Efficiency and Redistributive Effects of Progressive Housing Taxation*

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Abstract

Is it optimal to introduce progressivity in housing taxation? We explore this question by constructing a heterogeneous agent model featuring housing and entrepreneurship, calibrated to the Spanish economy. Our results indicate that a progressive housing tax can significantly enhance aggregate welfare and influence the economy through multiple channels. By imposing higher taxes on high-value properties, the policy curbs housing demand and lowers house prices—particularly benefiting lower-income and younger households. Moreover, it encourages rich households to reallocate savings from housing toward productive capital, thereby stimulating investment, output, and wages. In an economy with entrepreneurs, the optimal tax design combines a flat income tax with a highly progressive housing tax, as elevated income tax rates at the top discourage business expansion. The equilibrium price effects and resulting welfare gains from this policy are amplified when housing supply is more inelastic.

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1 Introduction

Housing is the single most important asset for most households and the most important asset on aggregate as it represents roughly 50% of the national wealth in a typical economy (Jordà et al., 2019). Consequently, the housing stock represents a substantial potential tax base; yet, housing taxation typically contributes only modestly to public revenues (OECD, 2022). In this study, we aim to explore the ramifications of housing taxation, with emphasis on a progressive housing tax schedule. In particular, our goal is to explore whether a progressive housing tax schedule might be optimal and how this progressivity interacts with the progressive income taxation, which is so far the main tax instrument used by governments.

To address this question, we develop a rich heterogeneous-agents, general equilibrium model with incomplete markets, incorporating both occupational and housing choices. The framework combines standard models of entrepreneurship (e.g., Cagetti and De Nardi (2006); Brüggemann (2021)) with heterogeneous-agent models that feature housing assets, such as Gervais (2002), Sommer et al. (2013) and Kaplan et al. (2020). Introducing progressive housing taxation into this setting generates several important mechanisms. First, housing taxation differentiates between workers and entrepreneurs with similar income and net worth, as workers typically hold a larger share of housing in their portfolios and thus face a higher tax burden. Second, when housing supply is inelastic, taxing high-value housing reduces aggregate demand and lowers house prices, which benefits poorer households. Third, the decline in house prices diminishes the collateral value available to entrepreneurs, thereby constraining their capacity to scale up business operations.

The model is calibrated to match a number of salient facts about the Spanish economy. Spain is an appropriate laboratory due to its large share of housing in the aggregate wealth: the median household allocates about 80% of their portfolio to housing wealth. The model generates realistic wealth and income distributions and broadly matches the portfolio share and homeownership rate across different dimensions, such as age, income and wealth. We introduce progressive housing taxation using a flexible functional form adapted from Heathcote, Storesletten, and Violante (2017). Employing this specification we compute the optimal effective housing and income tax functions. All of our experiments are budget-neutral reforms. Welfare is measured by the consumption equivalent gains of the newborn household in expected utility and we only rely on steady state comparisons.

In our main experiments, we consider the case where subsidies are permitted in both housing and income tax schedules. Under this setting, both optimal income and housing tax schedules exhibit strong progressivity. Optimizing the housing tax schedule while keeping income taxation fixed yields slightly greater welfare gains than the reverse approach —13.2% versus 11.6% in consumption-equivalent terms. However, these gains arise through distinct economic channels. A highly progressive income tax effectively redistributes income from high- to low-income households but leads to a substantial decline in the economy's capital stock. This decline is primarily driven by reduced capital investment among the self-employed, whose incentives to scale their businesses are weakened by high marginal tax rates. In contrast, the optimal housing tax schedule encourages households to reallocate resources away from housing, resulting in an increase in aggregate capital stock and only a modest reduction in self-employed capital—attributable to diminished collateral values. Moreover, the housing tax performs better in smoothing consumption over the life cycle, owing to the imperfect correlation between income and housing: individuals tend to earn more during working age but continue to reside in large homes during retirement. When subsidies are disallowed , housing taxation proves markedly superior to income taxation. The latter fails to benefit the poorest households, who already face no tax liabilities in the baseline economy. In contrast, optimal housing taxation without subsidies curbs housing demand among the wealthy, leading to significant declines in house prices—ultimately benefiting renters and young first-time buyers.

When jointly optimizing the income and housing tax schedules under a regime that allows subsidies, we find that the optimal policy entails a high, flat income tax rate of 52%, with revenues redistributed via a highly progressive housing tax. This combined approach balances the advantages and drawbacks of optimizing either tax in isolation. Crucially, the jointly optimal schedule preserves the capital stock at levels close to the baseline economy and results in only a modest reduction in self-employed capital. Although wages decline by 3%, house prices fall by 26%, substantially improving housing affordability. As a result, the homeownership rate rises by more tan 17 percentage points. This policy configuration effectively smooths consumption both across the life cycle and within age groups, yielding welfare gains of 22.2%

Our model incorporates three key assumptions that collectively drive the conclusion that income taxation should be flat, with redistribution occurring primarily through housing taxation. These assumptions are: (i) the presence of self-employed individuals, (ii) a fixed land supply that renders housing supply inelastic, and (iii) a household preference for homeownership. In a counterfactual model that excludes all three assumptions, the optimal policy reverses—favoring a flat housing tax and a highly progressive income tax. To isolate the contribution of each assumption, we sequentially activate them and solve the joint optimization problem. Entrepreneurship emerges as the most influential factor: its inclusion alone justifies a flat income tax and a steeply progressive housing tax. The preference for homeownership also supports progressive housing taxation, though it coexists with progressive income taxation. In contrast, modeling land in fixed supply alone does not imply a progressive housing tax. However, when all three assumptions are present, we find that a lower housing supply inelasticity amplifies both the optimal progressivity of housing taxation and the associated welfare gains. In essence, progressive income taxation imposes significant costs in the presence of entrepreneurs, as it dampens their incentives to expand their business. Conversely, progressive housing taxation lowers the opportunity cost for wealthy entrepreneurs to invest in their businesses and simultaneously reduces house prices—benefiting poorer households, especially when land is scarce.

Related Literature. This paper connects to three strands of the literature on optimal-taxation with heterogeneous-agents literature: models incorporating entrepreneurship; models that incorporate housing; and models focused on consumption taxation. Entrepreneurship models are widely used to study the effects of tax changes, which is not surprising given that these models are able to match the empirical concentration of wealth and income, see Quadrini (2000) and Cagetti and De Nardi (2006). Our model more closely resembles the works of Brüggemann (2021) and İmrohoroğlu et al. (2023). Both studies focus on progressivity of income taxation introducing entrepreneurship and superstar shocks, which allows them to get the right share of entrepreneurs at the top of the income distribution. The authors point out that the modeling of entrepreneurs is key in order to avoid overestimating the optimal progressivity. We contribute to this literature by noting that the modeling of entrepreneurs is not only crucial for income taxation, but also an important feature in the design of housing taxes. Crucially, we then show that this connection runs in both directions: just as entrepreneurship is key to understanding optimal housing taxes, the inclusion of housing is key to the optimal design of income taxation. When income and housing taxes are optimized jointly in our framework, the resulting policy differs markedly from prior findings: the optimal income tax is nearly flat, while the housing tax becomes the primary redistributive tool.

Since housing constitutes a form of wealth, our paper also relates to Guvenen et al. (2023) and Boar and Midrigan (2023), who both study wealth against capital income taxation. The former shows that in an economy where all production is carried out by financially constrained entrepreneurs using capital, shifting taxation from capital income to wealth improves capital allocation and is therefore optimal. In contrast, Boar and Midrigan (2023) argue that when private businesses employ labor and coexist with a corporate sector, the optimal policy reverses: taxing capital income becomes preferable, as the efficiency losses from misallocation are less severe. In our paper, which employs a framework similar to Boar and Midrigan (2023), with the difference that it incorporates housing and treats self-employment income as labor income for tax purposes, we find that the optimal policy combines a nearly flat income tax and a highly progressive housing one.

We also build on the literature on housing taxation in Aiyagari-Bewley models. Balke et al. (2025) find that a shift from capital income taxation to taxing housing (at a flat tax rate) in the US would result in welfare gains mainly due to capital deepening in the economy. The authors show that the tax shift largely benefits today's young and low-income households while imposing one-time wealth losses on incumbent homeowners, and they study how the reform could be phased in to secure the support of households' majority during the transition. We find similar results in an experiment with an optimal flat tax reform and we complement this study by evaluating the optimal progressive housing tax schedule. Chiocchio (2024) finds that in Italy the property tax is actually regressive due to the differences of assessment ratios along the housing distribution: the ratio of cadastral values to market values is lower for higher value houses. He then builds a heterogeneous agents model with housing to examine the welfare implications of various housing taxation reforms. Among them, he also studies progressive housing taxation, employing the same tax-schedule as his income taxation function, which is formulated as in Heathcote et al. (2017). This is the only other study that uses this type of progressive tax function to model housing taxation [1]. Though he doesn't perform an optimal taxation analysis, he shows that increasing housing taxation progressivity pushes house prices down, raises the home-ownership rate, and delivers net welfare gains. In addition, the lack of occupational choice in his model neglects the important housing-as-collateral channel.

The closest studies to the present work are Juan (2018) and Rotberg (2022). To our knowledge, these are the only other Aiyagari-Bewley type models with housing and entrepreneurship. Both show the a wealth tax that taxes capital and housing at the same rate hurts capital allocation and welfare[2]. Furthermore, Rotberg (2022) shows that allowing for a progressive wealth tax with high exemption thresholds and steep marginal rates at the top—while taxing housing and capital at different rates—reverses this result. The optimal policy taxes capital wealth at about 3% and housing at very high rates (around 288%) while exempting most residences. This differential progressive system produces large welfare gains, driven by capital deepening and lower house prices. We complement these papers in several key directions. First, we analyze the joint design of housing and income taxation, which is typically the prime redistributive tool in most economies. Second, we employ a flexible functional form for both income and housing progressive tax schedules, in the spirit of Heathcote et al. (2017), and we solve for the jointly optimal tax design. Crucially, we show that the result of a nearly flat income tax combined with a highly progressive housing tax hinges on the inclusion of entrepreneurs in the model.

In our model, housing delivers direct utility to households and therefore housing taxation functions as a form of consumption tax. Within the extensive literature on consumption taxation, most closely related to us lie the papers that focus on optimal consumption taxes that incorporate progressivity. Conesa, Li, and Li (2020) analyze replacing income taxes with two flat consumption tax rates—one on basic goods and one on non-basic (luxury) goods—in a framework with endogenous labor supply and find that, despite a 10% increase in aggregate output, the policy reduces overall welfare. By contrast, again working in a model with endogenous labor supply, da Costa and Santos (2023) allow for

[1] Cho et al. (2024) use the same tax function to estimate the effective property transaction tax rates in Australia.

[2] In a different setting, Borri and Reichlin (2021) also conclude that a uniform wealth tax on financial and housing assets decreases welfare.

progressive consumption taxation in the style of Heathcote et al. (2017), and report welfare gains of about 13% from replacing income taxes with a progressive consumption tax, a magnitude comparable to the welfare improvements we obtain under progressive housing taxation in this paper.

In what follows, section 2 sets up our model and the parametrization is described in section 3. Then, section 4 describes how our model replicates the relevant patterns of the Spanish economy and in section 5 we describe our main counterfactuals, before we conclude.

2 Model

We develop a general-equilibrium, overlapping-generations model. Households are heterogeneous in their labor productivity and entrepreneurial ability and make consumption, savings, occupational and dwelling decisions.

2.1 Demographics and preferences

The economy is populated by a continuum of finitely-lived households who age deterministically. Households survive from age j to $j+1$ with probability ζ_j and at age T die with certainty. Utility comes from consumption c, dwelling services d and bequests b. The per-period utility flow at age j is given by a standard Cobb-Douglas CES utility function:

$$u_j(c,d) = e_j \, \frac{\left(\frac{c^{\xi} d^{(1-\xi)}}{e_j}\right)^{1-\gamma}}{1-\gamma}$$

where ξ is the relative utility share of consumption in the utility of the household and γ represents the inverse of the intertemporal elasticity of substitution. Parameter e_j is an equivalence scale which adjusts for household size over the life cycle. Households also have a warm-glow bequest motive on the net wealth b as in De Nardi (2004):

$$\Phi(b) = \phi_1 \frac{(\phi_2 + b)^{1-\gamma}}{1-\gamma}$$

The parameters ϕ_1 and ϕ_2 capture bequest intensity and the luxury nature of bequests, respectively. We do not model intergenerational links. Instead all the bequests are aggregated and then divided among the remaining households based on their age and labor ability. This allows us to have a realistic wealth distribution among retirees and model intergenerational transfers without tracking an additional state for the amount of inheritances received by the newborns ($j=1$). Without the bequest motive households would tend to deplete their wealth, while this is not supported by the data.

2.2 Labor productivity and entrepreneurial ability

Working age households face idiosyncratic and persistent labor productivity (z) and entrepreneurial ability (θ) shocks, realized at the beginning of every period. The two shocks are independent and evolve over time according to a first-order Markov process with transition probabilities $\Lambda_z(z'|z)$ and $\Lambda_\theta(\theta'|\theta)$, respectively.

Total labor productivity also includes an age-dependent deterministic component $q(j)$. Upon retirement at age R, the household receives a fixed pension that is a share $\bar{p}$ of the income received before retirement.

$$n_j(z) = \begin{cases} q(j)z & \text{if } j < R \\ \bar{p}q(R)\bar{z} & \text{if } j \geq R \end{cases} \tag{1}$$

where $\bar{z}$ denotes the realization of the labor productivity shock upon retirement (at age R).

2.3 Tax system

We model the main features of the Spanish fiscal system. Labor and self-employment income are taxed progressively, with a zero-tax region for low earners. Following García-Miralles et al. (2019) we model the tax payment as:

$$t_y(y) = \begin{cases} 0 & \text{if} \quad \tilde{I} < \hat{I}_y \\ (1 - \tau_y^{lev(\tilde{I})^{-\tau_y^{prog}}})y & \text{if} \quad \tilde{I} \geq \hat{I}_y \end{cases} \tag{2}$$

where $\tilde{I} = y/\bar{y}$ is the ratio between the household's labor income and the average income of the economy. The kink in the function reflects the fact that a substantial share of the population does not pay any income taxes. Notice that the two parameters τ_y^{lev} and τ_y^{prog} govern the level and the progressivity of the progressive income tax function respectively. If there was no progressivity ($\tau_y^{prog} = 0$) in the tax, then the income tax rate would correspond to the $1 - \tau_y^{lev}$ parameter.

Working-age households also have to pay payroll taxes up to a cap. As in Fuster (2022), we model the workers social-security contributions as:

$$t_{ss}(y) = \min\{\tau_{ss}y, \tau_{ss}\hat{I}_{ss}\} \tag{3}$$

where $\hat{I}_{ss}$ is the maximum payroll tax base.

We choose to model capital income as a flat tax rate τ_k. Although the Spanish tax code allows for some progressivity in this concept, in reality is is barely so (see the estimates in García-Miralles et al. (2019)).

Spain also levies a progressive tax on net wealth holdings. Following Fuster (2022), we model the wealth tax as a simple flat rate tax with an exemption level:

$$t_w(W) = \max\{0, \tau_w(W - \hat{I}_w)\} \tag{4}$$

where W denotes the net wealth of the households and $\hat{I}_w$ is the exemption level of the wealth tax.

Inheritances are taxed progressively. To reflect the this fact we model the total amount of inheritance taxes as a stepwise function:

$$t_{inh}(b) = \begin{cases} \tau_{inh}^1 b & \text{if} \quad b \leq B_1 \\ \tau_{inh}^2(b - B_1) + \tau_{inh}^1 B_1 & \text{if} \quad B_1 \leq b \leq B_2 \\ \vdots & \\ \tau_{inh}^n(b - B_n) + \cdots + \tau_{inh}^1 B_1 & \text{if} \quad B_n < b \end{cases} \tag{5}$$

Finally, housing is subject to two set of taxes. First, there is a transaction tax. This tax is paid on the value of the purchased home and we set it to be a flat tax rate τ_h^t. Second, we introduce a progressive housing taxation using a similar structure to the income taxation. In particular we choose:

$$t_h(h) = (1 - \tau_h^{lev}(\frac{h}{\bar{\bar{h}}})^{-\tau_h^{prog}})h \tag{6}$$

where as before the parameter τ_h^{lev} governs the mean tax rate and τ_h^{prog} the progressivity. The parameter $\bar{h}$ represents the mean housing size in the baseline economy. When $\tau_h^{prog} = 0$, the recurrent housing tax collapses to a flat rate taxation, which is the case in the baseline economy. When τ_h^{prog} is positive, all households with houses lager than $\bar{h} \ \ (\tau_h^{lev})^{-\tau_h^{prog}}$ are paying the tax, while the rest are receiving subsidies [3]. In case of a rented property, the housing tax (or subsidy) is paid (received) by the renter.

