumption in Italy and the UK, identifying a significant and positive relationship in the latter. Similarly, Chen (2006) identifies a positive long-term link between housing wealth and consumption in Sweden, although the short-term effect is not significant. Other authors, like Cooper (2013) and Defusco (2018), have found that greater access to housing collateral has positive effects on households borrowing behavior, which ultimately stimulates their spending.

[2] Data concerning the evolution of the housing stock and its features is reported in the Census of Population and Housing, Censo de Población y Vivienda in Spanish, and the annual Housing Survey, Encuesta Nacional de Vivienda in Spanish, both conducted by the National Institute of Statistics and Geography, hereafter INEGI.

[3] For instance, the sectoral balance sheets provided by INEGI include dwellings as part of households' non-financial assets. However, these figures only consider the value of the structures of dwellings, ignoring the value of the land underlying.

calculate the value of residential land. Third, we add up the former series to compute the replacement value of the housing stock. Finally, using a housing price index, we obtain a measure of housing wealth that spans from 2005 to 2020.

The results show that, in general, changes in housing prices, rather than the addition of new dwellings to the stock, account for most of the growth of housing wealth over time. Nonetheless, we find evidence of a rise in the contribution of the stock of dwellings to housing wealth growth between 2006 and 2008, in line with the expansion of urban areas promoted by the housing public policy implemented during those years.

As in other countries that report this measure, housing wealth in Mexico has followed an upward trend as percentage of GDP since 2005. After 2017, this trend got steep due to an increase in housing prices following growing construction costs (BBVA, 2018), and reached 194.8% of GDP in 2020 following the sharp economic contraction as the COVID-19 pandemic unfolded.[4]

As mentioned before, housing wealth serves as a proxy of households non-financial assets, we are able to estimate household net worth next.[5] This measure provides a better insight into households overall economic position, especially in countries where they have limited access to financial markets. We find that, as of 2020, household net worth represented 363.2% of household net disposable income (NDI), a figure close to those reported by other developing countries. Furthermore, the estimation of said indicator supports a common finding in the literature on households wealth, that is, housing is the most important asset held by Mexican households, a result also reported by the ENFIH.

In the absence of some indicators required in the methodology, we introduce a set of assumptions that need to be tested in order to assess the robustness of the initial estimation. As a result, we derive a plausible interval of housing wealth over time, which we consider a more suitable output given the data constraints. The alternative housing wealth measures share the upward trend of the initial series, and yield an interval for housing wealth between 187.2% and 202.1% of GDP in 2020.

Moreover, our main estimation does not account for two common features of the housing market: mortgaged housing and housing informality, the latter principally attached to de-

[4] For 2019, based on the responses of households, the ENFIH reports an indicator that resembles our definition of housing wealth. Such figure represents 82.8% of GDP, almost half the size of ours. The difference between survey and macro-level indicators is a common issue reported by other countries. In Appendix C, we confirm this finding for the limited set of countries for which survey and aggregate data on households wealth were available. For instance, in Italy (2016), the figure from the survey represented around 59.3% of the aggregate measure, whereas the same ratios for France (2015) and the U.S.(2017) were 74.4% and 85.5%, respectively.

[5] Household net worth is calculated as the sum of financial and non-financial assets minus the value of outstanding liabilities, such as mortgages

veloping countries. Given that financial deepening in the Mexican housing market is rather low, mortgages do not represent an important source of adjustment for housing wealth. As for housing informality, it is commonly associated either with self-built homes or dwellings without property titles (Harris, 1991), although both features can be highly correlated and interfere with the role of housing as collateral. Using data from the Census of Population and Housing 2020,[6] we estimate a reduction of nearly 25 percentage points in housing wealth, in terms of GDP in said year, due to the lack of property titles, which is the feature that most likely prevents homeowners from using housing collateral.

To the best of our knowledge, this is the first time that a methodology to measure the evolution of housing wealth, using macro-level data, is developed in Mexico. Previous analyses tracked housing wealth either through the evolution of housing prices or through the dynamics on housing stock, the latter being available only on a five-year basis. A different approach is that of the ENFIH, which based on micro-level data describes the distribution of wealth among households.

All in all, our proposed methodology eases the data requirements commonly considered in international guidelines, which are hardly fulfilled in developing countries. Even when accounting for variations in key assumptions, needed to overcome the lack of data, it is possible to estimate a plausible interval for the housing wealth series over time. Besides, the resemblance between our approach and those implemented in other countries enables international comparison, as well as the calculation of other popular indicators concerning households, such as housing equity and household total net worth.

The remainder of the paper is organized as follows: Section 2 briefly reviews the existing literature on housing wealth estimation. Section 3 describes the methodology, as well as its data requirements. Section 4 displays our quantitative findings for Mexico, including a robustness analysis of the results. Section 5 presents conclusions.

2 Literature Review

Since housing is the largest asset held by households in most countries (Poterba, 2000; Xie and Jin, 2015), housing wealth is a widely-used proxy for households non-financial wealth. Accordingly, applications of this indicator range from estimations of money demand —in order to improve the identification of wealth and income effects in the household sector (Papademos and Stark, 2010) — to more traditional approaches where housing wealth is considered

[6] In that year, the Census assessed for the first time features like self-built housing and dwellings without property titles.

to play an important role both as collateral for borrowing and as a crucial determinant of consumption. In the former case, Guerrieri and Iacoviello (2017) and Aladangady (2017) find evidence regarding the effect of increasing housing wealth on higher household borrowing, which ultimately fuels a debt–driven consumption boom. On the contrary, a declination in housing wealth forces households to borrow less, and pushes to an economic contraction. As for the latter case, existing literature highlights the larger effect of changes in housing wealth on consumption as compared to that of financial wealth (Chen et al., 2020). The so-called consumption-wealth channel is based on the life-cycle and permanent income hypothesis (Modigliani and Brumberg, 1954; Lando and Modigliani, 1963; Friedman, 1957). Consumers configure the estimates of their ability to consume in the long-run and set their current consumption accordingly, using both labour income and financial and non-financial assets. Thus, changes in asset prices and wealth affect their expectations of future spending, causing a readjustment of their current spending in the same direction (Alp and Seven, 2019).

Housing wealth also serves to broaden statistics on households. For instance, the housing equity measure enables the estimation of the proportion of the value of the property truly owned by the household —by ruling out any assessment on the property (e.g., mortgages) from housing wealth (see Reinold, 2011)—; and that can be used for other purposes such as consumption or additional financing. Likewise, statistics on household balance sheet can be improved if a housing wealth measure is available since it allows a more thorough estimation of household net worth, by adding the said measure, as a proxy for non-financial wealth, to household financial wealth.

Despite this indicator's usefulness, there is not a standard methodology to estimate housing wealth since statistics on this sector differ by country; and, more importantly, are usually scant. In fact, literature often approximates said measure with the evolution of housing price indices (see Alp and Seven, 2019; Gillitzer and Wan, 2016), thus leaving aside the effects of changes in housing stock over time.

Surveys on household finance and wealth shed some light on the composition of these kind of indicators. Micro-level data can enrich the analysis of key household indicators as it provides distributional information and a level of granularity that is not usually available otherwise. Nonetheless, literature on this subject often remarks the existence of differences between survey and macro-level indicators, where the former are usually smaller than the latter. This issue is mainly explained by underreporting and truncation problems in the samples of the surveys (see Cervantes González and Cruz Salas, 2021; Bustos and Leyva, 2017; Altimir, 1987; Zwijnenburg et al., 2017). Adjusting survey indicators to macro-level ones is not a trivial task, several methodologies have been proposed and tested for this purpose (see OECD, 2013; Bustos and Leyva, 2017; Statistics Canada, 2019). However, the particular causes of the underestimation of survey-based indicators hamper the design of a common approach to address this issue.[7]

When looking for a more thorough measure of the evolution of aggregate housing wealth, literature refers to two main approaches of computation. First, the appraisal method, which builds the value of housing stock from individual characteristics of dwellings, such as location, price, size and age. This information is usually found in real estate registers or, alternatively, in appraisals of houses sold through mortgages. Housing appraisals also adjust the combined value of a dwelling by a factor that accounts for other facilities in the neighborhood. In this way, the value of the housing stock in a country is obtained either by simply adding up the value of all dwellings in the economy, or by multiplying the value of a representative sample of the stock by the weight of each type of dwelling, the latter obtained from census data. In both cases, data requirements are usually hard to fulfill, instead this method is most frequently used for the calculation of housing price indices —as it is the case for Australia, Italy and the United States. Second, in contrast with the former method, the quantity times price approach allows for more flexible estimations driven by data availability. The method can be summarized as the multiplication of housing stock, which corresponds to the "quantity" part, by housing prices that are representative of the total housing stock (for a detailed description of the different approaches to estimate Residential Property Price Indices see OECD et al., 2013). Such a generalized approach enables multiple interpretations, which can be as detailed as data permits. For instance, figures of the national housing stock are usually presented in censuses, and can be analyzed at different levels (i.e. types of dwelling, sales strata[8]), whereas pricing data can be obtained through average values of dwellings, (i.e. derived from stratified sales data, see Eurostat-OECD, 2015), or hedonic price regressions[9] based on housing sales or

7 Previous studies on this subject point out the case of Latin American countries, where differences between micro- and macro-level indicators for several household indicators (e.g., remittances, income, consumption, among others) seem to be greater than in other regions as population is more reluctant to participate in the surveys or to report personal data accurately (see OECD, 2013; Bustos and Leyva, 2017; Cervantes González and Cruz Salas, 2021).

8 By using sales data, it is assumed that sold dwellings are representative of the total stock, otherwise this could bias the results. Data can be stratified at any available level, usually regionally, in order to reduce compositional effects.

9 Although hedonic price regressions are a popular method for estimation housing prices, Coulson and Zabel (2013) suggest to interpret their results with caution since such kind of models are based on the assumption of market equilibrium. In addition, they argue that the estimations can be subject to some bias due to omitted variables.

residential developers information.[10] However, even when microdata is scarce, estimations based on data aggregated at the national level are a feasible alternative under said approach. Accordingly, one can compute housing wealth by adding up figures of the aggregate value of housing structures and land in the economy. The former can be estimated using the Perpetual Inventory Method (OECD, 2009), which is based on the concept that stocks are the result of cumulated flows of investment adjusted by depreciation. In this way, starting from the stock of a particular type of asset at a certain point in time, the method proceeds to adjust this value, for subsequent periods, following an appropriate depreciation profile according to the type of asset and adds on the corresponding flows of investment. In a similar way, land value can be estimated following the Perpetual Inventory Method basic idea, although taking into account the fact that land does not lose value across time.

A great part of the academic research that aims at estimating housing wealth uses census data to address the issue of the quantification of housing stock. For instance, Piketty and Zucman (2014) use balance sheets information to estimate housing wealth, as part of their computation of aggregate wealth for several developed countries. They also mention the possibility of estimating housing wealth through the Perpetual Inventory Method (PIM hereafter), although emphasizing an important gap between this approach and information from balance sheets, consisting mainly on the former capturing the value of the housing structures but dismissing the value of the land underlying dwellings. By contrast, balance sheets overcome this issue as they use data from censuses and housing prices to derive the market value of real estate. Following a different approach, Vetter et al. (2014) use microdata from the population census to calibrate a hedonic residential rent model that ultimately enables the estimation of the market value of dwellings in Rio de Janeiro, Brazil. The hedonic regressions are first calibrated based on characteristics of rented dwellings in the area as determinants of their rental value. Afterwards, they introduce characteristics of non-rental units so as to obtain their imputed rents. Housing wealth is finally computed as the sum of individual housing values, which are in turn calculated as the present value of perpetual flows of the monthly imputed and actual rents. Kuminoff and Pope (2013) also follow a hedonic approach but aiming at decomposing housing value into the market value of land and structures (separately) in 12 metropolitan areas in the United States. For this purpose, they regress housing sales prices on a set of characteristics of the structures and land underlying those units, adding data from

[10] The Eurostat-OECD (2015) suggests that for inter-census years the number of dwellings obtained from census could be extrapolated forward, using stratified information on construction statistics (e.g., dwelling completions). The stratification of national construction statistics can be conducted using the rates of participation of each stratum in the national stock, according to the last census available.

censuses that refer to common amenities in each area. Lastly, a more recent branch of the related literature (see Gallin et al., 2021; Fagereng et al., 2020) combines data from censuses with machine learning techniques that are applied to housing sales data, including information on housing characteristics, to compute market prices. As a result, higher frequency series of housing wealth are obtained with improved accuracy concerning the pricing part of the estimation.

In the case of Mexico, the open data sources available hinder the implementation of the appraisals method since, to our knowledge, access to data from the land cadastre is restricted, so we ignore its periodicity and quality. This makes the quantity times price approach the most feasible methodology given our constraints. In fact, this method is also used by national authorities in some other countries such as Australia (Eurostat-OECD, 2015; Australian Bureau of Statistics, 2011), France (INSEE, 2013) and Italy (Istat, 2019; Marini, 2011). However, in our case, estimating the "quantity" part through microdata still poses a challenge as census statistics on housing are rather scant, which is why we turn to the alternative of using aggregate data. Further assumptions and calculations are needed in order to tailor the quantity times price approach in the way we briefly describe above (e.g., the value of residential land or the depreciation rate of the housing stock). For such purposes, we consider some additional guidelines. Different methods to generate depreciation series are introduced in a manual from the OECD (2009). Concerning land value estimation, Davis and Heathcote (2007) describe an indirect method to estimate this series following the approach of the U.S. Census Bureau. Finally, Berge et al. (2006) provide an important reference of the implementation of the quantity times price approach to estimate housing wealth according to the methodology from the Central Bank of Norway.

3 Data and Methodology

The approach presented in this section matches the referred methodological guidelines with the available data in our country. In fact, most of our supply indicators are generally publicly available, which facilitates the implementation.

Given that our main purpose is to estimate housing wealth, we have to obtain the market value of housing stock by using any housing price index available. In turn, the value of housing stock is calculated as the sum of the value of land underlying dwellings and the replacement value of their structures, whose calculation requires several intermediate steps and assumptions. In the remainder of this Section, we detail step by step the stages of our approach, starting from the estimation of the value of the structures and the land underlying dwellings, so as to facilitate its implementation.

The remainder of this section elaborates on the procedure summarized above, along with its data requirements. In order to facilitate the reproduction of our approach, we start from describing the calculation of the main input series to estimate housing stock, and then delve into its transformation to market value so as to derive housing wealth. Given that most of the input series are available from 1980 onwards, we choose this as the starting point for all our computations but that of housing wealth. The latter is computed from 2005 onwards since the housing price index is not available before that year.

3.1 Capital Stock of Dwellings

As mentioned above, the capital stock of dwellings (K) refers to the current cost of replacing the structure of the dwelling. For this purpose, we use the perpetual inventory method (see OECD, 2009), which uses historical data on gross fixed residential capital formation (I) adjusted for depreciation expenses of these assets (D):[11]

$$K_t = K_{t-1} + I_t - D_t \tag{1}$$

Thus, it is necessary to set the initial capital stock of dwellings (i.e., at $t = 0$), and calculate the depreciation component over time. As for the estimation of the former, we follow the methodology proposed by the OECD (2009) represented in equation (2). Such calculation assumes a geometric depreciation rate (δ) and a constant growth rate (g) of I:

$$K_t = [I_{t-1} + (1-\delta)I_{t-2} + (1-\delta)^2 I_{t-3} + ...] \tag{2}$$

where $I_{t-2} = I_{t-1}(1+g)$, thus:

$$K_t = [I_{t-1} + (1-\delta)(1+g)I_{t-1} + (1-\delta)^2(1+g)^2 I_{t-1} + ...] \tag{3}$$

Finally, this geometric series converges to:

$$K_t = \frac{I_t}{g+\delta} \tag{4}$$

[11] Starting from 1993, INEGI reports gross fixed residential capital formation with the base year 2013. Consequently, from 1980 to 1992 the series was chained.

which is evaluated at $t = 0$ to obtain the initial capital stock of dwellings (K_0).

According to the World Bank (2010), the suggested initial depreciation rate can be calculated as follows:

$$\delta = \frac{1.6}{auh} \tag{5}$$

where auh represents the average useful life of the housing stock, which we estimate next.

Average Useful Life of the Housing Stock

The National Survey of Household Income and Expenditure (hereafter ENIGH) conducted in 2018 and 2020 provides data on the number of houses by building material and age.[12] This information allows the construction of time series of the housing stock by building material since 1970 (e.g., a house made of wood that in 2020 was 20 years old is considered in the annual stock since 2000). However, before going forward, we must acknowledge that this estimation disregards those dwellings that were *destroyed* in the interval 1970-2020 —e.g. those built with less resistant materials—, which we assume not to represent a significant proportion of the value of the total stock. Having said that, the proportion of houses of each building material (PV_t^i) is:

$$PV_t^i = \frac{v_t^i}{v_t} \tag{6}$$

where v_t^i represents the stock of dwellings made of material i reported at period t, and v_t corresponds to the total number of dwellings in the same period. Nonetheless, equation (6) does not take into account differences in the value of houses due to the material used for their construction. Adjusting for this, allows to partially offset the effect of short-lived building materials on the average useful life of the housing stock. In order to do so, we use data on the rental value reported by homeowners,

$$A_i = \frac{\sum_{j=1}^{n} ER_i^j}{n_i} \tag{7}$$

where A_i is the average rental value of a house made of material i, ER_i^j represents the rental value of house j made of material i, and n_i is the number of houses made of material i included in the survey.[13]

[12] See Appendix A for the descriptive statistics of the composition of housing stock in Mexico by building material over time.

[13] All the data used from the ENIGH takes into account the expansion factor reported in the survey.

Equations (6) and (7) are then used to calculate the rental value of dwellings made of material i (VI_i^t), and the weight of each material based on its assigned rental value (PPV_t^i) afterwards:

$$VI_t^i = PV_t^i * A_i \tag{8}$$

$$PPV_t^i = \frac{VI_t^i}{\sum_{i=1}^{n} VI_t^i} \tag{9}$$

Once we apply equation (9) to each material, we can use these figures to estimate the weighted average useful life of the housing stock in 1980 as follows:

$$VUP_{1980} = \sum_{i=1}^{n} VU^i * PPV_{1980}^i \tag{10}$$

where VU^i is the average useful life of houses made of material i in 1980 as reported by COPLAMAR (1982).[14] According to this equation, the weighted average useful life of the housing stock in 1980 was 47.5 years, hence the initial depreciation rate δ is 3.37% (equation (5)).[15]

As for the growth rate g of I, we assume it to be equal to the GDP average annual growth rate between 1950 and 1979, hence $g = 6.5\%$. Both figures, δ and g, are then plugged in equation (4) to get the initial value of the capital stock of dwellings K_0.