2.4 Entrepreneurs

An entrepreneur with entrepreneurial ability θ, labor productivity z and using k units of capital and l labor units (in efficiency terms) produces an amount of output equal to:

$$y_j^e(z, \theta, k, l) = \theta \left(k^\alpha (n_j(z) + l)^{1-\alpha}\right)^\nu$$

where $\alpha \in (0, 1)$ is the share of capital and $\nu < 1$ is the span-of-control parameter which governs the degree of returns to scale. Notice that we assume that the entrepreneurs uses all their labor productivity in their firm production. The total net-of-taxes income of an entrepreneur is given by:

$$\begin{aligned}
\Pi_j^e(a, h, z, \theta) = &\max_{k,l} \{\pi_j^e - t_y(\pi_j^e) + (a-k)r(1-\tau_k)\mathbb{1}_{k<a}\} \\
\text{s.t.} \quad & \pi_j^e = y_j^e(z, \theta, k, l) - \delta_k k - (r+\iota)(k-a)\mathbb{1}_{k\geq a} + m - wl \\
& m = -a(r+\iota)\mathbb{1}_{a<0} \\
& 0 \leq k \leq \lambda(p_h h + a) \\
& l \geq 0
\end{aligned} \tag{7}$$

where π^e stands for the gross business profits. The total income for entrepreneurial households is given by their net-of-taxes profits plus the net income from savings. Gross profit is just the total production of the entrepreneur, minus capital depreciation ($\delta_k k$), labor costs (wl) and the cost of financing capital for constrained entrepreneurs. The term m is just a slight adjustment so that the mortgage costs are not imputed into the business profits. Entrepreneurs will earn capital income only if the capital used in production does not exceed the amount of financial assets that the household has.

The amount of capital used by entrepreneurs is limited by the collateral constraint. As it is standard in the literature, the maximum capital is given by a multiple of the households assets. The main difference with respect to an one-asset-model is that here entrepreneurs can transform one unit of financial asset into capital, but they cannot do the same with housing. Nevertheless, entrepreneurs can use housing as a collateral to rent more units of capital. Hence, the housing value of a entrepreneur may influence his optimal capital decisions[4].

[3] In the appendix, we also present results for which we don't allow for subsidies.

[4] There is plenty of empirical evidence supporting this channel. For the Spanish case Basco et al. (2025) note that there is positive correlation between the growth of housing price and the growth of credit and investment.

2.5 Dynamic program

A household of age j enters the period with financial a and housing assets h carried over from the previous period. At the beginning of the period, it observes two idiosyncratic shocks: a labor productivity shock z and an entrepreneurial ability shock θ. The household's problem is thus defined over five individual state variables: (a, h, z, θ, j). If the household received inheritance it does not enter its budget constraint, instead it affects only the amount of financial assets that the household has. Thus, one can think about the financial assets represented here a as inheritance-adjusted.

To simplify the decision problem, we divide it into two sequential stages. In the first stage, the household makes consumption, savings, and occupational choices. In the second stage, it decides on whether to adjust its housing status for the next period.

First stage: the household decides on current consumption c, financial savings to carry into the next stage s, its occupational status $i \in \{\mathrm{w}, \mathrm{e}\}$ (worker or entrepreneur), and rental housing services h^r. The rental choice is only relevant when the household is currently a renter ($h = 0$).

$$\mathcal{V}_j(a, h, z, \theta) = \max_{c,s,h^r,i} \quad u_j(c, d) + \tilde{\mathcal{V}}_j(s, h, z, \theta)$$

$$\text{s.t.} \quad j < R$$

$$c + s + (p_r + t_h(h^r)p_h)h^r \mathbb{1}_{h=0} + m \leq a + y_j^i - p_h h \delta_h - p_h t_h(h) - t_w(a + p_h h) \tag{8}$$

$$m = -(r + \iota)a\mathbb{1}_{a<0} \tag{9}$$

$$i \in \{\mathrm{w}, \mathrm{e}\} \tag{10}$$

$$y_j^i = \begin{cases} wn_j(z) + r(1 - \tau_k)a\mathbb{1}_{a\geq 0} - t_y(wn(j, z)) - t_{ss}(wn(j, z)), & \text{if} \quad i = \mathrm{w} \\ \Pi_j^e(a, h, z, \theta) & \text{if} \quad i = \mathrm{e} \end{cases} \tag{11}$$

$$d = h^r \mathbb{1}_{h=0} + \chi h \mathbb{1}_{h>0} \tag{12}$$

$$s \geq \min\{a, 0\} \tag{13}$$

$$h^r \geq 0 \tag{14}$$

Households derive utility from non-durable consumption (c) and housing services (d). As described in section 2.1, utility is adjusted by an age-dependent equivalence scale factor e_j, to reflect the fact that household size changes along the life-cycle. The continuation value $\tilde{V}_j$ is the result of the second stage described below.

Dwelling services are produced linearly from either rented (h^r) or owned (h) housing units, see equation (12). Renters obtain one unit of housing service per rented unit, while owners receive χ units per unit of housing, introducing a preference or quality premium for ownership.

The budget constraint of working-age households is given by equation (8). The right-hand side represents the resources of the household, which is the sum of financial assets (a) and disposable income. Notice that $\Pi_j^e(a, h, z, \theta)$ is the net income of entrepreneurial households that comes from the problem (7). The other case in equation (11) represents the worker's net income. This income is the gross wage $wn_j(z)$ and net capital income minus progressive income taxes and social security contributions. Occupational choice is endogenous in our model. Nevertheless, since there are no entry nor exit cost the occupational decision becomes a static one: the household compares the net income from working (after labor income and payroll taxes) with expected profits from entrepreneurship $\Pi_j^e(a, h, z, \theta)$. It chooses to be an entrepreneur if the latter exceeds the former.

Regardless of their occupational status, homeowners incur in housing maintenance and property tax expenses, where maintenance is given by the housing depreciation rate δ_h. Households also pay a wealth tax on their net wealth holdings, which is the sum of financial and housing assets.

Second stage: the household decides whether to adjust its housing holdings for the next period. The objective of the household is to maximize the expected value function for the next period, taking into account the distribution of idiosyncratic shocks and the survival probability ζ_j. Next's period value function is discounted using the subjective discount factor β.

The resources available for the household are the savings carried from the first stage s and the value of their current housing, which comprises the right-hand side of the budget constraint in equation (15).

$$
\begin{aligned}
\tilde{\mathcal{V}}_j(s, h, z, \theta) = & \max_{h', a'} \beta \zeta_j \, \mathbb{E}_{z', \theta'} [\mathcal{V}_{j+1}(a' + B_{j+1}(z'), h', z', \theta')] + \beta(1 - \zeta_j)\Phi(b) \\
\text{s.t.} \quad & j < R \\
& p_h h' + p_h C_{adj}(h, h') + a' \leq s + p_h h && (15) \\
& C_{adj}(h, h') = \mathbb{1}_{h \neq h'}(\psi_s h + (\psi_b + \tau_h^t)h') && (16) \\
& b = p_h h' + a' - \psi_s p_h h' - t_{inh}(p_h h' + a') && (17) \\
& a' \geq -\psi p_h h' \mathbb{1}_{h \neq h'} && (18) \\
& h' \in \hat{\mathcal{H}} = \{0, h_1, h_2, ..., h_N\} && (19)
\end{aligned}
$$

Notice that the household is subject to several restrictions. First, there are transaction costs. As stated in equation (16), a household that chooses to change their current dwelling has to pay transaction costs buying ψ_b and selling ψ_s property. Additionally, the household has to pay a transaction tax, τ_h^t, which is effectively a buying cost for the household. This type of non-convex transaction costs are standard in the literature, see Sommer et al. (2013) or Cho et al. (2024). Second, there is a loan-to-value (LTV) restriction for mortgages. A household can borrow up to a ψ fraction of the value of the house. This simple constraint allows us to model access to credit markets to purchase a house without including the whole mortgage repayment system to keep the state space limited.

Third, to reflect the fact the housing is a lumpy investment, h' is restricted to be a part of a grid $\hat{\mathcal{H}}$. If a household chooses $h' = 0$, then the next period it becomes a renter and chooses the amount of rented units in the first stage, as described in above. In order to become a homeowner the household has to buy at least h_1 housing units.

As for bequests (b), notice that upon death the household transforms the housing assets, if any, into financial ones and pays the associated selling costs as well as the non-linear inheritances tax. In case the household survives, then it receives bequests $B_{j+1}(z')$ that depend on tomorrow's age and labor productivity.

The analogous dynamic problem for retirees – that is $j \geq R$– is described in the appendix section B.1. Their choices are analogous with two main differences. First, retirees do not face an occupational choice and earn a fixed pension (see eq. (1)). Second, retires households cannot take a mortgage to finance the purchase of their dwelling.

2.6 Production

Corporate sector. The technology in the corporate sector is given by a standard Cobb-Douglas technology $Y_c = K_c^{\alpha} L_c^{1-\alpha}$. The representative corporate firm solves the following problem:

$$\max_{K_c, L_c} Y_c(K_c, L_c) - (r(1+\tau_c) + \delta_k)K_c - wL_c \tag{20}$$

where as in Fuster (2022) we assume that the corporate tax τ_c only applies to the return of capital net of depreciation.

Construction firm. The construction firm uses capital, labor and land in order to produce housing units:

$$\Pi^h = \max_{K_h, L_h} \{p_h K_h^{\alpha_K^h} L_h^{\alpha_L^h} (\delta_h \bar{L})^{(1-\alpha_K^h-\alpha_L^h)} - (r+\delta_k)K_h - wL_h\}$$

Where $\bar{L}$ is the total land in the economy. Thus, effectively each period a δ_h fraction of houses are destroyed and the same proportion of land becomes available[5]. After taking into account the first-order condition this problem yields the following housing supply function:

$$I_h = p_h^{\frac{\alpha_K^h+\alpha_L^h}{(1-\alpha_K^h-\alpha_L^h)}} \left(\frac{\alpha_K^h}{r+\delta_k}\right)^{\frac{\alpha_K^h}{(1-\alpha_K^h-\alpha_L^h)}} \left(\frac{\alpha_L^h}{w}\right)^{\frac{\alpha_L^h}{(1-\alpha_K^h-\alpha_L^h)}} \delta_h \bar{L} \tag{21}$$

Notice that since land is a fixed factor of production the construction firm has positive profits in equilibrium. As in Favilukis et al. (2017) and Kaplan et al. (2020), we assume that these profits are collected by the government. This effectively assumes that the government is the owner of all land and hence collects the rents from this fixed input, as if these lands/permits are sold to the construction firm in a competitive market.

Financial Intermediary As in (Balke et al., 2025), there is a financial intermediary that lives for only 2 periods and discounts profits at the interest rate r. At the end of period t, the households deposit their savings $\mathcal{D}'$ to the newly born intermediary and receive an interest r next period. The deposits are used to lend mortgages to households ($\mathcal{M}'$) and capital to firms ad self-employed ($\mathcal{K}'$), as well as to purchase the rental stock ($p_h \mathcal{H}_r'$) from the dying financial intermediary. At the beginning of next period, receives interest from borrowers, firms and self-employed, and renters, liquidates its housing stock. For operating the rental market, the intermediary faces a zeros cost of transforming the rental stock into apartments of different sizes, and rents these apartments to households at price p_r,while paying depreciation costs. It faces also an intermediation cost η, proportional to the size of the rental stock. The problem of the intermediary can be described as:

[5]Notice the we normalize construction firm's TFP to 1, and since we will choose to also normalize house prices $p_h = 1$ when calibrating, land in the economy $\bar{L}$ will be used for scaling to ensure clarence of the housing market. Alternatively we could have normalized $\bar{L}$ to 1, and use the construction firm's TFP as a scaling parameter, or we could have normalized both construction firm's TFP and $\bar{L}$ to 1, and allow house prices to adjust at the baseline calibration. The model's results are invariant to these normalization choices.

$$
\begin{aligned}
V_f = \max_{\mathcal{K}'_f,\mathcal{H}'_{f,r},\mathcal{M}'_f,\mathcal{D}'_f,\mathcal{R}_f(h_r)} & \Bigg\{ - p_h\mathcal{H}'_{f,r} - \mathcal{K}'_f - \mathcal{M}'_f \\
& + \frac{\left(p_r\mathcal{H}'_{f,r} - \delta_h p_h \mathcal{H}'_{f,r} - \eta \mathcal{H}'_{f,r}\right)}{1+r} \\
& + \frac{p_h\mathcal{H}'_f}{1+r} + \frac{(1+r)\mathcal{K}'_f}{1+r} + \frac{(1+r)\mathcal{M}'_f}{1+r} \Bigg\} \\
\textit{s.t.} \quad \mathcal{K}'_f + p_h\mathcal{H}_{f,r} + \mathcal{M}'_f = \mathcal{D}'_f, &
\end{aligned}
\tag{22}
$$

where $\mathcal{R}(h_r)$ is the size-distribution of rented apartments.

At equilibrium, the no-arbitrage condition between investing in the rental stock or the on mortgages/capital implies that:

$$
p_r = (\delta_h + r)p_h + \eta \tag{23}
$$

and the financial intermediary has zero profits.

2.7 Government

The government collects the aforementioned set of taxes, as described in equation (2) to (6) from the households, denoted here as $T_{hh}(\cdot)$ for the sake of simplicity. This includes labor and capital income, payroll contributions, wealth, inheritances and housing taxes.

$$
G + \int wn(j,z)\mathbb{1}_{j\geq R} d\Gamma(\mathbf{x}) = \int T_{hh}(\mathbf{x})d\Gamma(\mathbf{x}) + \tau_c r K_c + \Pi^H + \int \tau^h(h^r)p^h\, dh^r \tag{24}
$$

Notice that $\mathbf{x}$ denotes the state variables of the economy, see the details below, and Γ the stationary distribution of households. Apart from the taxes levied on households, the government collects revenues from the capital expenditure of the corporate firm $\tau_c r K_c$, the total amount of profits of the construction firm (Π^h) and the housing taxes levied on the rental intermediary. This funds are used to fund a wasteful government expenditure G as well as pay-as-you-go pension system.

2.8 Equilibrium definition

We focus on stationary competitive equilibrium. Let $\mathbf{x} = (j, a, h, z, \theta, i, \mathcal{B})$ be the individual's state vector, where j is the age of the household, a and h represent the current asset holdings of the financial and housing assets respectively, and z and θ stand for the current realizations of the labor productivity and entrepreneurial ability shocks. i stands for the occupational status: worker, entrepreneur or retiree; while $\mathcal{B}$ represents the aggregate bequest bundle.

An equilibrium is given by sequences of prices $\{r, w, p_h, p_r\}$ and decision rules for non-durable consumption $c(\mathbf{x})$; consumption of rental units $d(\mathbf{x})$; interim savings $s(\mathbf{x})$; capital investment $k(\mathbf{x})$; efficient labor hired by entrepreneurs $l(\mathbf{x})$; housing consumption $h'(\mathbf{x})$, and savings $a'(\mathbf{x})$, along with distribution of households over the state variables: Γ, such that given prices and government tax schedules:

- The allocations $c(\mathbf{x})$, $d(\mathbf{x})$, $s(\mathbf{x})$, $k(\mathbf{x})$, $l(\mathbf{x})$, $h'(\mathbf{x})$ and $a'(\mathbf{x})$ solve the households maximization problems described above.

- Labor market clears: total efficient labor hired by the entrepreneurial sector $\int l(\mathbf{x})\mathbb{1}_{\mathrm{w}}(\mathbf{x})d\Gamma(\mathbf{x})$, the efficient labor employed in the corporate sector L_c and efficient labor units hired by the construction firm L_h equal the total labor supplied by workers

$$\int l(\mathbf{x})\mathbb{1}_{\mathrm{e}}(\mathbf{x})d\Gamma(\mathbf{x}) + L_c + L_h = \int \mathbb{1}_{\mathrm{w}}(\mathbf{x})n(j,z)d\Gamma(\mathbf{x}) \tag{25}$$

where $\mathbb{1}_{\mathrm{w}}(\mathbf{x}) = 1$ if the agents is a worker and $\mathbb{1}_{\mathrm{e}}(\mathbf{x}) = 1$ if the agents is an entrepreneur, and zero otherwise.