There might be some concern about the sensitivity of the capital stock of dwellings series due to variations in K_0 under different assumptions for g and δ. Nevertheless, the relatively long time span of this analysis allows us to prove that, as a result of depreciation, K_0 becomes less relevant the longer the time span is. For this reason, the capital stock converges to a similar value even under different scenarios for the initial stock (see section 4.2).

We also estimate the initial value of the capital stock of dwellings by wall building material K_0^i. As it will be explained in the next subsection, these series are needed for the computation of our proposed measure of depreciation D_t. For simplicity, we obtain the series as the product of K_0 and the weight of each material based on its assigned rental value PPV_0^i (equation (9)):

[14] COPLAMAR, *Coordinacion General del Plan Nacional de Zonas Deprimidas y Grupos Marginados* in Spanish, was a comission in charge of coordinating the National Development Plan for marginalized groups and areas.

[15] As suggested by an anonymous referee, we looked for information on housing average useful life in other countries, such as The United States, Canada, Brazil, Chile, European countries and Japan. However, the only available figure we found is from Chile, provided by its Tax Administration System, where the estimated housing average useful life, as of 2003, is 50 years. A more common indicator is that of the average life of the current housing stock in the country, which not necessarily matches average useful life.

$$K_0^i = PPV_0^i(K_0) \tag{11}$$

Depreciation by Wall Building Material

Ideally, data on consumption of fixed residential capital should be used to account for depreciation, however, this series is only available in the SNA from 2003 onwards. Therefore, we consider that a second-best option is to estimate this indicator by wall building material so as to account for the fact that each material depreciates at a different rate —i.e. bricks wear away less than wood within the same period of time—. In this way, depreciation of wall material i is calculated as follows:

$$D_t^i = \theta^i(K_{t-1}^i) \tag{12}$$

$$\theta^i = \frac{R^i}{VU^i} \tag{13}$$

$$R^i = VU^i * (1 - g_i^{\frac{1}{VU^i}}) \tag{14}$$

where θ^i represents the depreciation rate of each material. This rate is calculated as the ratio between the declining balance rate of dwellings built with material i (R^i) and its average useful life (VU^i). Likewise, R^i results from multiplying the average useful life of those dwellings (VU^i) times a given factor. According to the OECD (2009), there are two well-known ways to calculate the declining balance rate R^i, although it can also be determined by the researcher. Following the suggested approaches, we decided to adopt the one that ensures that at the end of its useful life, the housing stock preserves a certain portion g_i of its original value, depending on the building material: 20% for houses with brick or concrete walls, 10% for adobe and wood walls, and 5% for other materials.[16, 17]

Notice that a measure of I_t by wall material is also needed. For this purpose, we first construct the chained series of I_t out of two series released within the National Accounts, one covering the period 1980-1993, and another starting from 1993 onwards. This series

[16] The rationale behind this approach consists on assuming a compound depreciation formula such that $gV = V(1 - (R/VU))^{VU}$, where g is the percentage of the initial value V of the dwelling that is preserved at the end of its useful life VU. Solving this expression for R yields equation (14).

[17] We found no former available studies that specify how much of the original value of a house is preserved at the end of its useful life according to its building material. However, our assumption attempts to take into account the differences on the durability of each material. We conduct a robustness exercise with an alternative assumption in 4.

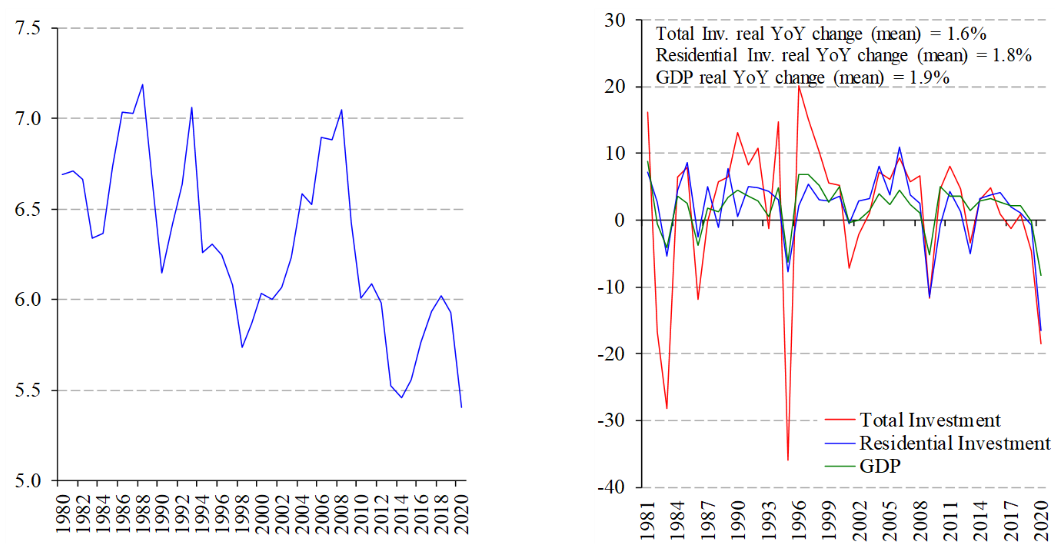
is deflated using its implicit price index and then multiplied by the weighted proportion of homes built with each material (PPV_t^i):

$$I_t^i = PPV_t^i * I_t \tag{15}$$

Together, equations (11), (12) and (15) enable the estimation of equation (1) by building material, and the resulting series are aggregated afterwards:

$$K_t = \sum (K_{t-1}^i + I_t^i - D_t^i) \tag{16}$$

In summary, once the value of the initial capital stock K_0^i is known, the rest of the calculation consists on adding yearly data on residential investment, and adjusting it for depreciation expenses. As shown in Figure 1a, residential investment in Mexico represents, on average, around 6.3% of the GDP since 1980, following since then a downward trend. This component is also less volatile than total investment with an average annual growth rate of 1.8% (Figure 1b). For the same period, the annual depreciation rate of housing has decreased as a result of the use of more durable building materials (see Figure 2).



(a) Residential Investment I_t (% of GDP)

(b) Real YoY % change in I_t and GDP

Figure 1: Gross Fixed Residential Capital Formation

Source: INEGI.

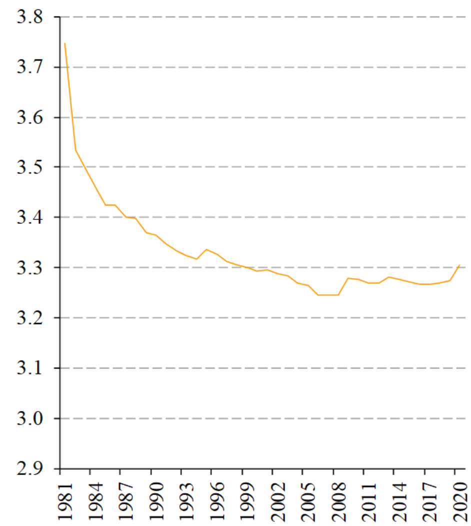


Figure 2: Annual depreciation rate of housing

Notes: Data corresponds to the total annual depreciation of dwellings over the capital stock of dwellings, in percentage terms.
Source: Own calculation.

3.2 Value of the Stock of Residential Land

Estimating the replacement value of land underlying dwellings (L) is not a trivial exercise. Currently, there is neither aggregated public data on this subject nor a residential land price index that would enable a more accurate measure of the series. Consequently, the estimation is based on a modified version of the perpetual inventory method accounting for the fact that land does not depreciate over time:

$$L_t = L_{t-1} + IT_t \tag{17}$$

Therefore, as in the estimation of the capital stock of dwellings, it is necessary to know its initial value, and add up the investment on residential land (IT) afterwards. Again, the former is estimated through a geometric approximation similar to the one presented in equation (4):

$$L_t = \frac{IT_t}{g} \tag{18}$$

Since there is no public data on IT_t, we follow the approach of Davis and Heathcote (2007) to calculate this series.[18] They base on the fact that residential investment (I_t) is calculated as the value of the structure of new dwellings, which in turn is a proportion κ of their sales value (S_t):

$$I_t = \kappa * S_t$$

Likewise, a proportion β corresponds to the value of the land underlying those dwellings. If data on home sales were available, then investment on residential land could be simply estimated as follows:

$$IT_t = \beta * S_t$$

Instead, given the confidentiality of such information, IT_t has to be calculated indirectly using a rule of three of the two previous equations, such that:

$$IT_t = \frac{[(\beta) * S_t]I_t}{\kappa * S_t} = \sigma I_t \tag{19}$$

where $\sigma = \frac{\beta}{\kappa}$. Thus, investment on residential land is calculated as a proportion σ of residential investment.

In order to compute σ, we use proportions of structures (κ) and land underlying dwellings (β), which were calculated by the Mexican housing consulting firm Softec in 2012 from reported homebuilders' total costs, by economic classification of housing.[19] First, to address the heterogeneity in the economic classification of the housing stock, we calculate the proportion of each classification using Softec's microdata.[20] Next, we apply these proportions to the shares of structure and land underlying dwellings by economic classification so as to calculate a weighted-average that represents the total housing stock.[21] According to this cal-

[18] Their approach resembles the land-to-structure ratio approach presented in Eurostat-OECD (2015), which basically consists on computing the value of land by multiplying the value of dwellings' structures times an estimated land-to-structure ratio.

[19] According to an internal study, conducted along with the National Autonomous University of Mexico in 2016, data from Softec is representative of the housing stock reported in the Census of Population and Housing in 2000 and 2010. Moreover, the proportions of housing by economic classification (i.e., economic, medium, and residential housing) in Softec's database are similar to those in Sociedad Hipotecaria Federal's database from 2008 to 2019.

[20] We use data of the three major cities in the country: Mexico City, Guadalajara and Monterrey.

[21] The categories of housing economic classification are more detailed in Softec's microdata. In particular, low-income housing is classified into popular, economic and traditional, whereas the cost figures of land and structures for this type of housing seems to be aggregated as economic housing. For this reason, we match the information assuming that popular and traditional dwellings have the same cost shares as the economic ones.

culation, the value of the structure (κ) and the land underlying dwellings (β) represent, on average, 72.7% and 11.1% of the total costs reported by homebuilders, respectively. This yields $\sigma = 15.2\%$.[22] However, a caveat of this calculation corresponds to the fact that the figures are estimated based on the total costs of building a new dwelling rather than on the sales value, which is the one actually used in the computation of I_t. As a result, the figures do not completely match the aforesaid approach. Still, our measure of σ seems to be reasonable, for instance, Davis and Heathcote (2007) report $\sigma = 12.7\%$ for the U.S in 1999. We provide an additional robustness check on this subject in section 4.

Finally, once equation (17) is computed, we obtain the nominal value of the stock of residential land using the implicit price deflator in the absence of a land price index.

3.3 Housing Stock and Housing Wealth

Having calculated both the capital stock of dwellings and the value of the stock of residential land, the replacement value of the housing stock results from adding up these series:

$$V_t = K_t + L_t \tag{20}$$

Once the value of the housing stock is known, the estimation of housing wealth (R_t) consists on converting the former to nominal prices using a housing price index. Ideally, the housing price index used for our purpose should be calculated based on the housing stock; however, available indices are usually limited to home sales, which might not closely represent the stock, consequently causing some bias in the results. With this in mind, we follow the method proposed by Berge et al. (2006):

$$R_t = R_{t-1}\left(\frac{P_t}{P_{t-1}}\right)\left(\frac{V_t^R}{V_{t-1}^R}\right) \tag{21}$$

where $\frac{P_t}{P_{t-1}}$ represents the change in housing prices and $\frac{V_t^R}{V_{t-1}^R}$ the change in the real value of the housing stock.

In order to evaluate equation (21), we use the housing price index released by Sociedad Hipotecaria Federal, which to our knowledge is the only available index on the subject for Mexico. Since it is calculated based on the value of mortgaged homes rather than on that of

[22] As a robustness check, we performed the same calculation using the proportions of the housing stock by economic classification obtained from Sociedad Hipotecaria Federal's appraisals data. This approach results in an almost identical figure for σ (14.9%). Nonetheless, we prefer to use Softec's microdata since there is evidence of its close resemblance to the national housing stock.

the whole housing stock, our results might be somewhat biased for this reason if the dwellings in the sample are not representative of the national stock. Furthermore, it is available only from 2005 onwards, thus preventing our housing wealth estimation from starting at 1980 as the former housing stock series.

Notice also that in order to evaluate equation (21) at $t = 1$, we need to know the initial value of households housing wealth (R_0). We estimate this figure following two assumptions. First, that at $t = 0$ the replacement value of the housing stock equals its market value. Second, that R_0 represents a proportion γ of the nominal value of the housing stock own by households at that period. The latter assumption follows previous studies on this subject that allude to the fact that some proportion of the housing stock is owned by a government authority.[23] For instance, according to the OECD (2020), social rental housing represented between 14.0% and 37.7% of the total housing stock in 2019 in France, the United Kingdom, Austria, Denmark and the Netherlands. This report also mentions that public rental housing in Mexico is only offered to armed-forces personnel, so its proportion with respect to the total housing stock must be close to zero. Moreover, we did not find additional evidence that points to a significant proportion of dwellings owned by other agents different from households or government, therefore we assume $\gamma = 100\%$.

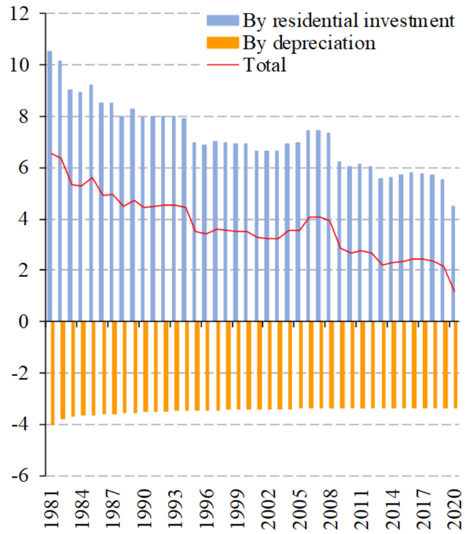
4 Results

The estimated series reveal several important facts. For instance, as observed in Figure 3, the annual growth rate of the capital stock of dwellings shows a downward trend since 1980 as a result of the decrease in residential investment. Nevertheless, its performance generally outpaces that of the GDP —the average growth rate of the former is 3.7%, whereas the latter has grown at an average rate of 1.9%—. This behavior can be attributed at least to two reasons: the quality improvement of the housing stock given that more durable building materials are being used, and the increase in the number and size of dwellings.[24]

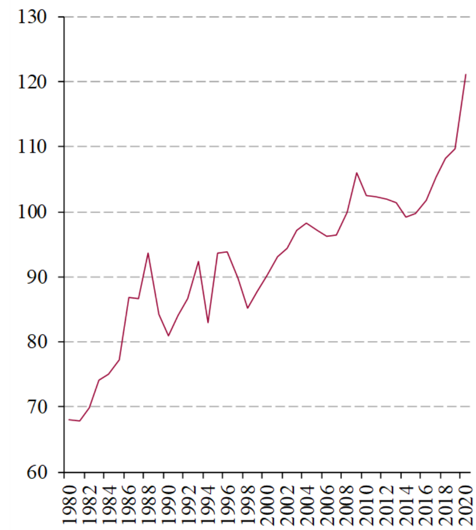
The previous conclusions can be extended to the evolution of the value of the stock of residential land given that its estimation relies also on the performance of residential investment. In consequence, this indicator is expected to follow a similar path to that of the capital

[23] Houses could also be owned by firms, however, there are no available figures in this regard.

[24] According to INEGI, the number of inhabited homes tripled between 1980 and 2015. Additionally, the median number of rooms doubled in the same period.



(a) Capital stock of dwellings' growth decomposition (in %)



(b) Capital stock of dwellings (% of GDP)

Figure 3: Capital stock of dwellings

Notes: In Figure 3a, the contribution of each variable to the growth of the capital stock of dwellings is calculated as its participation at time t on the value of the stock of dwellings at period $t-1$. In the case of residential investment, such proportion represents the increase in the value of the stock of dwellings would depreciation be 0 at time t. Similarly, the participation of depreciation indicates the decrease in the value of stock of dwellings assuming residential investment to be 0 at time t.
Source: Own calculations.

stock of dwellings (Figure 4).[25]

As noted earlier, once we add up both series, we obtain the value of the housing stock. Nonetheless, interpreting this indicator could be intricate as it refers to the replacement value of the stock, which is how much it would cost to rebuild the dwellings, as well as repurchase land, at a given point in time. Besides, the importance of housing in economic analysis is related to the market value of dwellings rather than their replacement cost. In fact, according to Figure 5a, changes in housing prices account for most of the growth of the housing wealth indicator. However, the greatest contribution of changes in the stock of dwellings to housing wealth growth was observed between 2006 and 2008 —the average contribution was of 4.0 percentage points during said years, decreasing afterwards to an average of 2.5 percentage points—, in line with the expansion of urban areas following the housing public policy implemented in the period. In aggregate terms, housing wealth has followed an upward trend

[25] As a robustness check of our measure, Appendix B presents the comparison with the value of the stock of land reported by the OECD in the "Balance sheets statistics for non-financial assets". Although the level of our series is somewhat higher compared to the latter, the OECD does not provide more information about its estimation (i.e., if it excludes residential land), see Appendix B.