- Capital market clears: total savings in the financial asset $\int a(\mathbf{x})d\Gamma(\mathbf{x})$ are either used as capital or borrowed by the rental intermediary to finance the purchase of the rental units.

$$K_c + K_h + \int k(\mathbf{x})\mathbb{1}_{\mathrm{e}}(\mathbf{x})d\Gamma(\mathbf{x}) + p_h \int d(\mathbf{x})d\Gamma(\mathbf{x}) = \int a(\mathbf{x})d\Gamma(\mathbf{x}) \tag{26}$$

- Housing market clears: total demand of new housing units equals the housing supply I_h, defined by Equation (21).

$$\delta_h \int d(\mathbf{x}) + h(\mathbf{x})d\Gamma(\mathbf{x}) = I_h \tag{27}$$

- The government budget – defined by Equation (24)– is satisfied.
- The marginal product of labor and capital in the corporate sector are equal to w and r, respectively.
- The total amount of bequest received equals to the total aggregate bundle of bequests left:

$$\int B_j(z)d\Gamma(\mathbf{x}) = \sum_{j=1}^{j=T}(1-\zeta_j)\int a'(\mathbf{x}) + p_h h'(\mathbf{x}) - \psi_s p_h h'(\mathbf{x}) - t_{inh}(p_h h'(\mathbf{x}) + a'(\mathbf{x}))d\Gamma(\mathbf{x}) \tag{28}$$

- The distribution of households $\Gamma(\mathbf{x})$ is invariant. That is, it reproduces itself according to a given transition function.

3 Parametrization

In this section, we explain how we map the model's initial steady state to the data. First, Table 1 reports the parameters that we fix exogenously. When possible, we directly use the data to set their values. Our main data source is the Spanish Survey of Household Finances or EFF (*Encuesta Financiera de las Familias*). This is a detailed survey that reports detailed income and wealth information for Spanish households. We rely on the 2020 wave for most of our own calculations. Otherwise we rely on reported values in previous research. The remaining set of parameters are calibrated internally to match relevant moments from the data. Table 2 reports these parameters, while in Table 3 we report the value of the model-generated moments and their empirical counterparts. Now we discuss these parameters in more depth.

Demographics. The model period is one year. Newborn households are born being 20 years old and retire exogenously when they reach 65 years. At age 85 the household dies with certainty. Along their lifetime, households face an exogenous and known age-dependent death probability ξ_j. This probability is taken from death rates published by the INE (the Spanish National Institute of Statistics). To make the data smoother we fit a fifth degree polynomial on age.

Table 1: Externally calibrated parameters

		Value	Source
Demographics and preferences			
γ	Relative risk aversion	1.5	Standard Value
ζ_j	Death probabilities	-	INE
e_j	Equivalence scale	-	EFF
Labor productivity			
$q(j)$	Income deterministic component	-	EFF
ρ_z	Persistence of income shock	0.96	Standard Value
$\bar{p}$	Ratio pension to last income	0.75	EFF
Taxes			
τ_y^{lev}	Income tax level	0.8817	(Carrillo & Ramos, 2024)
τ_y^{prog}	Income tax progressivity	0.0996	(Carrillo & Ramos, 2024)
$\bar{I}$	Zero income tax threshold	36%	(Carrillo & Ramos, 2024)
τ_{ss}	Payroll contribution tax rate	28%	(Fuster, 2022)
$\hat{I}_{ss}$	Payroll maximum tax base	$1.28\bar{y}$	Agencia Tributaria
τ_k	Capital income tax	20%	See text
τ_w	Wealth tax	0.42%	Agencia Tributaria
$\hat{I}_w$	Wealth exemption threshold	$17\bar{y}$	(Fuster, 2022)
τ_h^{lev}	Housing tax level	0.9938	(Barrios Cobos et al., 2019)
τ_h^{prog}	Housing tax progressivity	0	See text
τ_h^t	Housing transaction cost	8%	See text
τ_c	Corporate tax rate	25%	(Fuster, 2022)
Production			
ν	Span-of-control	0.88	Standard Value
λ	Collateral constraint	1.5	(Fuster, 2022)
α	Capital share	0.33	Standard Value
α_K^h	Capital share housing sector	0.18	See text
α_L^h	Labor share housing sector	0.36	See text
δ_K	Capital depreciation rate	0.06	Standard Value
Housing parameters			
ψ	Maximum mortgage LTV ratio	0.8	Standard Value
ψ_s	Cost of selling a house	0.045	Global Property Guide
ψ_b	Cost of buying a house	0.029	Global Property Guide
ϵ	Supply price elasticity	1.17	(Cavalleri et al., 2019)
δ_h	Housing depreciation rate	0.015	Standard Value
ι	Financial spread	1.6	Banco de España

The results, along with all other regression results, are in Appendix D.1.

Utility is adjusted by life-cycle changes in the household size. To obtain an age-dependent equivalence scale factor e_j we fit a standard OECD equivalence scale onto a second order polynomial using the data from the EFF. The relative risk aversion parameter γ is set to 1.5, a standard value in the literature.

This leaves us with four preference parameters to calibrate internally. The discount factor β rate is calibrated to match the wealth-to-income ratio of the Spanish economy. The value of this parameters is taken from Blanco et al. (2021), and we target the average reported wealth-to-income ratio of the last decade (2013-2023). The two bequest parameters – ϕ_1 and ϕ_2– are set to match the wealth distribution of retirees.

The relative preference for consumption goods over housing services ξ will help us to match the housing related moments in Table 3. In particular we use this parameter to to target the average housing portfolio share. Notice that in the limiting case where ξ tends to one, agents do not value housing services and hence they do not accumulate any housing assets. Thus, this parameter heavily influences the housing portfolio share as well as the share of renters in the economy.

Inheritances. Our households have an explicit warm-glow preferences for leaving bequests. When a household dies with a strictly positive net wealth, all those assets are bundled into an aggregate bundle $\mathcal{B}$. This aggregate inheritances are then redistributed across the households along two dimensions: age and labor productivity shock. We compute the share of inheritances by age using the EFF data, for estimation results see section D.1. The resulting humped-shaped function has two maximums: one at age 20 and another at 38. This reflects the fact that most households receive significant inheritances (such as a house) when they are around 40 years old. To reflect a degree of intergenerational persistence, we correlate the received inheritances with the labor ability of the household. We do so by scaling the value of inheritances received for each realization of the z shock, as the realization divided by the mean value of the shock with respect to the ergodic distribution.

Labor productivity and entrepreneurial ability. The deterministic component of labor productivity is taken from the EFF. We regress the logarithm labor income on second order age polynomial (see Appendix D.1). As for the stochastic part, assume that z can take 6 values. The first five are associated normal labor earnings, while z_6 represents a superstar shock, as in İmrohoroğlu et al. (2023) and Brüggemann (2021). The first five grid points are assumed to follow a standard AR(1) process – in logs– with persistence ρ_z and standard deviation σ_z. We fix the persistence parameter to be 0.96, a standard value in the literature; while the dispersion parameter is used to match the Gini of the workers earnings distribution[6].

This leaves us with 3 parameters to calibrate the superstar shock (z_6, $\pi_6^{z^+}$, $\pi_6^{z^-}$) which correspond to the value to the shock, the probability of reaching it and the probability of falling back to the medium ability level, z_3. Since our model already features entrepreneurship, the superstar shock is not introduced to match the wealth distribution but to have the right distribution of entrepreneurs and workers at the top. Without this high level of labor ability virtually all the households at the top 1% of the income distribution would be entrepreneurs, while in reality is 31.50%. Thus, we use this three parameters to match the right share of entrepreneurs at the top of the income distribution as well as the income share of the top 1% and top 10%. The full transition matrix and the values of the z shock are on Appendix D.2. Notice that the value of our superstar shock, z_6, is only 3.6 times larger than the highest value of the normal labor earnings (z_5). This, again, reflects the fact that our model does not rely on this mechanism to replicate the empirical levels of wealth inequality.

For the structure of entrepreneurial ability, we closely follow Brüggemann (2021). There are only four potential entrepreneurial endowments such that $\theta = \{0, \bar{\theta}(1-\hat{\theta}), \bar{\theta}, \bar{\theta}(1+\hat{\theta})\}$. For the transition matrix we assume that a household can only transition into neighboring ability states:

[6] We could rely on empirical estimates for the standard deviation of workers earnings. Nevertheless, because the occupational choice is endogenous it could be the case that households with low z are underrepresented in entrepreneurship, thus affecting the effective earnings distribution among workers.

$$\Lambda = \begin{pmatrix} \pi_1^\theta & 1-\pi_1^\theta & 0 & 0 \\ \pi_2^\theta & \pi_3^\theta & 1-\pi_2^\theta-\pi_3^\theta & 0 \\ 0 & \pi_2^\theta & \pi_3^\theta & 1-\pi_4^\theta \\ 0 & 0 & \pi_4^\theta & \pi_4^\theta \end{pmatrix}$$

The six parameters characterizing the entrepreneurial ability process are calibrated internally to match 6 empirical moments: the fraction of entrepreneurs in the economy (7.33 percent); the Gini coefficient of entrepreneurs' income of 45.30; the share of hiring entrepreneurs (55.22 percent); the median income of entrepreneurs relative to the workers median (1.36); the share of entrepreneurs at the top 10% of the wealth distribution, and the gross wealth Gini coefficient of 63.80.

Table 2: Internally calibrated parameters

		Value
Housing		
χ	Homeownership utility premium	1.65
h_1	Minimum housing size for homeowners	60
Preferences		
ϕ_1	Luxury good parameter of bequests	113
ϕ_2	Bequest intensity parameter	1150
β	Discount factor	0.975
ξ	Consumption utility share	0.63
Entrepreneurial ability process		
$\hat{\theta}$	Dispersion of ent. ability	0.26
$\bar{\theta}$	Average of ent. ability	2.00
$(\pi_1, \pi_2, \pi_3, \pi_4)$	Transition probabilities	(0.989, 0.205, 0.718, 0.9665)
Labor productivity process		
σ_z	St. dev. labor productivity	0.666
z_6	Highest labor prod. level	13.54
$\pi_6^{z^+}$	Probability of reaching z_6	0.00075
$\pi_6^{z^-}$	Probability of leaving z_6	0.1143

Taxation. The parameters of progressive income taxation are taken from the parametric estimates of Carrillo and Ramos (2024). The authors also provides an estimated kink function for the capital income tax. Nevertheless, the function is barely progressive and stabilizes at a 20% effective tax rate. Thus, we set $\tau_k = 0.2$.

The effective rate of wealth taxation is taken directly from the Spanish fiscal authorities. The wealth exemption threshold $\hat{I}_w$ reported by Fuster (2022) is 700.000€, which is roughly equivalent to 17 times the average household income in Spain. We rely on the same source to set the inheritance taxes: Table D2 in Appendix D.2 reproduces the statutory tax schedule of inheritances. As in Fuster (2022), we adjust the statutory tax rates to take into account different regional tax credits. On average this credits are about 58% of the quota implied by the statutory tax.

The tax rate for housing transaction, τ_h^t, ranges from 6 to 10% depending on whether the housing unit is brand new or not. In our model there is no difference between new and old houses, the only important feature is the size. This is why we decide to set the value of $\tau_h^t = 8\%$, to be in the middle ground. The corporate tax rate si set to $\tau_c = 25\%$ (Fuster, 2022).

As for the effective property tax, we rely on the estimates of Barrios Cobos et al. (2019)[7], who construct homogeneous estimates of the effective tax rates across European nations. In the baseline the housing tax is flat, implying that there is zero progressivity $\tau_h^{prog} = 0$. Thus, the effective tax rate is just $1 - \tau_h^{lev}$[8].

These tax values in equilibrium imply a unique government spending value G that balances the budget. We solve for this value and keep this wasteful government expenditure fixed thought the rest of our experiments.

Technology. The capital share in the corporate and entrepreneurial sector is set to 0.33 and the depreciation rate in both sectors is fixed to $\delta_k = 0.06$, both being standard values in the literature. For the collateral constraint we follow Fuster (2022) and set $\lambda = 1.5$. Notice that not only this is a standard value in entrepreneurial models, but it also aligns with the empirical estimates of García-Posada and Mora-Sanguinetti (2014) for the small Spanish firms. The span-of-control parameter is set to 0.88, standard value in the literature.

Housing. The maximum loan-to-value for mortgages is set to 80%, standard value in the literature. For the housing depreciation parameter we set a value of 1.5%, which is standard in the literature (Kaplan et al., 2020). The mortgage debt spread ι is taken from the interest rates data provided by Banco de España (Spanish Central Bank). We estimate this spread as the difference between the average interest rate for new mortgages and the return of one to two year deposits. The cost of selling and buying property is taken from the Global Property Guide website, which provides a comprehensive overview of real estate markets on country by country basis. The reported cost for selling a house is 4.5% and the one for purchasing a house is 10.9%. Nevertheless we fix $\psi_b = 0.029$ to reflect the fact that most of that cost is the transaction tax rate, which we set to be 8%.

As for the housing supply price-elasticity for Spain we rely on the estimated value of 1.17 from (Cavalleri et al., 2019). As one can observe from equation (21), the elasticity implied by the model depends only on $(\alpha_K^h + \alpha_L^h)$ the weight of capital and labor in the housing production function. Thus, this elasticity implies a weight of capital and labor equal to 54%. The individual shares of each of the variable factors are set such that the relative weight of each of them is the same as in the corporate sector[9].

Without loss of generality we assume $p_h = 1$ in the baseline. This allows us retrieve two parameters from the model by imposing equilibrium conditions. The first one is the rental intermediary cost, η. Once we set $p_h = 1$, then the rental price in the baseline economy boils down to rent-to-price ratio. According to the estimates of Khametshin et al. (2024) this ratio is 5.7%. Thus we set $p_r = 0.057$ in our baseline economy and using equation (23) we solve for η. A similar procedure allows us to directly solving for the amount of land available for production $\bar{L}$. Once the housing price is known, we impose the equilibrium condition in the housing markets and solve for $\bar{L}$ needed to exactly offer the demanded quantity in this market from equation (21). Both of this parameters are then fixed throughout our experiments.

Notice that assuming a unitary price in the baseline only affects the interpretation of our grids: not only the grids are quantities but they reflect the baseline price level. Thus each grid point of $\hat{\mathcal{H}}$ is a quantity and baseline-price adjusted measure of housing units. Nevertheless, this does not affect any of our experiments since the change in p_h will still reflect the change in relative values[10].

[7]Neither the wealth no property taxes are homogeneous across Spain. Wealth taxes are set at the regional level while property taxes are set at the local level. Since we model a consolidated government budged we abstract from these details.

[8]Although in most countries the housing taxes are flat at the local level it is difficult to determine wether this taxation is progressive or regressive due to several issues. The two most important ones are the variation of the taxes across municipalities and the fact that households are taxed on the cadastral value of the properties rather than the market one (for example see McMillen and Singh (2020)).

[9]For example for the capital share in the housing sector it requires that $\alpha_K^h/(\alpha_K^h + \alpha_L^h) = \alpha$.

[10]On the other hand, assuming a unitary housing price in the baseline saves us a significant amount of computational time. This comes from

Table 3: Targeted moments. Data vs Baseline values.

	Data	Model
Housing		
Renters share	26.03	26.203
Avg. housing portfolio share	50.10	51.90
Housing holdings Gini	43.94	39.60
Entrepreneurs		
Share entrepreneurs	7.33	7.37
Share of hiring entrepreneurs	55.22	56.73
Entrepreneur's earnings Gini	45.30	45.90
Share of E among the top 1% of income	31.54	31.57
Ratio of median income of E/W	1.36	1.96
Share ent. top 10% wealth	22.90	20.80
Workers and retirees		
Worker's earnings Gini	39.52	39.60
Ratio of median net-worth of retirees	1.48	1.47
Gross wealth Gini of retirees	59.20	61.30
Overall economy		
Wealth-to-Income Ratio*	6.57	6.66
Gross wealth Gini	63.80	62.50
Top 10% income share	30.70	35.40
Top 1% income share	7.60	8.60

Data source: EFF (2020) with the exception of * which we take from Blanco et al. (2021).

The two renaming parameters, h_1 and χ, are calibrated internally, along with ζ, to target the three housing moments in Table 3. In particular, the parameter χ is used to target the share of renters in the economy. Remember that χ represents the utility premium from owning your dwelling. Thus, the higher this value this value the more incentives there are for the households to become homeowners. The minimum grid size, h_1, is used to pin down the distribution of housing assets among the homeowners. Notice that, for example, if h_1 is set too high the minimum size restriction will be binding for most of the owners, which will lead to a low dispersion.

Notice that a value of $\chi = 1.65$ may appear to be large, but this is mainly due to the frictionless modeling of the renters choice. Renters choose their h^r without any restrictions. Meanwhile, homeowners are subject to adjustment costs and their choice is limited to a discrete grid. Thus the model requires a relatively high utility premium from homeownership.