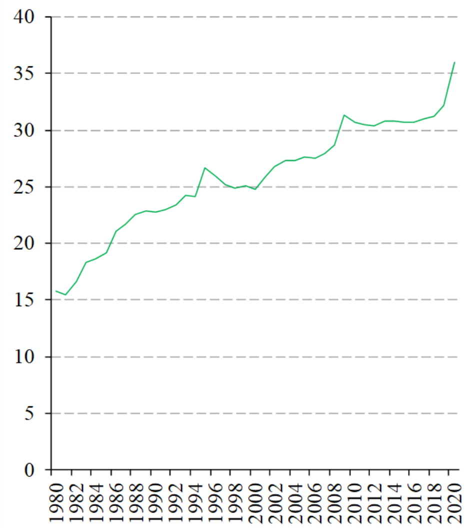


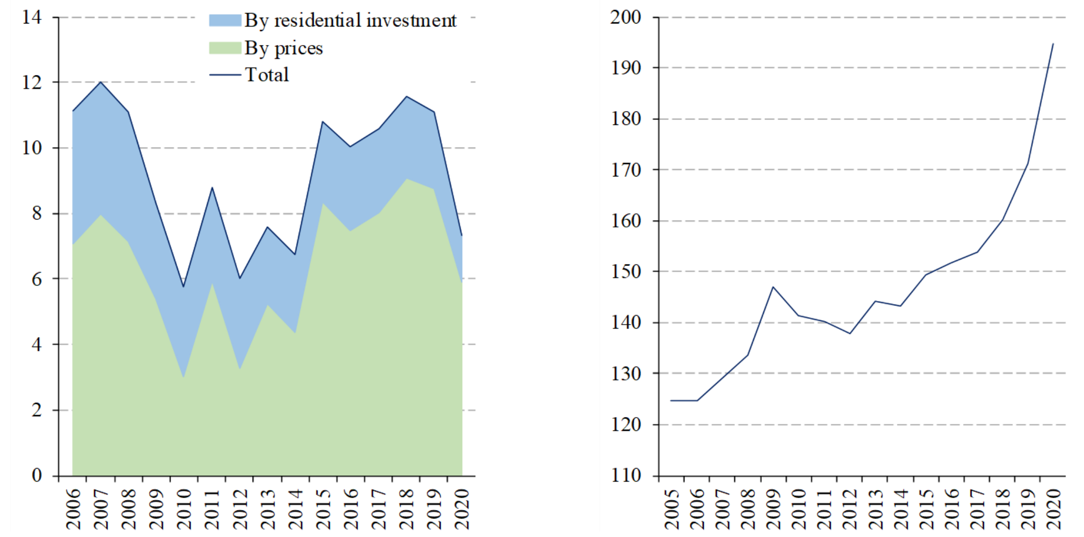
Figure 4: Stock of residential land (% of GDP)

Source: Own calculation.

with respect to GDP since 2005 (Figure 5b), although the bump that stands out around 2008 along with the recent increase in 2020 are closely related to sharp declines in GDP —the former during the financial crisis and the later as the COVID-19 pandemic evolved— rather than to a significant rise in housing value.

We have mentioned that each country adapts the existing methodologies for housing wealth estimation. However, it is still interesting to compare our measure in an international context, although taking into account the existence of at least some differences underlying each series. As Figure 6 shows, global housing wealth as percent of GDP has followed an upward trend since 2000, although in some countries interrupted by the global financial crisis in 2008, particularly in the United States, as a result of the drop in housing prices. In 2017, housing wealth in Mexico represented 154% of GDP, a similar figure to those reported by other OECD countries such as Sweden and the United States. In the following years, and in a context of lower demand, housing wealth in Mexico augmented at a faster pace with respect to other countries, explained not by a greater stock of dwellings but by an increase in housing prices due to growing construction costs (BBVA, 2018). [26] At this stage, we advise a cau-

[26] Using data from the ENFIH, housing wealth represented 82.8% of GDP in 2019. For that same year, our measure reached 171.2% of GDP. In Section 2, we briefly discuss the widely-known issue of differences between survey and macro-level indicators. Latin American countries tend to register greater discrepancies than other regions due to the low participation of population in the surveys. Appendix C provides further insight into the size of the differences between both types of indicators for a limited set of countries, given data availability. Considering this analysis, the differences for the case of Mexico are comparable to those in other countries.



(a) Households housing wealth growth's decomposition (in %)

(b) Households housing wealth (% of GDP)

Figure 5: Households housing wealth

Notes: In Figure 5a, the contribution of residential investment is computed as the real year-on-year change of our measure of housing stock, whereas the contribution of prices results of subtracting the former series from the year-on-year change in households housing wealth.
Source: Own calculations.

tious interpretation of our results since our indicator faces an important caveat related to the large portion of housing that remains under informality. Consequently, the implications of an increase in housing wealth on the availability of greater liquidity sources or higher collateral for households cannot be derived as straightforward as for developed countries. In order to overcome this limitation and improve the accuracy of our estimation, we introduce a set of additional indicators in the remainder of this section.

4.1 The Role of Housing Wealth in Households Position

First, we address the possibility of overestimating housing wealth due to informal housing by excluding dwellings without property titles from our initial estimation, hereafter referred to as effective housing wealth. Second, we provide an alternative estimation that accounts for the fact that, even if housing informality did not represent an issue in our estimations, assessments on at least a proportion of the property (e.g., mortgages) reduce the value that is truly available for homeowners for consumption or additional financing. Finally, our estimation of the stock of housing wealth serves as a proxy for households non-financial assets, and thus contributes

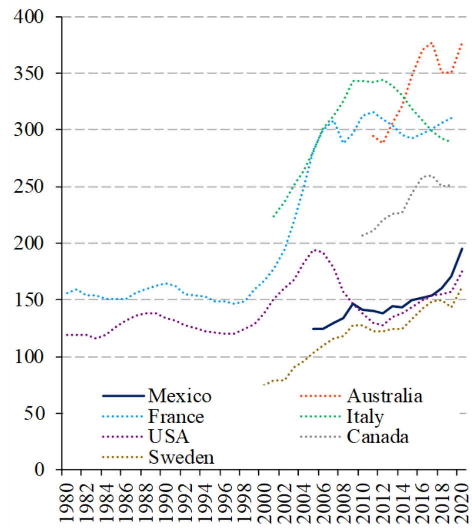


Figure 6: International comparison of households housing wealth (% of GDP)

Notes: For France and Sweden, the series are obtained from their national balance sheets, they correspond to the sum of the value of dwellings, and land underlying them, owned by households. The series for USA is defined as the real estate owned by households and nonprofit institutions at market value as reported in the Z1 accounts. In the case of Australia, households housing wealth is defined as the reported value of the stock of residential dwellings owned by households. In Italy, the series is calculated as the value of the stock of dwellings owned by households and nonprofit institutions. Lastly, Canada's measure corresponds to the real estate wealth owned by households.
Source: INSEE France, Federal Reserve Bank's Z1 data, Statistics Sweden, Australian Bureau of Statistics, Istat Italy, Statistics Canada and own calculations.

to the estimation of household total net worth.

4.1.1 Housing as Collateral

The Census of Population and Housing Units 2020 released a figure regarding the number of dwellings with property titles. Even if such information limits the adjustment of the entire housing wealth series, it allows us to adjust our initial estimation for that year. In order to do so, we simply multiply the percentage of dwellings with property titles times housing wealth in 2020. As a result, effective housing wealth represents roughly 160% of GDP, 34.5 percentage points lower than the original estimation (Figure 7). Additionally, data from the referred survey enables another approach to rule out informality which consists on isolating the portion of self-built housing from our original estimation, we call it formal housing, which in turn yields a lower figure for housing wealth: 148.8% of GDP.[27] Despite the considerable

[27] We assume self-built housing as informal as it might fail to fulfill legal building guidelines, although this may not be a generalized issue.

difference between both figures, we consider the former as a better proxy to rule out housing informality given that it is the lack of property titles which limits selling or using a dwelling as collateral.

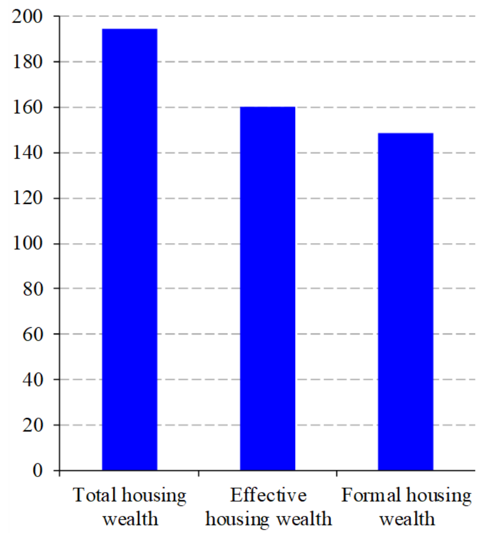


Figure 7: Effective and formal housing wealth in 2020 (% of GDP)

Source: Own calculation with data from the Census of Population and Housing Units 2020.

As mentioned before, mortgages also reduce the proportion of housing wealth that is immediately available for households for other purposes different from paying off their debt. In this sense, a widely-used indicator to measure the proportion of housing wealth with no lending secured on it is known as *housing equity* (hereafter HE). This approach consists on subtracting the outstanding amount of mortgage credit granted by all financial intermediaries (M_t) from the housing wealth series (R_t):

$$HE_t = R_t - M_t \tag{22}$$

According to Reinold (2011), changes in HE can be explained by (i) changes in the stock of secured lending (M_t) as households take out or repay debt; (ii) changes in the stock of housing wealth (R_t) when new properties are built or improvements are made to existing ones; and (iii) revaluations of the stock of housing wealth (R_t) as a result of changes in house prices.

Financial deepening in the Mexican housing market is rather low. As a result, Figure 8 shows that the housing equity indicator does not differ from our housing wealth estimation as greatly as when accounting for housing informality.

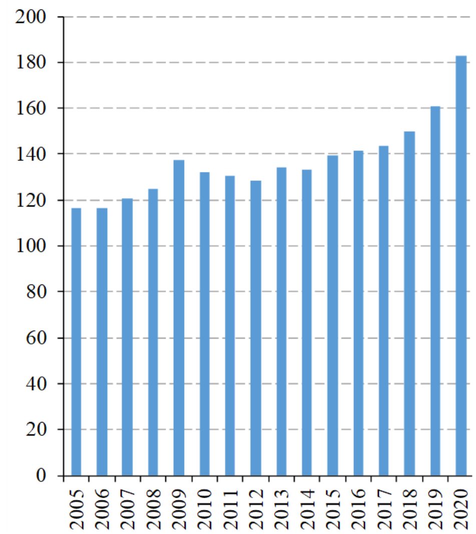


Figure 8: Housing equity (% of GDP)

Source: Own calculation with data from Banco de México.