4 Benchmark Economy

In this section, we evaluate the benchmark economy's performance at its initial steady state. Table 3 demonstrates that the target moments are broadly well-matched. Overall, our model replicates the central features of the entrepreneurial sector as well as the aggregate homeownership and portfolio shares of the Spanish economy. There are, however, some discrepancies concerning the relative incomes of entrepreneurs and the income inequality predicted by the model.

These discrepancies arise due to the introduction of housing. Housing is broadly held across most households and tends to be relatively evenly distributed compared to overall wealth inequality. Moreover, it represents a sizable share

the two parameters that we solve for (η and $\bar{L}$) and from having one less market clearing condition to satisfy.

of the total assets in the economy, around 50%. Consequently, the remaining half of household wealth in the model has to be extremely unequally distributed (a Gini coefficient around 80) to match aggregate wealth distribution. In reality, the non-housing portion of wealth encompasses diverse assets —-including bonds, bank accounts, stocks, and private businesses—- each differing in terms of risk and returns. Nevertheless, in our model all households that invest in the financial asset face the same return. Moreover, households use this asset to smooth their consumption.

Table 4: Housing distribution (homeowners only)

	Gini	0-50	50-90	90-99	Top 1%
Data	43.94^{t}	20.95	46.10	25.17	7.79
Model	39.55	20.22	50.27	24.49	5.03

Data source: EFF (2020). *Note*: ^{t} Targeted.

Having noted these perks, we also note that our model also does a good job in matching the overall wealth and income distributions, as reported in Table 5. Same is true for the housing distribution, reported in Table 4[11]. Additionally, the model performs well in replicating the of total housing wealth that each income (and wealth) quintile holds. Notice that we do not explicitly target any of these moments from the bi-variate distributions, the model delivers a realistic concentration of housing in the top income and wealth brackets. Matching this bi-variate distributions – without targeting them explicitly– reassures us that the model is a good tool to deal with housing taxation.

Table 5: Distributions of Income and Wealth

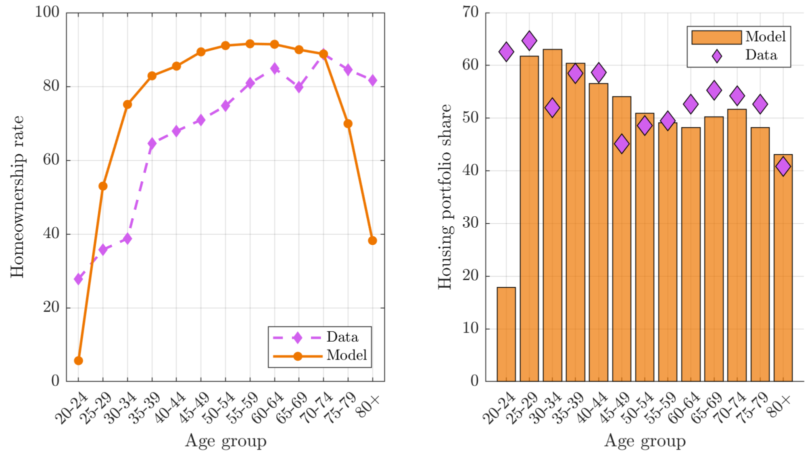
	Gini	0–20	20–40	40–60	60–80	80–90	90–95	95–99	Top 1%
Wealth									
Data	63.80^{t}	0.48	5.24	10.48	18.28	15.57	11.93	17.48	20.55
Model	62.50	1.21	4.60	9.88	18.26	16.57	15.82	21.42	12.25
Housing share by wealth									
Data	–	1.98	8.18	15.00	23.60	17.96	11.77	14.08	7.43
Model	–	1.57	7.20	11.95	24.20	18.62	14.20	15.75	6.5
Income									
Data	41.63	4.92	10.16	15.52	22.59	16.11	10.62	12.49	7.60^{t}
Model	45.33	5.20	9.20	13.34	21.25	15.55	12.09	14.77	8.59
Housing share by income									
Data	–	8.07	13.40	16.71	23.58	15.08	9.32	9.35	4.46
Model	–	5.82	11.38	13.81	23.72	16.04	10.84	13.45	4.94

Data source: EFF (2020). *Note*: ^{t} Targeted. The share of the top 10% of the income distribution is also targeted. The housing shares by income and wealth represents what share of total housing assets in the economy belong to those particular bins.

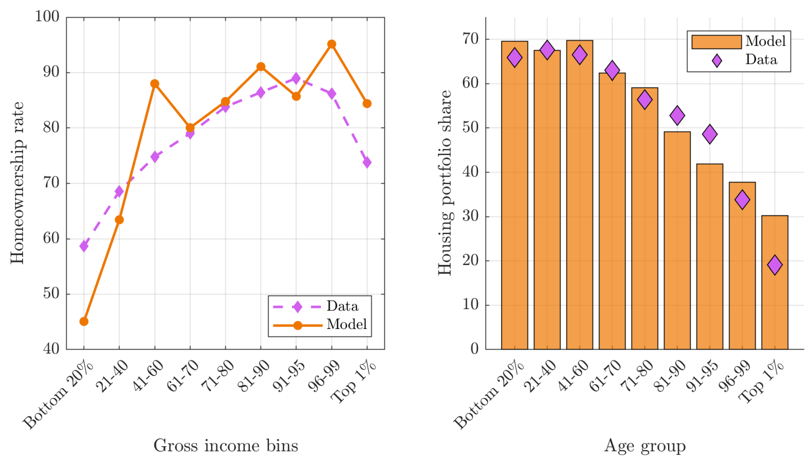
As for the other housing moments, we only targeted the aggregate homeownership rate and portfolio shares. An important question is whether the model replicates the empirical patterns of these moments across different groups. Figure 1 depicts homeownership rates and housing portfolio shares across age, income, and wealth dimensions. Overall, our

[11] We do not report a more detailed distribution due to the discrete nature of housing in our model. We only have 10 grid points for homeowners.

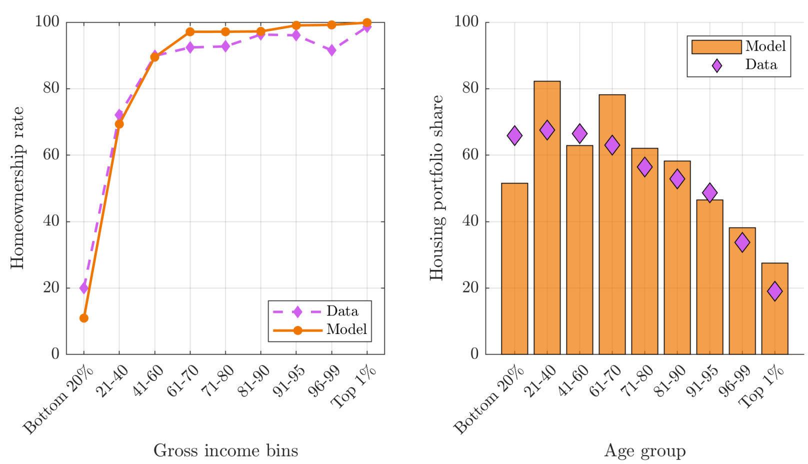
Figure 1: Homeownership rates and portfolio shares across different dimensions.



(a) By age groups



(b) By income percentile bins



(c) By wealth percentile bins

model captures the essential features of the housing distribution across these three dimensions. That is: 1) homeownership rates increase with income and wealth, and this increase is steeper in the former case; 2) portfolio shares of housing are decreasing in both income and wealth; 3) portfolio shares exhibit a double-hump pattern over the life cycle. The fit is not perfect, which is not surprising given that we only targeted the average homeownership and portfolio shares. Since our households are born at age 20 without any housing, we under-predict the homeownership rate and the portfolio weight of housing for the youngest households. Another dimension that is difficult to capture are the portfolio shares at the very top of both income and wealth. Notice that in the data the housing portfolio shares at the top 1% decrease steeply. The reason is that those households invest in other assets that we are not considering here, such as shares or private businesses[12].

Nevertheless, the model's ability to reproduce several untargeted features of the data, such as the joint distribution of housing, income, and wealth, as well as life-cycle and cross-sectional patterns in ownership and portfolio shares, further strengthens our confidence in its structure. This good fit along non-targeted dimensions suggests that the model captures the key mechanisms shaping housing decisions and can therefore be reliably used to study housing taxation.

5 Main Experiments

After showing that the model economy replicates the empirical distributions of wealth, housing and income, we analyze whether a change in the housing taxation system might be welfare-enhancing. In order to compute optimal policy rules we have to take a stand on a welfare measure. As a measure of optimality we use the expected value function of newborn agents. This is a reasonable optimality measure because our experiments are steady-state comparisons. In effect, we ask whether a newborn agent would prefer to live in the baseline economy or in an alternative one with a different tax structure. To make quantitative comparisons on welfare, we define a consumption-equivalent measure as:

$$V^*(\tilde{\tau}_h^{lev}, \tilde{\tau}_h^{prog}, \tilde{\tau}_y^{lev}, \tilde{\tau}_y^{prog}) = \int V\big((1+\bar{ce})c(\mathbf{x}), (1+\bar{ce})d(\mathbf{x})\big)d\Gamma(\mathbf{x}) \tag{29}$$

where $V^*(\cdot)$ is the value function of a newborn under the counterfactual economy where we modify the tax system and $V(\cdot)$ represents the value function in the benchmark. Thus, our welfare measure $\bar{ce}$ can be interpreted as the change in consumption, in both non-durable and housing, needed so that a household is indifferent between the benchmark and the counterfactual economy.

All of the considered fiscal reforms are budget-balanced. Note that a balanced-budget reform is not necessarily revenue-neutral, due to the presence of a pay-as-you-go pension system that depends on the wage of the economy. Thus, any reform that increases (decreases) wages will require higher (lower) revenues than in the baseline.

We next examine alternative several counterfactuals. Section 5.1 analyzes the optimal housing tax schedule in our economy, highlighting the role of progressivity and contrasting housing and income tax schedules. Finally, Section 5.2 presents the joint optimization of housing and income taxation to simulate the overall optimal fiscal system.

[12] If we compute housing shares without taking the value of private businesses into account, then our estimates are even more closely aligned since the top portfolio shares become 25% and 23% for income and wealth respectively.

5.1 Optimal housing vs income taxation

We begin by comparing the optimal housing and income tax schedules. Progressive income taxation is the primary redistributive tool in most economies and has been widely studied in the literature. Therefore, it constitutes a natural benchmark for assessing the redistributive and efficiency implications of progressive housing taxation. To ensure a fair comparison, we do not contrast the existing income tax schedule with the optimal housing tax design. Instead, we compare the effects of both tax schedules at their respective optimal structures.

By optimal housing taxation, we refer to maximizing jointly the expected utility of a newborn at steady state with respect to housing tax level and tax progressivity parameters, subject to the government budget constraint. By optimal income taxation, we refer to maximizing the expected utility of a newborn with respect to income progressivity and balancing the government budget constraint using the income tax level parameter. For brevity, we will refer to them as *Opt H* and *Opt Y* respectively. Table 6 presents the detailed results of these experiments. Now we precede to compare the tow optimal schedules along different dimensions.

Table 6: Housing vs Income Taxation Results

			Counterfactuals		
		Baseline	*Opt Y*	*Opt H*	*Joint*
Tax Parameters					
τ_h^{lev}	Housing tax level	0.9938	0.9938	0.9690	1.1186
τ_h^{prog}	Housing progressivity	0	0	0.0741	0.1667
τ_y^{lev}	Income tax level	0.8817	0.7542	0.8817	0.4709
τ_y^{prog}	Income progressivity	0.0996	0.5585	0.0996	0.0010
Tax Structure					
Effective income tax rate (%)		13.471	18.303	13.741	52.914
Share of hhs paying income Tax		77.29	43.52	80.95	100
Effective housing tax rate (%)		0.620	0.620	2.613	-12.905
Share of hhs paying housing Tax		100	100	68.819	2.35
Prices					
p_h	Housing price	1	0.81	0.78	0.74
p_r	Rental price	0.05	0.06	0.02	0.04
r	Interest rate (%)	5.65	8.05	4.34	6.24
w	Wage	1	0.90	1.07	0.97
Aggregate Variables					
Production		100	88.9	107.3	97.4
Aggregate capital		100	69.6	120.2	89.1
Real housing stock		100	90.5	67.7	72.7
Rental stock		100	30.7	32.8	31.9
Net Wealth		100	71.9	76.8	66.1
Share of homeowners		73.7	92.3	87.7	91.5
Welfare (Δ%)		–	11.59	13.19	22.23

Tax Rates: Table 6 presents the detailed results of these experiments. As shown in the third column, the optimal housing tax schedule features progressivity and a higher average effective tax rate. The average tax rate is 2.6%, and 68% of households are effectively paying this tax, with the 0-tax threshold being at roughly the 45th percentile of the baseline's housing size distribution. The progressivity of optimal housing taxation stands at 0.07, only little below the progressivity of the current income tax. On the other hand, the optimal income taxation features is highly progressive (at 0.5585, about 6 times more than current progressivity), and the average tax rate is also somewhat 50% larger than the baseline economy[13]. About 43% of households pay this tax, while the rest receive subsidies. Given that both tax schedules are highly progressive, it is worth remembering that the model does feature financially constrained entrepreneurs, but no endogenous labor supply or human capital accumulation, which would impose a further limit on the optimal progressivity of both the income and housing tax schedules.

Resources Allocations and Prices: The two tax schedules have distinct effects on prices and the allocation of the economy's resources on capital and housing. The optimal housing tax reduces the demand for housing and generates a large drop in the housing stock by 32% with respect to the baseline, as well as a drop in the housing price by 22%. Since the increase in tax rates for high houses reduces the opportunity cost of investing into the financial asset for rich households, the interest rate goes down, and the capital stock in the economy rises by 20% (fig. 2). The capital deepening leads to an increase in wages by 6.9%. The production of the consumption good also increases in this case by 7%.

Figure 2: Capital and Housing Demand

Note: Housing is evaluated in constant (baseline) prices ($p_h = 1$) across counterfactuals

On the other hand, the optimal progressive income taxation causes a large drop in the stock of capital (by 30%), while leaving the housing stock only 9% lower. The lion's share of the fall in the capital stock comes from the self-employed, whose demand more than halves, which aligns with the expected result of a highly progressive income tax on entrepreneurs. In this economy the production of the consumption good drops by 11%, interest rates rise to 8%, and wages fall by 10%. These results are consistent with the broader literature covering the effect of higher progressivity, see Brüggemann (2021) or İmrohoroğlu et al. (2023). In our setting, the optimal income policy also leads to a lower housing demand due to income shrinking, resulting in housing price decreasing by 19%.

What is worth noting, is that the optimal housing tax schedule increases aggregate capital, with opposite affects on the the capital employed by the corporate sector (increases) and the self-employed (decreases). To understand why this happens, in table 7 at the share of constrained self-employed, the mean value of unconstrained capital, that they would like to employ, and the mean value of their collateral. Notice that the share of self-employed barely changes between

[13]Both functions are graphically displayed in appendix fig. A1.

the baseline and the optimal housing tax schedule. The housing tax reduces the interest rate and also incentivizes entrepreneurs to save more on the financial asset, both of which lead to increase in the value of optimal unconstrained capital. However, the collateral of self-employed takes a blow both from the lower housing quantities held and their lower price. The share of constrained self-employed rises by 7 p.p., helping explain why the demand for capital from self-employed decreases.

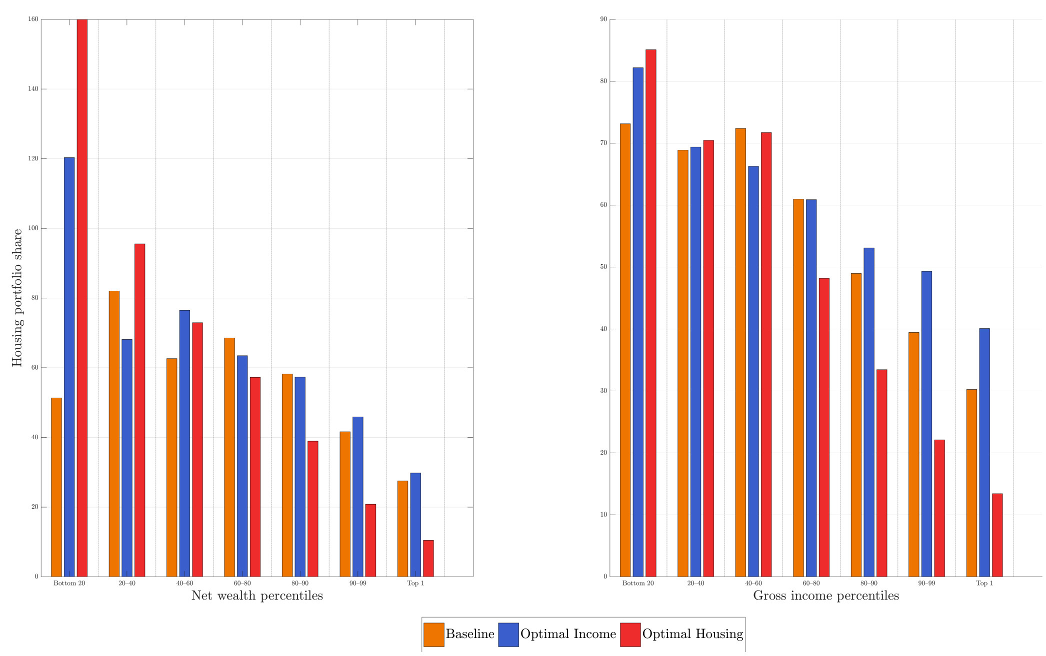
Table 7: Self-Employed: The Role of Collateral

	Baseline	*Opt Y*	*Opt H*
Mean Unconstrained k*	100	83.64	107.39
Mean collateral	100	46.28	84.66
Share S.E.	7.37	7.70	7.35
Share constrained S.E.	55.44	54.41	62.35
Entrepreneurs, wealth share	14.29	9.62	15.72

Having emphasized the effect of housing taxation on the collateral value of self-employed, we note also that the overall drop of capital stock employed by self-employed is limited (about 3 p.p.). As noted above, income taxation treats workers and entrepreneurs similarly, thereby inhibiting entrepreneurs' wealth accumulation. On the other hand, housing taxation taxes an entrepreneur less than a worker of same wealth, due to the portfolio of the latter having less housing share, and no matter the income. Under the *Opt H*, which is a budget neutral reform, the level of income taxation decreases, and the tax shift exerts an upward force on entrepreneurs' financial wealth accumulation.

We can see this differential treatment by looking at the effect of the considered fiscal policies in the portfolio shares. Figure 3 shows that progressive housing taxation generates distinct incentives across the income and wealth distribution. Under the *Opt H* scenario, low-income and low-wealth households increase both their absolute and relative holdings of housing, while the steep tax rates reduce the housing share among the wealthiest groups.

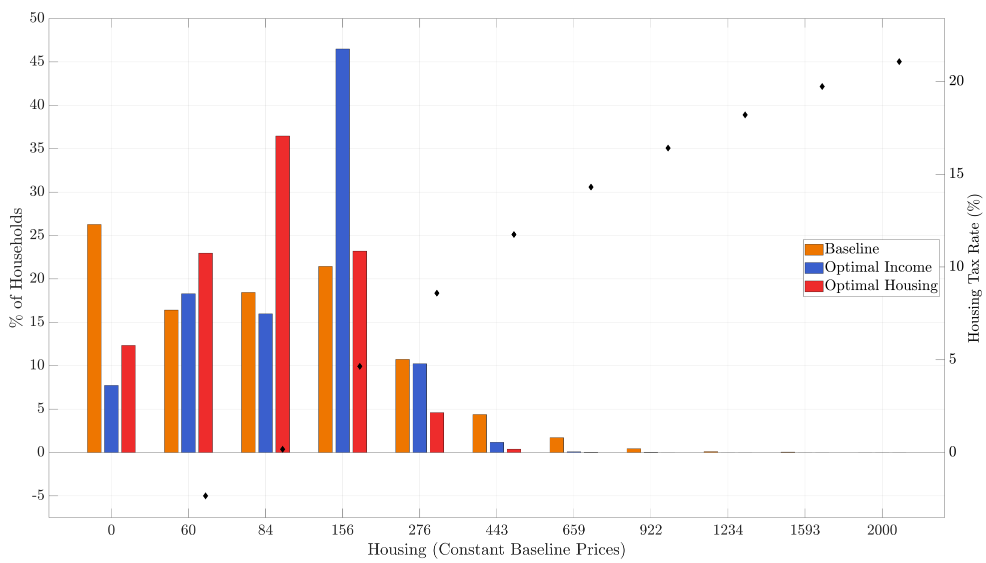
Figure 3: Portfolio shares by income and wealth percentiles



Consequently, the *Opt H* policy yields a more efficient allocation of wealth accumulation. Lower-ability households—unlikely to engage in future entrepreneurial activity—shift toward housing, whereas higher-ability households reallocate toward financial assets (see Appendix table A1). The *Opt Y* scenario produces similar effects for poorer households but raises housing shares throughout the entire income and wealth distribution.

Housing Distribution: Although both tax schedules squeeze the right tail of the housing distribution, the mechanics differ. Under the *Opt Y* the high effective income taxes at the top decrease their ability to purchase bigger housing units. Meanwhile, the *Opt H* makes it prohibitively expensive to live in those luxury buildings, without a direct tax that lowers the disposable income of the households at the very top. Nevertheless, both policies decrease the inequality in the holding of both assets in similar ways: the Gini index of housing decreases from 39.50 to around 25.50 under both counterfactuals.

Figure 4: Housing distribution under counterfactual reforms



Note: The graph presents the housing distribution (left axis) and the corresponding tax rates under Opt H (right axis) for each housing size. Y-axis reports house values at constant baseline prices ($p_h = 1$). The first bin (0 housing value) corresponds to renting. Reported tax rates are percentage shares of housing values. For Baseline and Opt Y the housing tax is flat and equal to 0.62%.

Effects on Consumption: Both tax schedules yield significant welfare gains with respect to baseline, 13.2% and 11.6% under the optimal income and housing tax respectively. To understand the source of the welfare gains we perform a variance decomposition of total consumption C_{tot}, which we define as $c^{\alpha}d^{1-\alpha}$, to uncover consumption smoothing effects between and within ages. In table 8 we present the results. Both policies reduced the mean of C_{tot} by 9%. It is worth point out that under the *Opt H* scenario the average non-durable consumption actually increases. Nevertheless, the fall in the consumption of housing services is much stronger under this scenario (-30%) than compared with the *Opt Y* counterfactual (-5%).

As for the variance, both of the policies lower it substantially: by 71% in the case of the *Opt Y*, and 51% in the case of the *Opt H* tax. *Opt Y* is very successful in reducing the within-age variance (by 82% third column of table 8), but only modestly reduced the between-age variance (by 10%). On the other hand, *Opt H* reduced both variances similarly (by 50% and 58%), but slightly more the between-age part, which is why the share of the total variance explained by age decreases slightly.

A key feature of the model that generates this discrepancy is that income and consumption are not perfectly correlated in

Table 8: C_{tot} Variance Decomposition

	$E[C_{tot}]$	$Var(C_{tot})$	$E[Var(C_{tot}\|Age)]$	$Var[E(C_{tot}\|Age)]$
Baseline	53	2274	1950	323
Opt Y	48	636	347	289
Opt H	49	1114	980	135

Note: $C_{tot} = c^{\alpha} d^{1-\alpha}$. The last two columns show the within- and between-age shares of $Var(C_{tot})$.

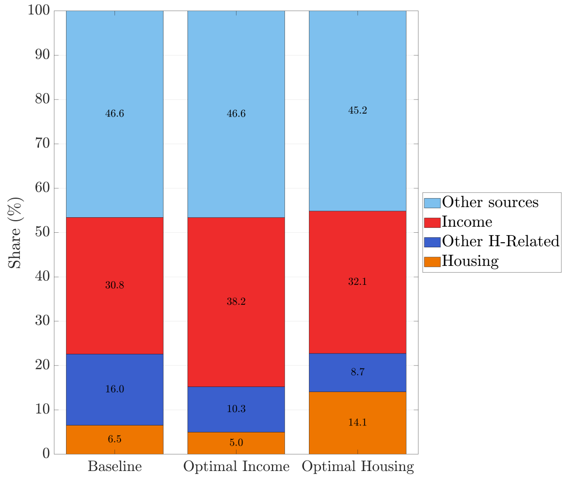
the model. Agents earn higher incomes when young, but choose to smooth consumption over the life-cycle. As fig. A2 shows, baseline C_{tot} grows at a fast pace until the age 50, and is close to flat afterwards. Housing consumption has the same pattern. The *Opt Y* tax fails to smooth C_{tot} over age much, as it taxes high-earning working-age households, and redistributes to low-income, but potentially wealthy in terms of consumption, retirees. On the other hand, housing taxation, as every consumption tax would do, successfully smoothes C_{tot} over the life-cycle, by taxing consumption-rich retirees and subsidizing consumption-poor young. Notice also that C_{tot} doesn't account for equivalence scales, and household size decreases at retirement, amplifying the importance of this channel for welfare, and explaining why *Opt H* achieves higher welfare gains than *Opt Y* despite a lower decrease in $Var(C_{tot})$ for similar decrease in mean total consumption.

Government Revenues and Tax Burden: The two taxation plans modify the structure of government revenues in different ways. The *Opt Y* tax leads to a substantial increase in the share of income taxation, from 31% to 38%, at the expense of wealth taxation, inheritance tax, the housing tax, and the profits of the construction sector. This is the result of less savings on the part of households and lower housing prices. On the other hand, under *Opt H* tax schedule, the housing tax revenues expand to 14.1 of total government revenues, but this does not happen at the expense of the income tax revenues, which slightly rise. Instead, the shares that drop are housing-related taxes, such as inheritance, transaction taxes, and the profits of the construction firm, all affected by the lower housing stock and the lower price.

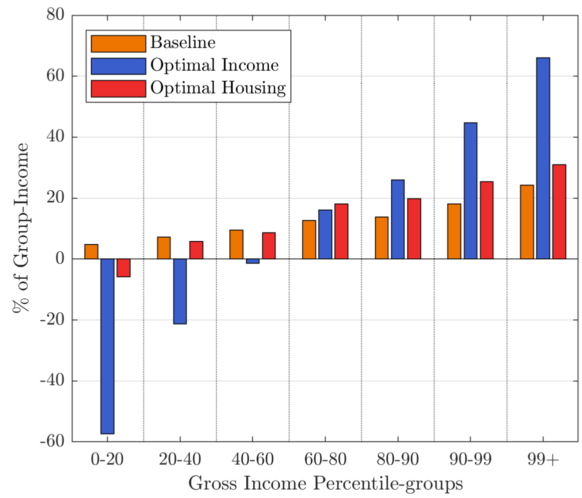
They also differ on whom the tax burden falls, as the *Opt Y* reforms' taxes are primarily paid by income-rich working-age households, while *Opt H* also taxes significantly retirees. To show this, we categorize households by income bins, (total) consumption bins and age groups, and for each bin we aggregate income and taxes paid, and calculate the total housing and income tax burden that this group pays as a fraction of their income. We plot the results in fig. 5b. As expected, *Opt Y* taxes heavily the top of the income distribution (with the joint burden of housing and income taxation being 65% of income for the top 1%), and provides large subsidies to the bottom 20% (56%). In contrast, *Opt H*'s tax burden for the top 1% is 31%, which is significantly higher than baseline's 24%, but much lower than *Opt Y*'s. Subsidies to the poorest 20% are also much lower than in *Opt Y*, at 5%.

In terms of (total) consumption bins, both tax schedules pose a large tax burden to the top of the distribution, with the top 1% being taxed 41% under *Opt Y*, and 30% under Opt H. The vast deviation between the tax burden paid under *Opt Y* from the top 1% of the income distribution and the top 1% of the consumption distribution highlights that these groups are composed by different households; the highest earners are not always the highest spenders. The same holds for the bottom part of the income and consumption distributions, as *Opt Y*'s subsidies offered to the consumption-poorest 20% are only 10% of bin's income, a far cry from the 56% calculated for the bottom 20% of the income distribution. It is worth noting how much lower the Opt H subsidy rates are to the bottom 20% of both income and consumption distribution relative to *Opt Y*'s. Thus, in the Opt H reform, direct subsidies are no less important than the equilibrium effects of lower house prices and higher wages for improving welfare of poorest households.

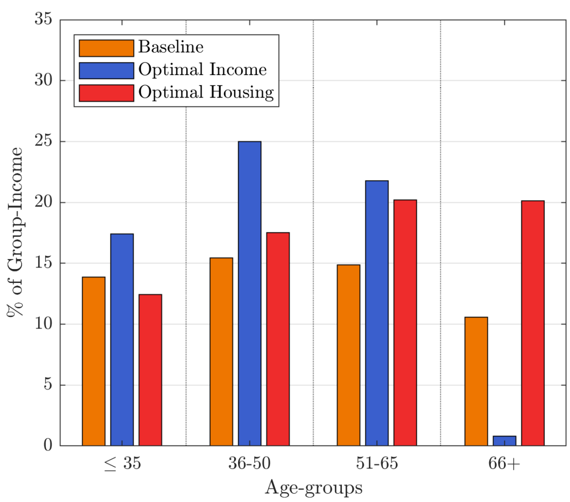
Figure 5: Comparison of revenue shares and tax burdens under *Opt Y* and *Opt H* reforms



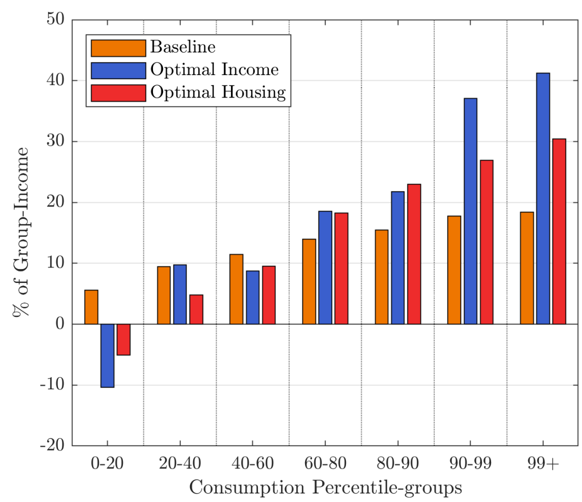
(a) Comparison of governments' revenue shares



(b) Tax burden by income bins



(c) Tax burden by age groups



(d) Tax burden by C_{tot} bins

Note: Panel (a) reports the composition of government revenue by source. The category "Other H-Related" taxes corresponds to property transaction tax, wealth tax, inheritance tax and the profits from the construction firm. "Other sources" corresponds to social security contributions and the corporate tax. Panels (b)–(d) split the population by Income, age or consumption - bins, aggregates all taxes paid and all gross income received by households in each bin, and plot their percentage ratio. For consumption-bins total consumption $C_{tot} = c^{\alpha} d^{1-\alpha}$ is used

Where the two reforms differ the most is on the tax burden they impose across age groups (fig. 5c). *Opt Y* reform significantly increases the tax burden to working age households (from 15% to 25% for the 36-50 bins and from 15% to 22% for the 51-65 bin), while it eliminates it for the retirees; as many retirees are income-poor they earn subsidies and the 66+ bin contributes in net only 1% of bin's income. On the other hand, the *Opt H* tax plan, increases significantly the tax burden paid by retirees, from 11% to 20%, while decreasing it for those below 35s (from 14% to 12%). This way the *Opt H* reform transfers some of the tax burden from young households to income-poor but consumption-rich retirees, which is crucial since the average household consumers more in retirement than under the age of 35, as shown in fig. A2).

Welfare Gains/Losses across ability: In order to uncover the winners and losers from each reform, we calculate the welfare gains of newborns of different labor and entrepreneurial ability (table 9). Both reforms reduce the expected welfare of high labor and entrepreneurial ability newborns, and increase that of low labor and entrepreneurial ability newborns. However, the distribution of welfare gains is much more polarized under *Opt Y* reform, ranging from gains of 66% for the households with the lowest realizations of z and θ, to losses of 51% for the households with the highest realizations of both. Under *Opt H*, welfare gains range from -25% to to 38%. Another crucial difference, is how the "middle-class" of labor ability (z_4, z_5) fares across reforms, especially for newborns of the lowest entrepreneurial ability. Under *Opt Y*, they suffer losses of -11% and -27% due to the high progressivity of income taxation, while under *Opt H* the newborn with skills $((z_4, \theta_1)$ gains 3% in consumption equivalent and the one with skills $((z_5, \theta_1)$ faces losses of only 6.8%. Newborns born in these states constitute a sizable 27.5% of each cohort's population. Overall, a majority of 65% of each newborn's cohort would prefer living in the *Opt Y* economy instead of in the baseline, while the *Opt H* economy is preferred by 89% newborns.