4.1.2 Household Total Net Worth

Statistics on household balance sheets usually disregard information of households non-financial assets due to missing data on this subject. However, the estimation of *household net worth* (e.g., the sum of financial and non-financial assets minus outstanding liabilities) can improve the analysis of households overall economic position, especially in countries where households have limited access to financial markets.

The methodology of the OECD National Accounts Statistics suggests using housing wealth as a proxy for households non-financial assets. Following this approach, we present an estimation of *household net worth* as a percent of net disposable income (NDI) in Mexico in Figure 9.[28] As of 2020, household net worth represented 363.2% of NDI. Only Chile, out of the set of Latin American countries, reports officially this indicator, which by 2018 was 0.8 percentage points below the estimated figure in Mexico in the same year (304.1% and 304.9%, respectively). Moreover, the comparison across OECD members illustrates the fact that household net worth in developed countries —such as the United States, Canada and some European countries— is considerably higher than in developing countries.

The estimation of household net worth leads us to confirm that housing is the most important asset owned by households in Mexico. This finding is also consistent with that of the

[28] We present household net worth as a percent of net disposable income in order to match the approach followed by the OECD for this indicator.

ENFIH, representing around 70% of household total net worth in 2019 in both sources.

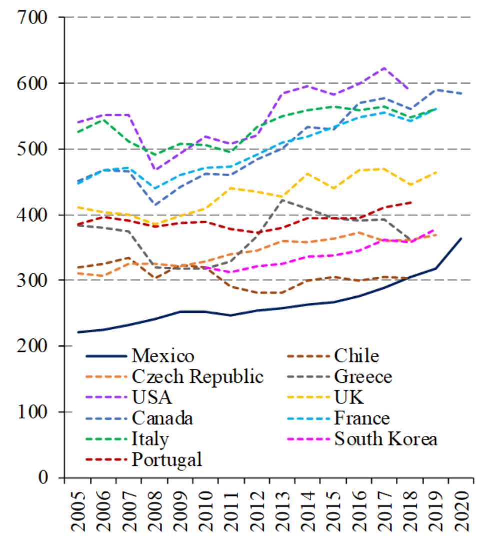


Figure 9: International comparison of household net worth (% of NDI)

Notes: Household total net worth represents the total value of assets (financial and non-financial) minus the total value of outstanding liabilities of households (including non-profit institutions serving households). Housing wealth is used as a proxy for non-financial assets.
Source: OECD and own calculations using information from Banco de México.

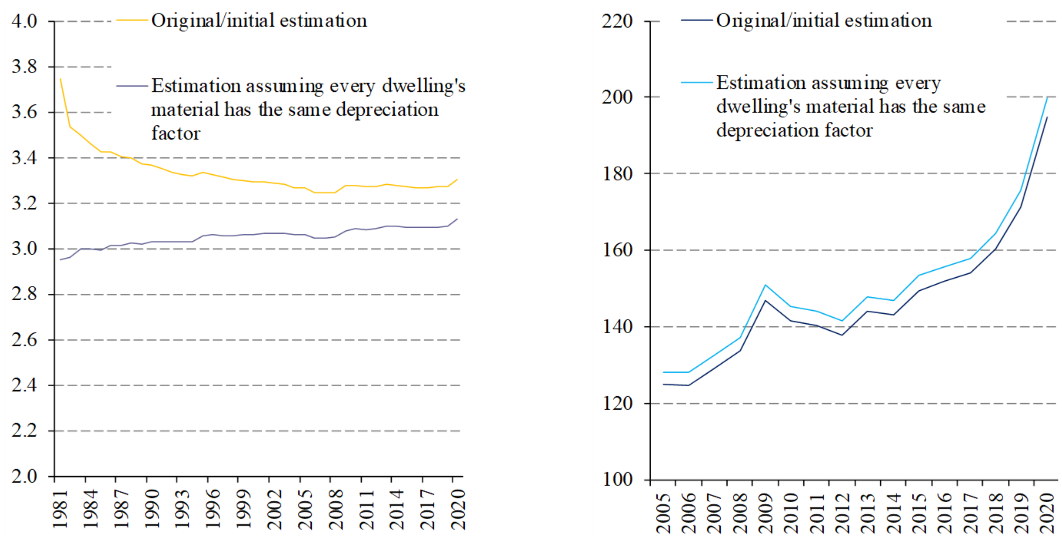
4.2 Robustness Analysis

Earlier on, we introduced a set of assumptions needed to account for unavailable data in Mexico, yet it is important to assess the bias in the housing wealth series due to these assumptions. Thus, we calculate alternative housing wealth measures under different scenarios that ultimately allow us to provide a *plausible interval* of our main estimation.

4.2.1 Durability of Housing Building Materials

In Section 3.1, we follow the idea that each material depreciates at a different rate depending on its durability, which seems to be a relevant assumption looking at the composition of the housing stock in Mexico (see Table A). In order to assess the significance of such argument, we conduct an additional exercise in which the quality of each building material plays no role in its depreciation rate. Accordingly, the depreciation rate θ^i (where i refers to each building material) from equation (13) is replaced by θ. Given that a great share of dwellings are built with high-quality materials, we apply the depreciation rate of bricks, $\theta = 3.2\%$, to compute an alternative series of depreciation expenses of housing by building material as shown in equation (12)).

As a consequence of applying a low depreciation rate to low-quality materials, rather than considering a faster depreciation given their short durability, we underestimate the aggregate depreciation expenses series (Figure 10a). In turn, a lower loss of value of the housing stock over time translates into higher figures of housing wealth (Figure 10b), which, on average, differ by 3.8 percentage points of GDP from our main estimation.



(a) Annual depreciation rate (b) Household housing wealth (% of GDP)

Figure 10: Robustness analysis: Equal Depreciation Rate for all Building Materials

Notes: In Figure 10a, data corresponds to the total annual depreciation of dwellings over the capital stock of dwellings, in percentage terms.
Source: Own calculations.

4.2.2 Measuring Depreciation through Consumption of Fixed Capital

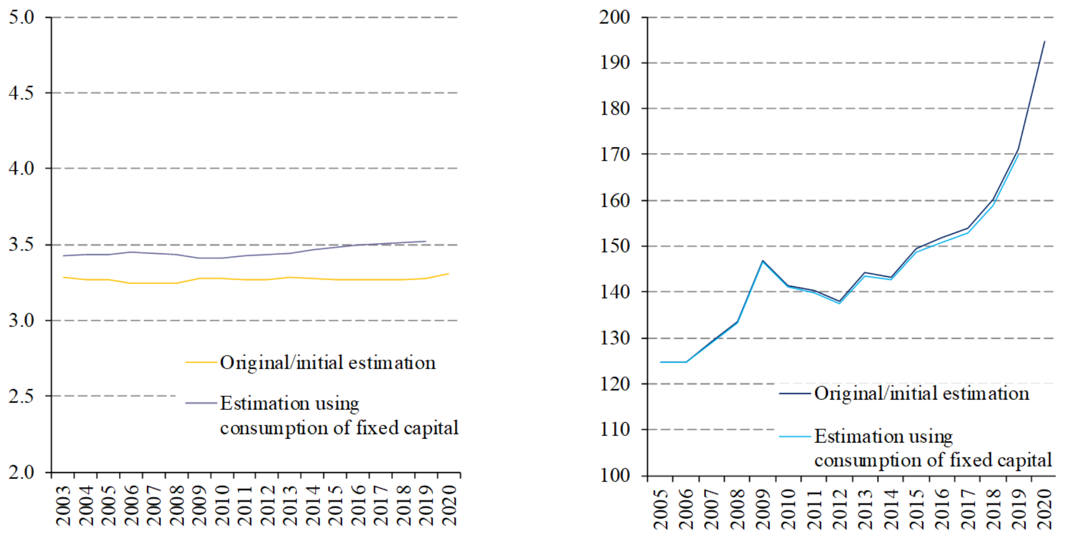
As a robustness check, we replace our measure of depreciation by wall building material for the consumption of fixed capital series starting from 2003 onwards.[29] As Panel A in Figure 11 shows, both series are quite similar, so the alternative housing wealth measure should not differ greatly from the original one.

Given the shorter period for which the consumption of fixed capital series is available, our robustness estimation starts at $t_0 = 2002$, using our best approximation for the initial

[29] Consumption of Fixed Capital is released as part of the Capital Account within the Goods and Services Account introduced in the SNA in 2003. As of the date of this preliminary version of the paper, the INEGI has not released the figure for 2020.

capital stock of dwellings by building material K_0^i at that year, which are obtained in our main calculation in that same year. The rest of the steps followed in Section 3 remain unchanged.

As expected, changes in the housing wealth series are almost indiscernible in Panel B of Figure 11. Due to these results, along with the ones presented in Section 4.2.1, we consider that the approach of estimating depreciation by building material is a fair approximation of actual depreciation expenses.



(a) Annual depreciation rate

(b) Household housing wealth (% of GDP)

Figure 11: Robustness analysis: Consumption of fixed capital as a measure of depreciation

Notes: In Figure 11a, data corresponds to the total annual depreciation of dwellings over the capital stock of dwellings, in percentage terms.
Source: Own calculations.