Table 9: Newborns' Welfare Gains by Labor & Entrepreneurial Ability Rank

(a) Optimal income tax (*Opt Y*)

	θ_1	θ_2	θ_3	θ_4
z_1	66.65 (5.46)	65.83 (0.29)	58.34 (0.11)	32.84 (0.26)
z_2	35.50 (22.05)	32.37 (1.17)	21.66 (0.45)	-4.52 (1.04)
z_3	10.94 (33.62)	8.41 (1.79)	-1.29 (0.68)	-23.37 (1.58)
z_4	-10.51 (22.05)	-10.40 (1.17)	-17.61 (0.45)	-34.89 (1.04)
z_5	-27.42 (5.46)	-25.84 (0.29)	-29.65 (0.11)	-42.58 (0.26)
z_6	-36.60 (0.58)	-37.63 (0.03)	-40.64 (0.01)	-50.56 (0.03)

(b) Optimal housing tax (*Opt H*)

	θ_1	θ_2	θ_3	θ_4
z_1	38.52 (5.46)	36.30 (0.29)	31.82 (0.11)	21.24 (0.26)
z_2	23.52 (22.05)	20.34 (1.17)	13.92 (0.45)	0.65 (1.04)
z_3	12.26 (33.62)	8.60 (1.79)	2.38 (0.68)	-9.40 (1.58)
z_4	2.79 (22.05)	-0.27 (1.17)	-5.90 (0.45)	-15.63 (1.04)
z_5	-6.78 (5.46)	-8.17 (0.29)	-12.35 (0.11)	-19.71 (0.26)
z_6	-18.02 (0.58)	-18.62 (0.03)	-20.19 (0.01)	-24.77 (0.03)

Note: The cohort share of households for each combination of the labor z and entrepreneurial ability θ shock is reported in parentheses.

To sum up, progressive housing taxation facilitates welfare redistribution through channels distinct from those of income tax progressivity. By raising the opportunity cost of housing investment for wealthy households, it triggers two key effects. First, reduced demand for housing among the rich leads to lower house prices, thereby improving affordability for poorer and younger households—especially when complemented by housing subsidies. Second, as affluent households reallocate their portfolios from real estate to financial assets, aggregate savings rise, expanding the capital stock. This capital deepening results in higher wages and lower interest rates. Crucially, this mechanism is especially potent in the presence of entrepreneurship, as entrepreneurs exhibit higher returns on wealth and saving rates.

Unlike income taxation—which applies uniform rates to income-rich workers and entrepreneurs—progressive housing taxation implicitly favors entrepreneurs by taxing them less at equivalent income and wealth levels, due to their lower housing exposure. High-ability entrepreneurs, who also save at higher rates, can expand their business, raising aggregate production and wages. In doing so, it mitigates the trade-off inherent in progressive income taxation, which tends to suppress capital accumulation and thereby dampen output and wages.

Moreover, housing taxation proves more effective in smoothing consumption across the life cycle. Since income and consumption are imperfectly correlated—many retirees are consumption-rich but income-poor—income taxation is a weak tool for redistributing welfare from old to younger cohorts. In contrast, progressive housing taxation achieves this goal by making retaining large homes costly for income-poor retirees, thereby reallocating housing resources toward younger, liquidity-constrained households

5.2 Optimal Joint Housing and Income taxation:

Having presented the distinct macroeconomic effects of optimizing the housing and income tax schedules separately, we now turn to the jointly optimal design of income and housing taxation. Specifically, we optimize the tax system over four parameters: the level and progressivity of both income and housing taxes ($\tau_y^{lev}, \tau_y^{prog}, \tau_h^{lev}, \tau_h^{prog}$). As in the previous section, we allow for subsidies in both income and housing tax schedules and restrict our attention to budget-neutral reforms. The objective remains to maximize the expected lifetime welfare of a newborn in steady state.

Table 6, 4th column, presents the optimal tax parameters together with equilibrium prices and aggregates. What stands out is the nearly flat and sizable income tax, under which all households contribute 53% of their earnings. Interestingly, this elevated uniform rate remains below the tax rates faced by the top 1% of earners under the *Opt Y* reform (see fig. 5b). Redistribution is implemented entirely through a steeply progressive housing tax schedule, whereby 98% of households receive subsidies, with an average effective subsidy rate of 12.9%[14].

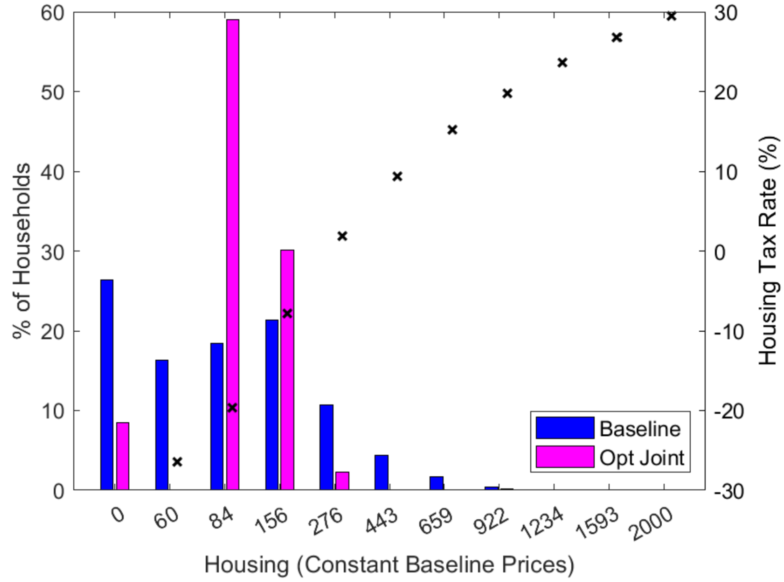
As fig. 7a shows, the net housing subsidies account for a massive 68.3% of government revenues, and they are financed mainly by the flat income tax which stands at 113.0% of government revenues.The steepness of the tax schedule prevents households from living in houses much larger than the 0-tax threshold, which corresponds to the 85th percentile of the housing size distribution in the Baseline economy (fig. 6). The policy exerts effects on prices that are mix of the two separate policy changes. Housing price falls more than opt Y, and opt H, while interest rate rises moderately to 6.2%, and wage slightly falls by 2.6%.

Figure 7b plots the stocks of housing and capital in the economy. The housing stock decreases by 27%, and the capital stock decreases by 11%, half of the drop under opt Y. The housing stock also decreases by 26%, which is higher than what the decrease under both Opt Y and Opt H tax plans.

In term of consumption smoothing, the optimal Joint tax schedule reduces mean C_{tot} by 11%, but it also reduces the variance by 70%. Importantly it succeeds to reduce both intra-age C_{tot} variance, by 73%, as well as inter-age variance by, 54%. The capacity of the joint tax schedule to smooth consumption over the life-cycle, is key to understand why the welfare gains yield by the policy are much higher than the opt Y ones, even if under opt Y reduces mean C_{tot} by only 9%, and total variance by 71% (table 8).

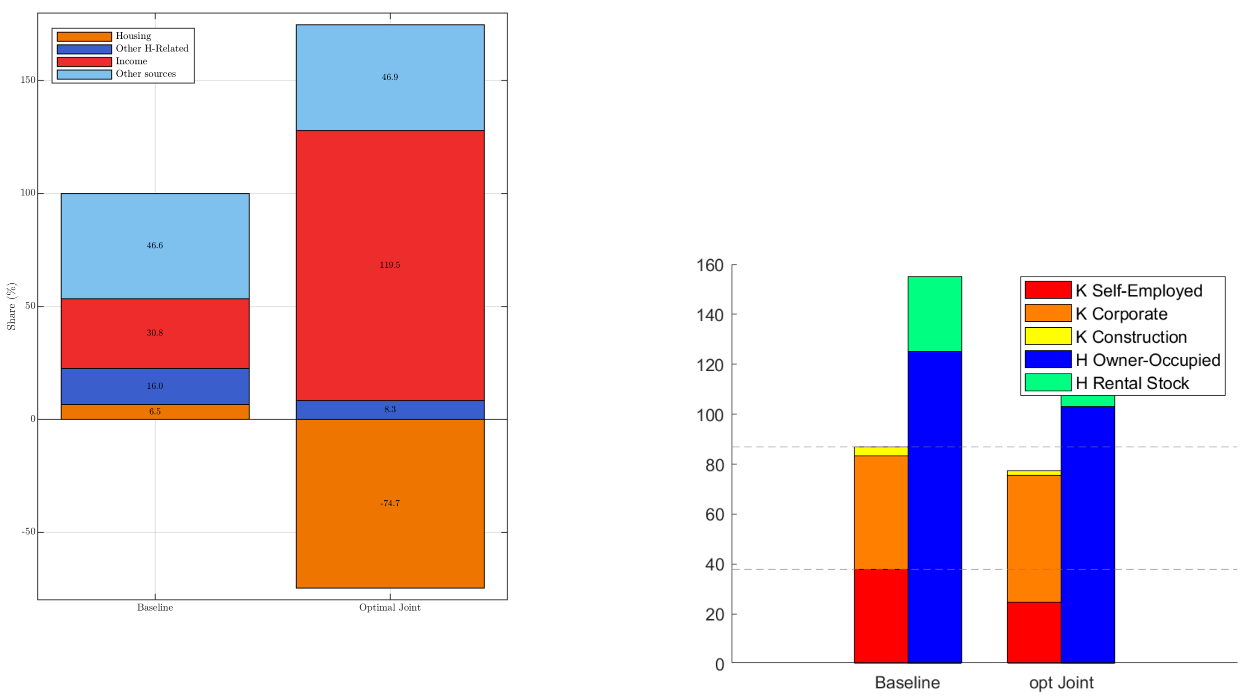
Figure 8 plot the 25th and 99th percentiles of (log) consumption and (log) housing services across age. Looking at the 25th percentile, consumption rises about 50% for those at their 30s, and about 20% for those above 60s, while housing

[14]The precise income and housing tax functions are depicted in fig. A3, in the appendix.



Note: The graph presents the housing ditribution (left axis) and the corresponding tax rates under Opt Joint (right axis) for each housing size. x-axis reports house values at constant baseline prices ($p_h = 1$). The first bin (0 housing value) corresponds to renting. Reported tax rates are percentage shares of housing values. In baseline calibration, the housing tax is flat and equal to 0.62%.

Figure 6: Housing distribution under optimal joint tax schedule



(a) Comparison of Revenue Shares

(b) Capital and Housing demand

Figure 7: Optimal Joint Housing and Income tax schedule:
Government Revenues and Resources Allocation

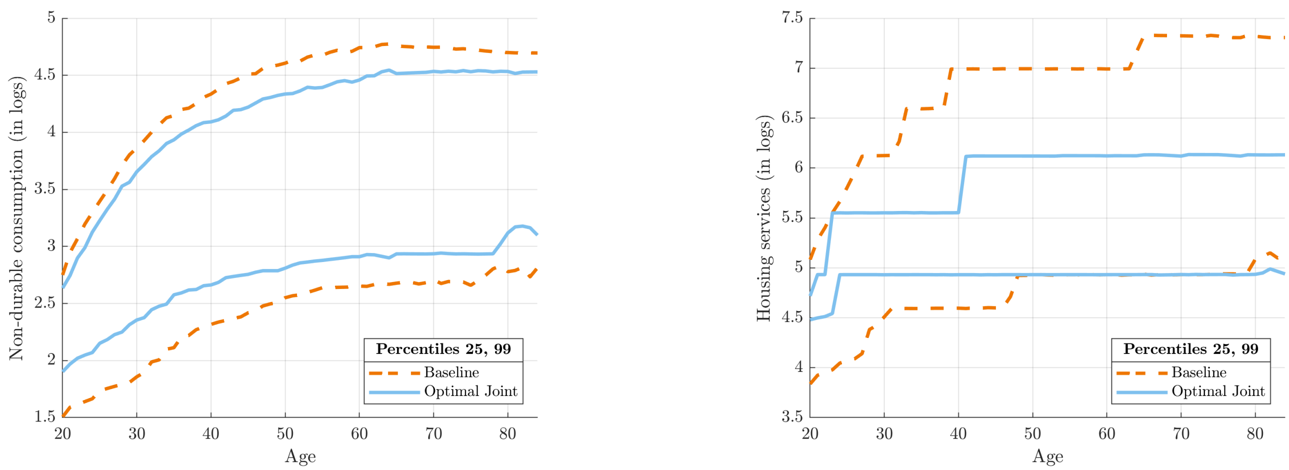
rises only for the young about 40%. The pattern shifts markedly at the top of the distribution: the 99th percentile of housing services declines sharply—by nearly 70% for older households and 35% for younger ones. Meanwhile,

Table 10: Consumption-Age Variance Decomposition: Optimal Joint Tax Schedule

	$E[C_{tot}]$	$Var(C_{tot})$	$E[Var(C_{tot}\|Age)]$	$Var[E(C_{tot}\|Age)]$
Baseline	53	2274	1950	323
Opt Joint	48	638	492	146

consumption at the 99th percentile declines more modestly, by roughly 20% for both young and old households. Notice that the policy change affects the housing choices at old age both directly, by taxing heavily large houses, and also through general equilibrium effects; while the drop in housing prices reduces the effects of progressive taxation, it also lowers the value of housing as a bequest, and the incentive to stay at large houses at old age.

Figure 8: Optimal Joint housing and income tax schedule:
Consumption and Housing Across Age



(a) Consumption-age Profiles

(b) Housing Sevices-age Profiles

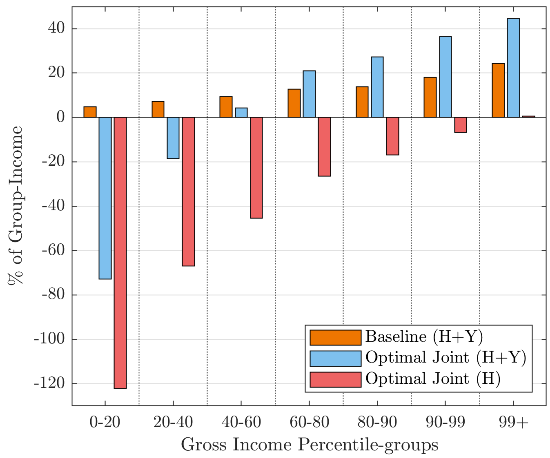
Note: Housing services (d) defined as in equation (12). That is: $d = h^r \mathbb{1}_{h=0} + \chi h \mathbb{1}_{h>0}$. The percentiles of consumption and housing services are compute using the invariant distribution for each age value.

Lastly, we explore how tax burdens are allocated among age,income and consumption bins, and compare it with the baseline tax schedule. For each bin, we aggregate taxes paid (or subsidies received) and income received by households, and report the ratio of the two.

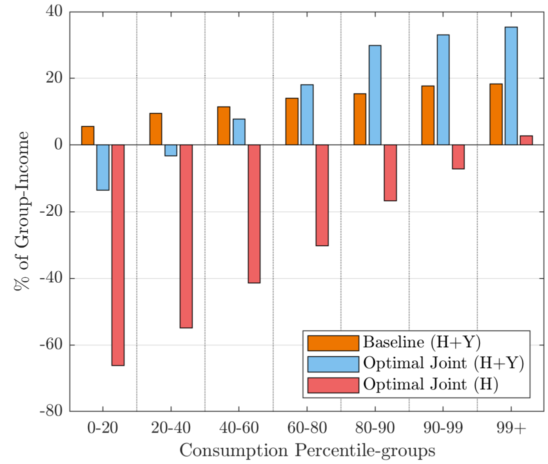
In terms of income, the total tax burden as a share of income for households in the upper 20% of the income distribution nearly doubles, while the bottom 40% receives massive subsidies equal to 34% of their income (fig. 9a). Crucially, the top 1% faces negligible housing tax, not only because their income is very large (a denominator in the reported ratio), but also because the high progressivity of housing taxation effectively prevents even the richest households from living at the upper h-gridpoints. For households in the bottom 40% income bin, housing subsidies are compensating for the high flat income tax, leading to a negative total tax burden. In terms of total consumption (C_{tot}), the picture is rather similar, again with households at the bottom 40% of total consumption receiving net subsidies, and net taxes being higher than baseline at the top C_{tot} bins (fig. 9b).

In fig. 9c we plot the net tax burden as a share of income for different age bins. We find that the policy increases the tax burden for households aged 36-50 and 51-65 by 7 p.p, due to the higher level of income taxation, but reduces the overall tax burden for retirees (aged 66+), since for the latter age bin, increased housing subsidies offset the effect of rising income taxation.

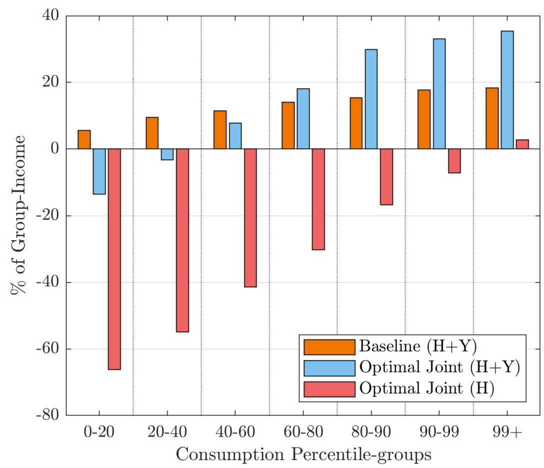
Figure 9: Tax burden under optimal joint taxation



(a) Tax burden by Income Bins



(b) Tax burden by C_{tot} bins



(c) Tax burden by Age bins

Note: Panels (a)–(c) split the population by income, consumption, or age bins. Each panel aggregates all taxes paid and all gross income received by households in each bin, and plots their percentage ratio. For consumption bins, total consumption $C_{tot} = c^{\alpha} d^{1-\alpha}$ is used.

Welfare Gains from the reform are a mix of *Opt Y* and *Opt H* reforms described above. For the newborns with the lowest combination of labor ability z and entrepreneurial ability θ they reach 103%, while the worst affected are the ones with the highest z and θ who lose 37%. Notice that these loses are still below the -50% welfare loss for this group under the *Opt Y* reform. Also in contrast to *Opt Y*, newborns with the middle of labor ability (z_4) and low entrepreneurial abilities face only mild welfare loss, around 5%. Overall, a majority of 67% of newborns would be better off if they were born in an economy that had implemented the Opt Joint reform.

Table 11: Newborns' Welfare Gains by Labor & Entrepreneurial Ability Rank, Opt Joint

	θ_1	θ_2	θ_3	θ_4
z_1	103.42 (5.46)	98.03 (0.29)	82.62 (0.11)	47.41 (0.26)
z_2	52.12 (22.05)	46.2 (1.17)	31.79 (0.45)	2.51 (1.04)
z_3	18.68 (33.62)	14.45 (1.79)	3.52 (0.68)	-17.75 (1.58)
z_4	-4.62 (22.05)	-6.22 (1.17)	-13.46 (0.45)	-27.93 (1.04)
z_5	-19.87 (5.46)	-20.56 (0.29)	-23.98 (0.11)	-33.61 (0.26)
z_6	-22.95 (0.58)	-24.26 (0.03)	-27.77 (0.01)	-36.95 (0.03)

Note: The cohort share of households for each combination of the labor z and entrepreneurial ability θ shock is reported in parentheses.

6 Sensitivity Analysis

6.1 Model Drivers: Entrepreneurship, Homeownership preference and Land

In section 5 we showed that the optimal joint income and housing tax schedule features a high (close to) flat income tax and a very progressive housing one. The model features several mechanisms that drive this result. First, income uncertainty and the borrowing constraint introduces different saving rates along the income distribution. Household with high income save a larger part of their income to ensure against a possible negative income shock. The savings of these households are crucial for supplying enough capital in the economy, raising productivity and wages. Therefore, an increase in progressivity of (income or housing tax), apart from insuring households against income risk, also has the negative side-effect of lowering mean consumption.

Second, entrepreneurship introduces a trade-off in raising the progressivity of both income and housing tax; as the tax burden for rich households increases, entrepreneurs are discouraged from operating at a larger scale, hurting the production of the consumption good and wages. Both the first and this channel act through capital accumulation, and therefore their effects are more intense under progressive income taxation; progressive housing taxation also introduces an incentive for rich households to shift their wealth allocation from housing to the financial asset, dampening the aforementioned effect on the capital stock.

Third, the preference of homeownership implies that there are large welfare gains from increasing the homeownership rate, even if the housing stock were constant. This can be done even by lowering the after-tax price of housing for poor households or by increasing their resources through income-tax redistribution

Lastly, in section 6.2 we show that the short-supply of land is important in proportion with the share of land in the construction's sector production function; the higher the land share the higher the benefits for a progressive housing taxation. If the construction is heavily dependent on land, then the elasticity of housing supply to price is low, and this implies that curbing the housing demand of rich households makes housing more affordable for the poor. We find that while a low elasticity of housing supply in itself doesn't imply that the optimal housing tax should be progressive, it does increase the optimal progressivity of the housing tax when other mechanisms that ask for progressive housing taxation are present.

To investigate the role of the 3 factors, we first shut down all 3 channels, by setting the mean entrepreneurial ability $\bar{\theta}$ equal to ϵ ("No Self-employed"), the preference for homeownership χ equal to 1 ("No Home-Ownership") [15], and the share of land in the construction's sector production function α_L^h equal to ϵ ("No Land"). We solve for the joint income and housing taxation schedule that balances the budget and maximizes the utility of the newborn in the steady state.

[15] In our model, setting $\chi = 1$ is enough to bring homeownership rate to 0.

We then compare the results with optimal tax values of alternative models in which we turn on each channel at once.

Table 12 presents the results. In the stripped-down model in which there are no-entrepreneurs, no preference for homeownership and no land, the optimal housing is a flat one and significant, at about 2.7%. Redistribution should be performed in this model by a highly progressive income tax. Notice that this is the exact opposite of the optimal tax schedule in the baseline model.

Table 12: Optimal Taxation Parameters Sensitivity

	τ_h^{lev}	τ_h^{prog}	τ_y^{prog}	τ_y^{lev}
No Land, No S.E.,No H.O.	0.973	0	0.518	0.83
Only Land	0.945	0	0.617	0.904
Only S.E.	1.048	0.082	0.001	0.6
Only H.O.	0.745	0.076	0.858	0.947

Notes: The table presents the tax parameters of the jointly optimal income and housing tax schedules, under different model assumptions. In "No Land, No S.E., No H.O." model, land has a 0.1 weight in construction sector's production funciton, all agetns have insignificant entrepreneurial ability and there is no preference for homeownership. In the following 3 experiments, we turn on each assumption at once.

We find that introducing land in the construction sector's production function, is not able by itself to change the results of the optimal tax plan qualitatively. The income progressivity rises significantly, and the optimal level of the flat housing tax increases.

The key assumption in our model turns out to be incorporating entrepreneurship. The adverse effects of progressive income taxation on the wealth accumulation of entrepreneurs are enough to bring down the optimal income tax progressivity close to 0, as in the baseline model. Housing taxation turns significantly progressive, and the optimal flat tax on income is high, at 40%, similar to the baseline results.

Lastly, the preference for homeownership channel is characterized by a very high income tax progressivity and a housing tax that features both a very high level and significant progressivity.

6.2 The Role of the Elasticity of Housing Supply

Having shown that modeling an inelastic housing supply doesn't yield in itself an optimal tax schedule with a progressive housing tax ("Only Land" results), we now describe its role in affecting quantitatively optimal tax parameters in the presence of entrepreneurship and preference for homeownership. In the baseline we rely on the results of Cavalleri et al. (2019) who provide a point estimate of 1.17, nevertheless it is important to know whether the optimality of the progressive housing tax schedule relies on the low value of this parameter. We assume two alternative values for this elasticity: 10 (high supply elasticity scenario) and 0.1 (low supply elasticity scenario).

The elasticity in our model directly pins down the share of land in the construction sector's production function, as $\epsilon_h = \frac{\alpha+\beta}{1-\alpha-\beta}$ Maintaining the normalization $p_h = 1$ at Baseline requires also rescaling the amount of land in the economy $\bar{L}$ in the economy. Since construction firm's profits are collected by the government, the government expenditure also needs to be adjusted. The rest of the calibrated parameters are not affected, as well as the simulated moments.

The optimal *Joint* counterfactuals for the two scenarios are reported in table 13. The results suggest that the housing supply elasticity significantly affects the degree of progressivity and the corresponding welfare gains. Nevertheless,

Table 13: Optimal *Joint* Taxation Parameters
Under Different Housing Supply elasticities

		Baseline Economy	Low elasticity $\epsilon_h = 0.1$	Main estimate $\epsilon_h = 1.17$	High elasticity $\epsilon_h = 10$
Tax Parameters					
τ_h^{lev}	Housing tax level	0.9938	1.3352	1.1186	1.0833
τ_h^{prog}	Housing progressivity	0.0000	0.4148	0.1667	0.1074
τ_y^{lev}	Income tax level	0.8817	0.4028	0.4709	0.5268
τ_y^{prog}	Income progressivity	0.0996	0.0185	0.0010	0.0056
Tax Structure					
Effective income tax rate (%)		13.471	59.838	52.914	47.366
Share of hhs paying income Tax		77.290	100	100	100
Effective housing tax rate (%)		0.620	-26.856	-12.905	-8.785
Share of hhs paying housing Tax		100	2.361	2.35	3.629
Prices					
p_h	Housing price	1	0.314	0.74	0.945
p_r	Rental price	0.051	0.002	0.04	0.054
r	Interest rate (%)	5.654	5.735	6.24	6.401
w	Wage	1	0.996	0.97	0.967
Aggregate Variables					
Production		100	100.3	97.4	95.0
Aggregate Capital		100	94.2	89.1	88.24
Real housing stock		100	89.3	72.7	73.0
Rental stock		100	20.3	31.9	48.2
Net Wealth		100	51.7	66.1	75.8
Share of homeowners		73.7	95.5	91.5	86.0
Welfare ($\Delta\%$)		–	42.37	22.23	13.15

in both cases the income tax is close to flat. A significant difference lies in house prices which drop only by 5% when $\epsilon_h = 10$, but by 70% when $\epsilon_h = 0.1$. The latter may explain why the income tax progressivity under low housing supply elasticity is low but close to 0.02; when redistributing through housing subsidies that are calculated based on house values has limits, the very low house prices limit the effectiveness of the tax instrument. Welfare gains are significantly larger when the housing supply elasticity is smaller for two reasons. First, low house prices exert a diminished pressure on real housing stock, so households enjoy more housing services on average. Second, the muted response of housing supply allows for a steeper housing tax schedule: this is especially important for wealthy households who lift their portfolio from housing to deposits and help the economy sustain a large capital stock, only 5.8% lower than baseline, and maintain production of consumption's good at the same levels.

7 Conclusion

We examine the impact of introducing a progressive housing tax in a heterogeneous-agent model that incorporates housing and entrepreneurship. Using Spain as our laboratory, our findings suggest that the optimal progressive housing tax schedule enhances the welfare of newborns by 13.2% in consumption-equivalent terms—slightly surpassing the gains from optimizing the income tax schedule (11.6%). While progressive income taxation reduces consumption variance within age cohorts at the expense of a diminished capital stock, progressive housing taxation fosters capital deepening and shifts consumption from wealthy, older households toward poorer, younger ones.

When jointly optimizing the housing and income tax schedules, we find that the optimal policy involves imposing a flat, high income tax rate and redistributing the resulting revenues through a highly progressive housing tax. This combined approach yields welfare gains of 22.2%, primarily driven by improved consumption smoothing both across the life cycle and within age groups. Moreover, joint optimization mitigates the decline in capital stock typically associated with high income tax rates. These optimality results critically depend on the inclusion of entrepreneurship in the model: income tax-based redistribution imposes efficiency costs by discouraging business expansion among entrepreneurs. In contrast, progressive housing taxation incentivizes the wealthiest households to increase deposit savings, thereby promoting capital deepening and reducing house prices—benefiting younger and poorer households. The more inelastic the housing supply, the stronger the equilibrium effects on prices and the greater the resulting welfare gains.

Our findings broadly align with and extend the existing literature on housing taxation. As shown in (Balke et al., 2025) and (Rotberg, 2022), housing taxes promote capital deepening and reallocate consumption from older to younger households. In our framework, the costs of progressive income taxation stem from the inclusion of entrepreneurship, but other mechanisms – such as endogenous labor supply or human capital accumulation— would likely reinforce our results. Indeed, (da Costa & Santos, 2023) demonstrates similar dynamics in the context of progressive consumption taxation within an overlapping generations Bewley model featuring endogenous labor supply. In this sense, housing taxation in our model can also be interpreted as a form of consumption tax.

Our analysis highlights the potential of progressive housing taxation to generate substantial welfare gains. However, these results warrant cautious interpretation. First, a key mechanism in the model is that reducing housing demand among wealthy households lowers house and rental prices for poorer households. This link may weaken if rich and poor households occupy distinct housing segments (e.g., holiday homes vs primary residences). In such cases, progressive housing taxation may still yield benefits through portfolio reallocation by the rich, but the welfare gains for poorer households could be attenuated. Second, our model abstracts from house price uncertainty. High transaction costs combined with price volatility may temper the welfare benefits of the policy. Third, we treat savings in rental housing as equivalent to deposits. Introducing frictions such as illiquidity or minimum investment thresholds for real estate could alter the results. On one hand, higher returns on real estate investments may amplify the redistributive potential of progressive taxation. On the other hand, illiquidity could reduce the optimal degree of housing tax progressivity. These are promising avenues for future research.

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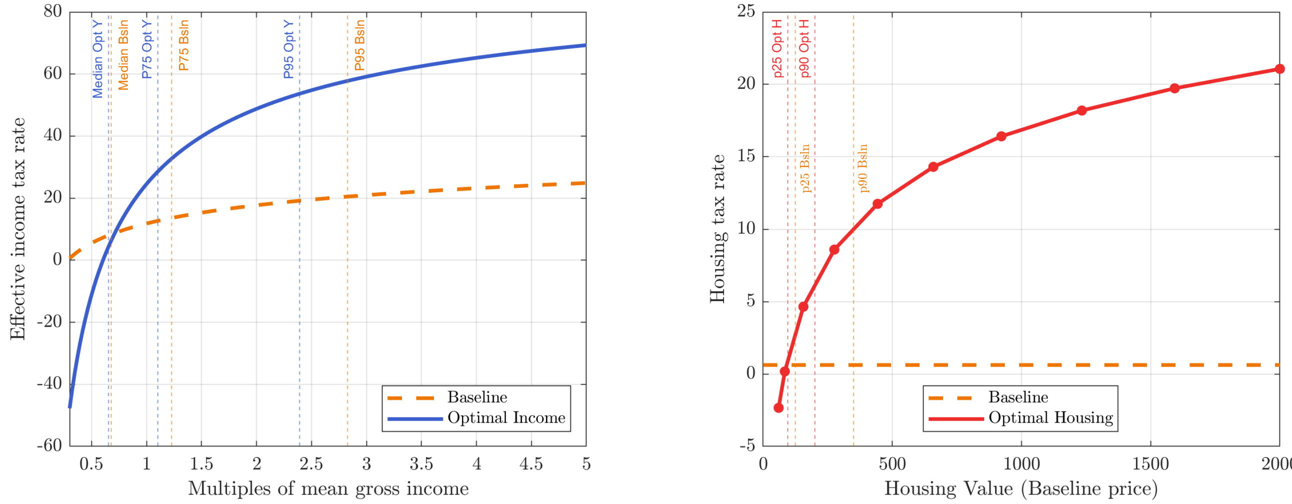
A Additional figures

Figure A1: Optimal Tax Functions: Optimal Income vs. Optimal Housing tax schedules



(a) Optimal Income Tax Function

(b) Optimal Housing Tax Function

Note: this figure plots the optimal tax functions described in section 5. Panel (a) plots the optimal income tax function (*Opt Y* in the main text) and panel (b) describes the optimal housing tax schedule (*Opt H*). The circles denote tax rates at the housing grid points.