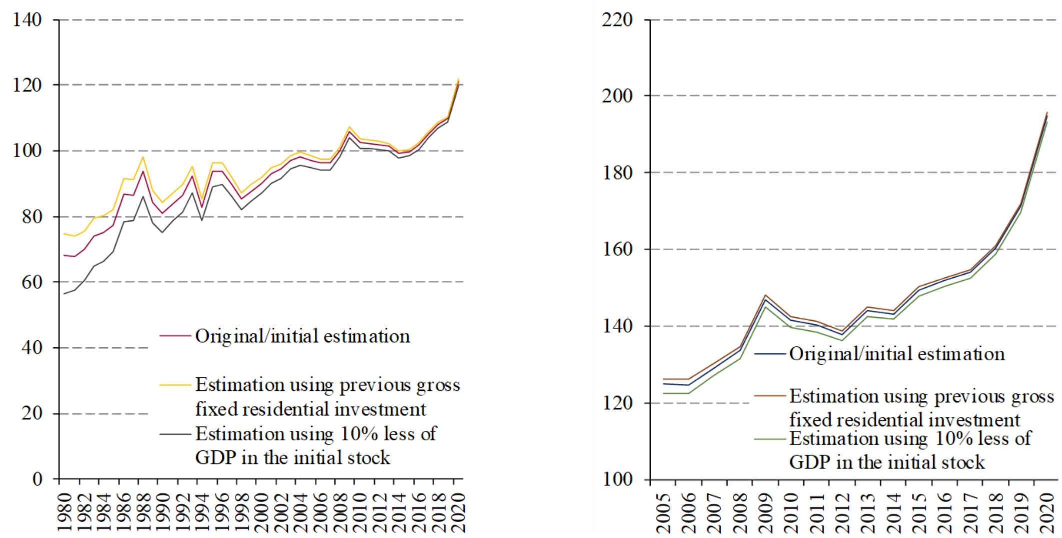
4.2.3 Initial Capital Stock of Dwellings

The value of the initial capital stock of dwellings K_0 represents 68% of GDP in 1980 in our main calculation. In the absence of an official figure of this concept, we estimate two alternative measures that are used to recalculate housing wealth afterwards. The first option consists on assuming K_0 is 10 percentage points below the original figure, in terms of GDP in 1980. For the second option, we use a previous version of the gross fixed residential capital series released in the SNA 2003.[30] Then, we calculate K_0 as in equation (4), which yields a

[30] The 2003 version of gross fixed residential capital included fewer economic sectors than the 2008 version. As a result, the new series is on average 27% higher than the previous one.

figure of 74.8% of GDP in 1980. Both alternative figures help us to test the sensitivity of our proposed methodology to setting a lower and a higher amount of the initial capital stock.

Indeed, the level of K_0 initially affects to some extent the housing wealth series, although such effect seems to vanish the longer the estimation horizon is (Figure 12). This behaviour occurs due to the depreciation of K_0 at every period t (equation (1)). In other words, as time goes by, the materials of the stock of dwellings registered in 1980, especially low quality materials, tend to wear away, causing a cumulative loss in its value that ultimately reduces the amount of K_0 close to zero. Therefore, if the estimation horizon is long enough, as it is ours, the referred methodology does not produce a biased measure due to the chosen value for the initial capital stock of dwellings.



(a) Capital stock of dwellings (% of GDP) (b) Household housing wealth (% of GDP)

Figure 12: Robustness analysis: Alternative initial capital stock of dwellings

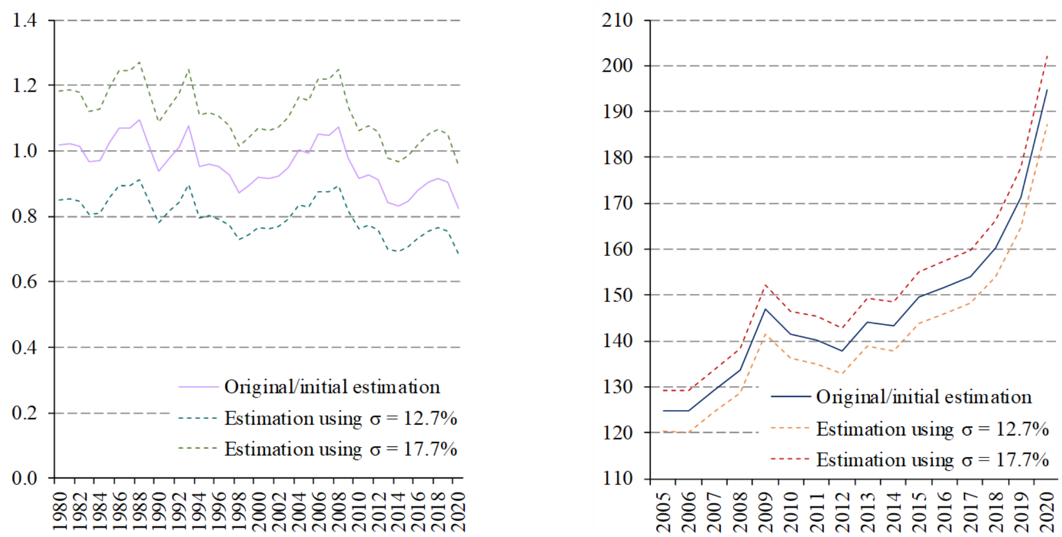
Source: Own calculations.

4.2.4 Investment on Residential Land

As mentioned earlier, the features of the data involved in the derivation of a σ for the Mexican housing market do not completely fulfill the definition in Davis and Heathcote (2007). Our σ

is estimated based on total building costs of new dwellings rather than on their sales value.[31]

Due to the bias this feature can produce in our original estimation, we test its robustness by replicating the methodology within an interval of $\sigma = 15.2 \pm 2.5$ percent, that is, taking into account the possibility of a higher/lower investment on residential land over time. Moreover, we choose such interval because, in this way, the lower bound coincides with that reported by Davis and Heathcote (2007) for the U.S. As Figure 13 shows, a change of ± 2.5 percentage points in σ translates to a deviation of approximately ± 7.5 percentage points in our original housing wealth series in 2020, in terms of GDP. Indeed, the more biased is our σ from its actual value, the more significant the revisions of the estimated housing wealth will be. However, we did not find additional evidence that suggests the latter to be the case, instead our figure is quite similar to that in the U.S.



(a) Investment on residential land (% of GDP) (b) Household housing wealth (% of GDP)

Figure 13: Robustness analysis: Sensitivity to alternative measures of investment on residential land

Source: Own calculations.

[31] The fact that our calculated σ is greater than that reported in the U.S. may be the result of several factors for which we do not have further evidence. First, building costs might not be totally comparable to sales value. Second, the figure for the U.S. corresponds to data from 1999, 13 years before ours, so this proportion might be greater in recent years. Third, data on the proportion of vertical dwellings to the total housing stock could shed light on the intensity of land used in both markets for residential purposes.

4.2.5 Base Year in the Housing Price Index

In order to measure housing wealth according to the *quantity times price* approach, we need to figure out the market value of housing stock in the initial year of the series (R_0) in the absence of an official measure of this concept. Starting from that value, changes in house prices and stock (quantity) will be added at every point in time. A practical assumption is that in the starting year of the series the market value equals the replacement value of the housing stock. This assumption seems to be arbitrary, and in case both values actually differ greatly, it would lead to miscalculations. Figure 14a shows that from 2005 to 2006 the gross fixed residential capital formation deflator and the housing price index grew at relatively similar rates, so our initial assumption might not cause a significant bias in our results. Nonetheless, we verify this idea by looking for a period in which both growth rates are closer.

Such condition is met in 2008, three years after the beginning of the housing wealth series, so equation (21) needs the following modifications

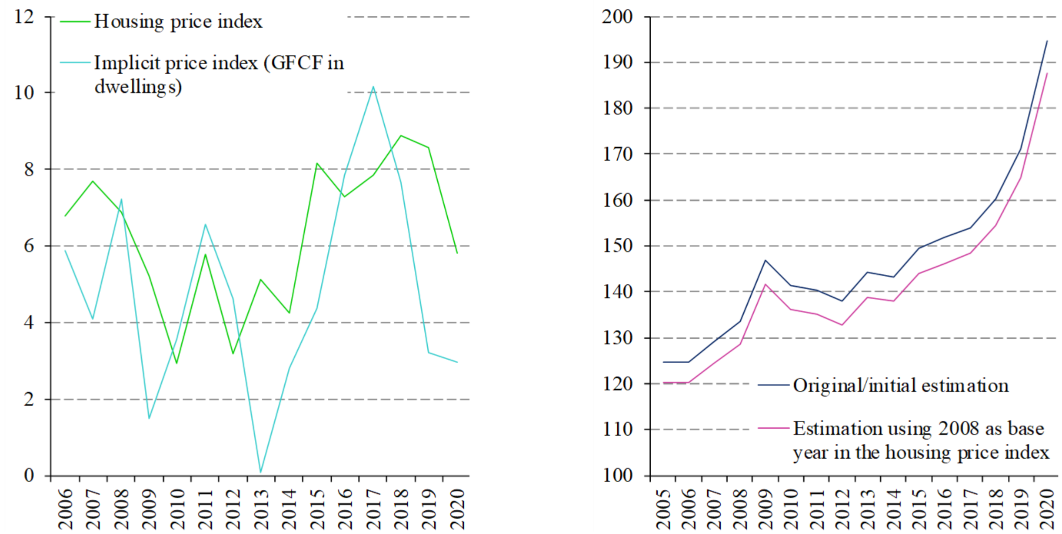
$$R_{t-1} = R_t \left(\frac{P_{t-1}}{P_t} \right) \left(\frac{V_{t-1}^R}{V_t^R} \right); \text{ for } t < \text{2008}$$

$$R_t = V_t^R; \text{ for } t = \text{2008}$$

$$R_t = R_{t-1} \left(\frac{P_t}{P_{t-1}} \right) \left(\frac{V_t^R}{V_{t-1}^R} \right); \text{ for } t > \text{2008}$$

The result is presented in Figure 14b, both housing wealth series differ from each other, on average, by 5.2 percentage points in terms of GDP. This difference does not imply significant changes to our initial conclusions, confirming the validity of our original approach. All in all, this robustness check highlights the importance either of having an official measure of R_0 or, as second-best, choosing an appropriate period to justify our assumption regarding the market value being equal to the replacement value of the housing stock.

To sum up, the set of exercises presented in this Section supports the following conclusions. First, that the upward trend of housing wealth in Mexico is robust to changes in the assumptions of our proposed methodology. And second, that the plausible interval of housing wealth is estimated to be around 187.3% to 202.1% of GDP in 2020.



(a) Price indices YoY growth rates (%) (b) Household housing wealth (% of GDP)

Figure 14: Robustness analysis: Base year change in the housing price index

Source: INEGI, Federal Mortgage Society (SHF) and own calculations.

5 Conclusions

Adapting the existent approaches to estimate an aggregate time-series of housing wealth has proven to be a particularly difficult task for developing countries, where microdata on housing features is mostly confidential. These countries usually face an additional challenge due to prevalent housing informality.

This paper proposes a more flexible methodology —mainly based on the *quantity times price* approach (Davis and Heathcote, 2007) and the perpetual inventory method (OECD, 2009)— to produce housing wealth statistics. An advantage of adapting these widely used guidelines is that our estimations are compatible with those reported by other countries, providing an insight into Mexican households wealth position with respect to foreigners. The implementation of our approach provides four key findings. First, housing wealth in Mexico has followed an upward trend over time, reaching around 187.3% and 202.1% of GDP in 2020. Second, we estimate housing wealth is reduced by nearly 25 percentage points in terms of GDP due to housing informality. Third, our estimation of housing wealth serves as an approximation of households non-financial assets, which are included in household net worth statistics; as expected, among OECD members, our measure resembles the figures reported by developing countries. Four, consistent with the findings presented in the ENFIH, our analysis shows that housing is, by far, the most important asset held by Mexican households.

Our approach has two important limitations. First, because of the assumptions made to overcome the lack of data, we perform a set of robustness exercises that provide a *plausible interval* of housing wealth instead of interpreting the initial figures straightforward. Second, our measure does not completely account for informal housing given that statistics on this subject were introduced in the last Census of Population and Housing 2020, yet the approach followed to adjust the series at a certain point in time can be extended to the entire period when information is available. In this sense, a thorough assessment of the impact of housing informality on disposable housing wealth could be a subject for future analysis.

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Appendix

A Composition of the Housing Stock in Mexico

Table 1: Housing Stock by Building Material, 1980-2020
Percentage of dwellings

Year	High-quality materials	Low-quality materials	Not specified
		Walls	
1980	56.1	42.4	1.5
1990	69.5	29.9	0.5
2000	78.9	20.6	0.5
2010	86.3	13.0	0.7
2015	88.7	10.7	0.6
2020	91.5	8.4	0.1
		Floor	
1980	71.6	26.4	2.0
1990	80.0	19.5	0.6
2000	86.2	13.2	0.6
2010	93.2	6.2	0.6
2015	95.8	3.6	0.6
2020	96.2	3.5	0.3
		Ceiling	
1980	44.0	53.6	2.4
1990	51.4	48.0	0.6
2000	63.9	35.6	0.6
2010	71.6	27.5	0.8
2015	75.1	24.3	0.6
2020	78.6	21.3	0.1

Note: For walls, high-quality materials include bricks, concrete, cinder blocks, stone and quarry; other materials, such as adobe, mudbricks or wood, are considered as low-quality. For floors, high-quality materials include concrete, wood, mosaic and other coatings' floor tiles; low-quality materials only refer to earthen floors. For ceilings, high-quality materials include concrete slab and rib/block slab; every other material not listed in this category (as palm leaf or metallic foil) is regarded as low-quality.

Source: Censuses of Population and Housing Units from 1980 to 2020 and Intercensal Survey 2015, INEGI.

B Value of the Stock of Land in Mexico

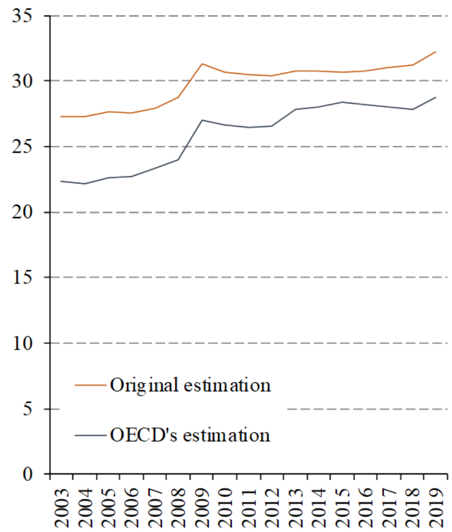

Figure .1: Value of the Stock of Land (% of GDP)

Notes: The OECD's estimation is obtained from the Dataset 9B (Balance sheet for non-financial assets) from OECD Stat.
Source: OECD.

C Mismatches between survey and macro-level indicators

As discussed in Section 2, differences between survey and macro-level indicators is a common issue in several countries. In this section, we provide further insight into the size of mismatch among statistics on household wealth. We collect data from surveys on household finance and wealth, as well as matching aggregate indicators, for four countries: France, Italy, the United States and Mexico.[32] The statistics correspond to housing wealth and household total net worth.

As expected, aggregate statistics are available for a longer time-horizon than survey-based indicators. Moreover, each country conducts its survey on household finance and wealth in different years. For these reasons, we were left with few and time-mismatching data points to compare, hence our decision to present the last available estimations in Figure .2. The differences are calculated as the division of the survey indicator by its corresponding macro-level indicator.

Overall, our results are consistent with the literature on said differences, the analyzed countries present data mismatches when comparing survey and macro-level indicators. In particular, the size of the differences in the statistics for Mexico are closer to those observed in Italy.[33]

[32] Originally, we attempted to collect data from 12 countries, but due to the lack of public information either from surveys or national aggregates, we ended up with the sample referred above.

[33] We acknowledge that a comparison with a similar developing country would be valuable. In this regard, we attempted to collect data from Chile, but the available data both in the survey and national aggregates were not compatible in different aspects. For instance, data on aggregate housing wealth is not publicly available —the OECD presents a time-series as part of its household non-financial balance sheet, but it excludes the value of the land underlying dwellings—, whereas survey figures are reported as median values.

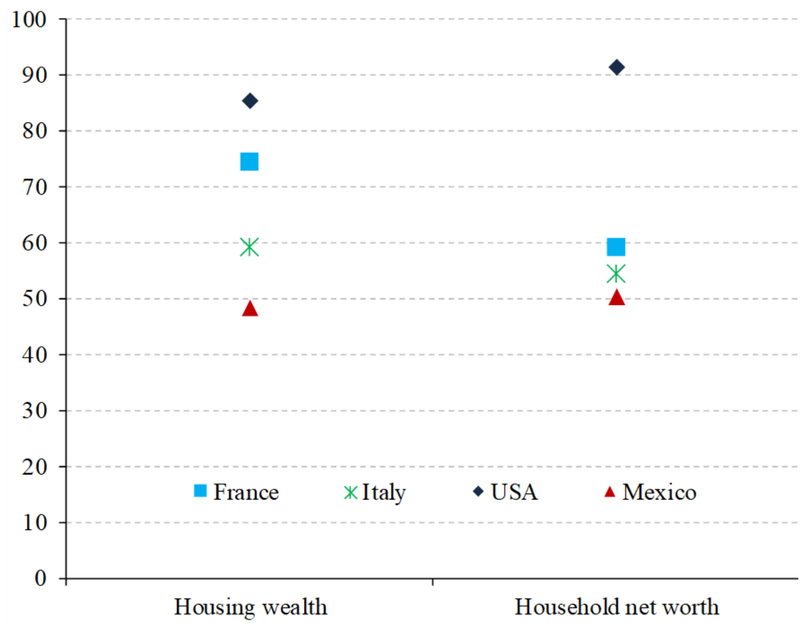

Figure .2: Ratio of survey indicators to macro-level indicators (%)

Notes: Ratios are calculated using the last year of information available in each country. France: 2015; Italy: 2016; USA: 2017; Mexico: 2019.
Survey indicators are collected as follows. *France:* Mean values of households, in current euros, multiplied by the number of households that reside in metropolitan France. *Italy and USA:* Mean values of households (housing wealth is reported as the mean value of households' main dwellings), in current euros or USD, multiplied by the number of households that hold the corresponding asset or liability. *Mexico:* Total value of housing held by households and housing net worth, in current pesos.
Macro-level indicators are obtained as follows. *France:* Data from the National Balance Sheet of Households, in current euros. For housing wealth, the data corresponds to the sum of the value of dwellings and land underlying them. *Italy:* Data from the Household Wealth tables, in current euros. *USA:* Data from the Financial Accounts of the United States - Z1, in current dollars. *Mexico:* Main figures presented in this paper.
Source: Insee (France), Enquêtes Patrimoine (France), Istat (Italy), Bank of Italy (Italy), Survey on Household Income and Wealth (Italy), Federal Reserve Bank's Z1 (USA), Survey of Consumer Finances (USA), ENFIH and own calculations (Mexico).