Table A1: Housing portfolio Share by Labor (z) and Entrepreneurial Ability (θ) Rank

(a) Baseline

	θ_1	θ_2	θ_3	θ_4
z_1	54.2	49.6	43.9	39.3
z_2	61.3	54.1	45.8	39.3
z_3	58.2	52.6	46.0	38.5
z_4	57.3	53.3	46.6	38.5
z_5	47.8	46.4	42.0	37.0
z_6	30.4	31.0	31.9	33.7

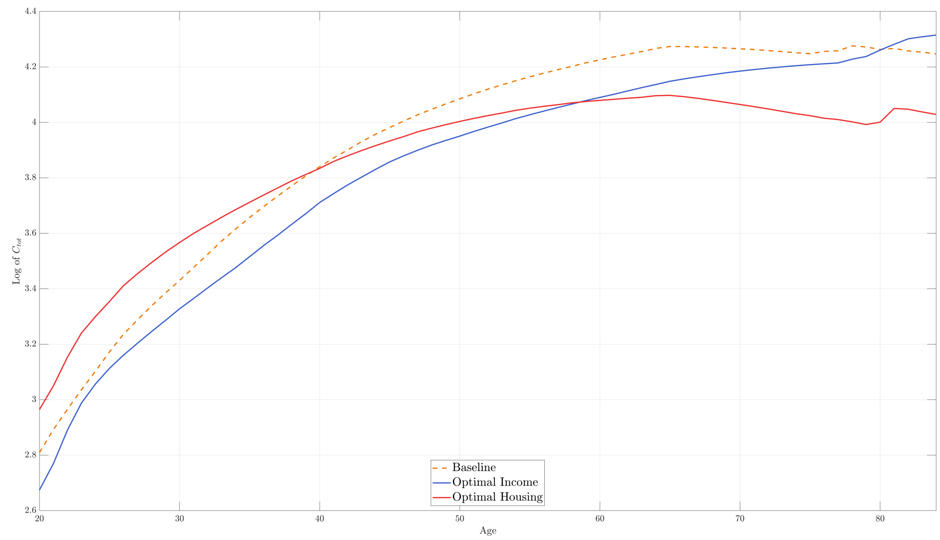
(b) Optimal Income Tax (*Opt Y*)

	θ_1	θ_2	θ_3	θ_4
z_1	86.2	81.5	77.4	75.6
z_2	81.7	79.6	77.6	76.0
z_3	77.5	75.9	75.2	75.0
z_4	75.4	72.9	72.6	74.5
z_5	64.2	65.8	68.0	73.3
z_6	43.6	44.2	45.8	50.0

(c) Optimal Housing Tax (*Opt H*)

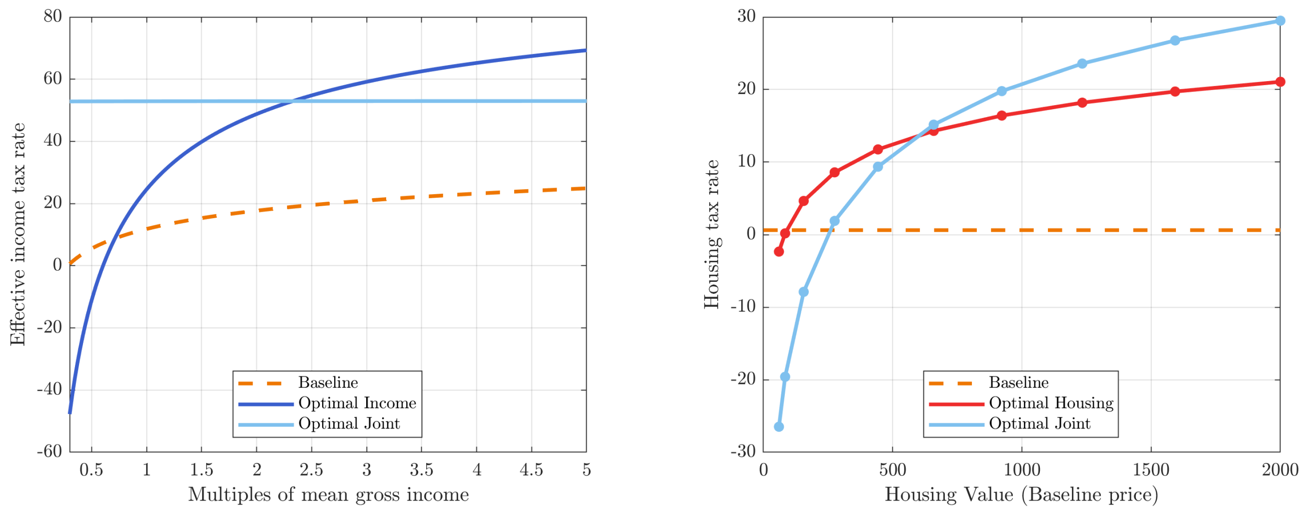
	θ_1	θ_2	θ_3	θ_4
z_1	84.2	58.6	38.8	27.7
z_2	81.0	59.2	39.3	27.5
z_3	59.8	51.4	37.3	26.7
z_4	59.8	50.4	37.0	24.9
z_5	38.4	35.9	29.8	22.5
z_6	17.9	17.9	17.7	16.8

Figure A2: Mean total consumption across counterfactuals



Note: The graph plot the average of total consumption (C_{tot}) defined as $c^{\alpha}d^{1-\alpha}$.

Figure A3: Optimal Tax Functions. Comparison with the optimal joint tax schedule.



(a) Optimal Income Tax Function

(b) Optimal Housing Tax Function

Note: this figure plots the optimal tax functions described in section 5. Panel (a) plots the optimal income tax function (*Opt Y* in the main text), the optimal income schedule under the joint optimization (*Opt Joint*), and the baseline income tax function. Panel (b) describes the housing tax schedules that correspond to the same two counterfactuals. The circles denote tax rates at the housing grid points.

B Further model detail

B.1 Dynamic problem of retired households

The problem of the retirees is analogous to the working-age maximization problem described in Section 2. As in that case, the problem of the retirees in divided into a first stage (Equation (30)), where households optimize on the controls that are realized on the current period; and a second stage where households maximize over their future states (eq. (31)).

In the first stage, a retired household decides on the amount of current non-durable consumption c, the savings for the next stage s, and current size of their dwelling if the household is a renter. That is, if the current holding of their housing wealth are zero ($h = 0$).

$$
\begin{aligned}
& \mathcal{V}_j(a, h, z, \theta) = \max_{c,s,h^r} \frac{u(c, d)}{e_j} + \tilde{\mathcal{V}}_j(s, h, z, \theta) \\
\text{s.t.} \quad & j \geq R \\
& c + s + (p_r + t_h(h^r)p_h)h^r \mathbb{1}_{h=0} \leq a + y_p - p_h\, h\, \delta_h - p_h\, t_h(h) - t_w\big(a + p_h\, h\big) \\
& y_p = w\, \bar{p}\, q(R)\, z - t_y\big(w\, \bar{p}\, q(R)\, z\big) \\
& d = h^r\, \mathbb{1}_{h=0} + \chi\, h\, \mathbb{1}_{h>0} \\
& s \geq 0, \quad h^r \geq 0
\end{aligned}
\tag{30}
$$

The main difference with respect to the first stage of working-age households resides in the lack of occupational choice. Instead, retirees receive a fixed pension, which is also subject to progressive income taxation.

The second stage also resembles the one of working-age households. Nevertheless, notice that retired households are no longer subject to labor productivity or entrepreneurial ability shocks. Thus, the only uncertainty the household face is about survival for the next period. Additionally, we restrict retirees from taking mortgages in order to finance the purchase of a dwelling.

$$
\begin{aligned}
& \tilde{\mathcal{V}}_j(s, h, z, \theta) = \max_{h', a'} \beta\, \zeta_j\, \mathcal{V}_{j+1}(a', h', z, \theta) + \beta\, (1 - \zeta_j)\, \Phi(b) \\
\text{s.t.} \quad & j \geq R \\
& p_h\, h' + p_h\, C_{adj}(h, h') + a' \leq s + p_h\, h \\
& C_{adj}(h, h') = \mathbb{1}_{h \neq h'}\big(\psi_s\, h + (\psi_b + \tau_h^t)\, h'\big) \\
& b = p_h\, h' + a' - \psi_s\, p_h\, h' - t_{inh}\big(p_h\, h' + a'\big) \\
& a' \geq 0 \quad h' \in \hat{\mathcal{H}} = \{0, h_1, h_2, \ldots, h_N\}
\end{aligned}
\tag{31}
$$

C Computation

C.1 Model Computation

To solve the model we rely on the Markov chain approximation method developed in (Bakota & Kredler, 2022),which we adapt to deal with features specific to our environment. The methodleverages the insight that during a single period most of the agents move no further away than a single on the financial asset grid, allowing the use of first-order conditions in those cases.In infinite-horizon settings, reducing the model period can ensure that it is never optimal to move beyond one gridpoint. However, in finite-horizon problems, wealthy households approaching the end of life have strong incentives to deplete their assets. To deal with this behavior, we extend the original algorithm by searching across segments of the financial asset grid for state values where agents may optimally move more than one gridpoint. Because the value function features kinks—arising from occupational choices and the discrete nature of housing—this extension requires searching over non-adjacent grid segments whenever such discontinuities are present. To limit the computational burden, we restrict the extended search to two cases: for kinks above the current gridpoint, we search only if the move is affordable; for kinks below, we exploit the monotonicity of the policy function and search only if the optimal saving choice at the previous gridpoint lies below the kink.

Another computationally intensive component of the paper is the joint maximization problem. Since we focus on budget-neutral reforms, we search over the three-dimensional space spanned by $(\tau_h^{lev}, \tau_h^{prog}, \tau_y^{prog})$ and for each combination of them we find the implied τ_y^{lev} that balances the government budget. This is a non-differentiable and potentially non-convex problem, with a costly to evaluate objective function. To address this, we employ global optimization algorithms that require only continuity of the objective function. Specifically, we use the Dividing Rectangles. Specifically, we use the Dividing Rectangles (DIRECT) algorithm as described in (Jones & Martins, 2021) which guarantees convergence to the global optimum as the number of function evaluations increases. To validate our results, we also apply MATLAB's surrogateopt function, which implements a surrogate-based optimization approach.

D Calibration Details

D.1 Regression results

In Table D1 we report the linear regression coefficients that we used in Section **??** to construct smoother function of the data. We only regress on age because we are only interest in obtaining the mean outcome by age. The first regression result corresponds to the death probability. The data is taken directly from the INE.

The variable s_j^{inh} stands for the inheritance share by age, measured in percentage points. For the largest assets (such as housing or a business) the EFF reports whether those assets were inherited or received as gifts. Nevertheless we cannot directly use this variable since we would overestimate the share of inheritances in later life stages. Thus, we construct an indicator variable that tells us if a household received an significant inheritance (such as a house) in the last 3 years. Then for each survey year we obtain a share of households that received a significant inheritance by age (20 to 85 years old). It is like a synthetic cohort panel structure, but since we are only interested in the average share by age we just regress all of these observations into a third degree polynomial. This will help us achieve a doubled-hump shape, consistent with the data.

The forth column represents fit of the equivalence scale. We define the equivalence scale using the standard OECD definition.

Lastly, we regress labor income onto a second-degree age polynomial. We define labor income as wages, in kind benefits as well as unemployment benefits. We use this results to retrieve the age-specific component of labor productivity, common to all households.

Table D1: Regression Results

	$ln(\zeta_j)$	s_j^{inh}	$ln(e_j)$	$ln(y)$
c	8.050	25.113	-0.4669	9.0426
age	-1.200	0.0726	0.0539	0.0497
age^2	0.0435	-0.0009	-0.0008	-0.0006
age^3	-0.0007	0.000006	0.0000013	
age^4	0.0000			
age^5	-0.0000			
N	76	527	6.298	3.146
R^2	0.999	0.1724	0.3026	0.0047

D.2 Calibrated parameters

The full set of labor ability levels z and the associated transition matrix is given by:

$$z = \{z_1, ..., z_6\} = \{0.23, 0.52, 1, 1.95, 3.79, 13.54\}$$

$$\Lambda_z(z' \mid z) = \begin{pmatrix} 0.9217 & 0.0752 & 0.0023 & 0.0000 & 0.0000 & 0.0008 \\ 0.0188 & 0.9228 & 0.0565 & 0.0012 & 0.0000 & 0.0008 \\ 0.0004 & 0.0376 & 0.9232 & 0.0376 & 0.0004 & 0.0008 \\ 0.0000 & 0.0012 & 0.0565 & 0.9228 & 0.0188 & 0.0008 \\ 0.0000 & 0.0000 & 0.0023 & 0.0752 & 0.9217 & 0.0008 \\ 0 & 0 & 0.1143 & 0 & 0 & 0.8857 \end{pmatrix}$$

The inheritance statutory tax schedule is taken from Fuster (2022) and reproduced in table D2 below.

Table D2: Inheritances: statutory tax schedule

	Bequest Brackets (thousand Euros)							
Tax Brackets	0–8	8–16	16–24	24–32	32–40	40–48	48–56	56–64
Tax Rates	0.0765	0.0850	0.0935	0.1020	0.1105	0.1190	0.1275	0.1360
Tax Brackets	64–72	72–80	80–130	130–160	160–240	240–400	400–800	+800
Tax Rates	0.1445	0.1530	0.1615	0.1870	0.2125	0.2550	0.2975	0.3400

E Additional Results

E.1 Optimal flat vs. progressive housing taxation

In this section, we examine the effects of adjusting only the progressivity or only the level of housing taxation. We search over budget neutral changes, and use the level of income taxation to balance the budget. We don't allow for subsidies at any tax schedule, i.e. we truncate income and housing taxes at 0 in both experiments.

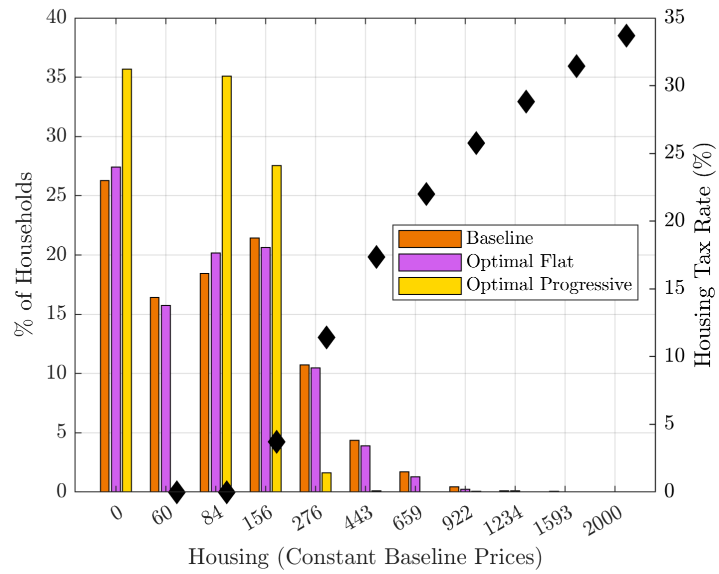
In Table E1 we report the result of the first experiment, under the "Flat" column. We find that the flat housing tax rate that maximizes welfare is 2.13%, significantly higher than the current 0.62%. Meanwhile, the average effective income tax rate decreases from 13.50% in the baseline economy to about 8.20%. The increase in the housing tax shifts the housing consumption towards smaller units (fig. E1) and slightly reduces homeownership by 1.1 percentage points. Households reallocate their savings away from housing—whose aggregate stock contracts by 6.5%—toward financial assets, which expand by 5.4%. This reallocation boosts capital accumulation, resulting in a 3.4% increase in output, a 3.3% rise in wages, and a decline in the interest rate. Households that were previously paying a positive income tax rate experience an increase in their after-tax labor income larger than the rise in wages because of the fall in income tax rates. Overall, the productivity gains from higher capital stock outweigh the welfare losses associated with more expensive after-tax housing. As a result, the reform delivers modest welfare improvements of approximately 1%.

Table E1: Flat vs. progressive housing taxation

		Baseline	Flat	Progressive
Tax Parameters				
τ_h^0	Housing tax level	0.9938	0.9787	0.9938
τ_h^1	Housing progressivity	0	0	0.1460
τ_y^0	Income tax level	0.8817	0.9448	0.8841
τ_y^1	Income progressivity	0.0996	0.0996	0.0996
Tax Structure				
Effective income tax rate (%)		13.471	8.184	13.491
Share of hhs paying income Tax		77.290	57.415	80.144
Effective housing tax rate (%)		0.620	2.130	1.866
Share of hhs paying housing Tax		100	100	29.684
Prices				
p_h	Housing price	1	0.983	0.832
p_r	Rental price	0.051	0.043	0.031
r	Interest rate (%)	5.654	4.979	4.723
w	Wage	1	1.033	1.047
Aggregate Variables				
Production		100	103.4	105.1
Financial wealth		100	105.4	113.0
Real housing stock		100	93.5	75.6
Rental stock		100	93.5	134.5
Net Wealth		100	98.4	81.0
Share of homeowners		73.7	72.6	64.3
Welfare (Δ%)		–	0.99	10.24

In the second counterfactual, we report the optimal progressivity scenario. In this case we keep the tax level parameter fixed and only adjust the progressivity parameter. To balance the government budget the level of income taxation is adjusted. This counterfactual yields significantly higher welfare gains (10.24% vs 0.99%) and presents similar results to the flat case in the aggregate. As before, we see an increase in the supply of capital due to the higher housing taxation and lower investment in real estate, which ultimately leads to a higher production (+5.1%).

Figure E1: Distribution of households over the housing grid



The main differences emerge in the housing distribution. Figure E1 displays the distribution of homeowners across the housing grid, the share of renters, and the corresponding effective tax rates. The optimal progressive schedule imposes very high rates on large housing units—exceeding 20%—while smaller dwellings are almost exempt, creating bunching just below and above the zero-tax threshold. Under this schedule, only about 30% of households effectively pay the tax. The resulting decline in demand for large houses leads to a substantial contraction in overall housing demand and a 27% reduction in aggregate housing price.

Notice that, somewhat surprisingly, the aforementioned decline in the housing price does not lead to an increase in homeownership. Moreover, the homeownership rate decreases by 9.4 p.p. This occurs because rental prices fall more than house prices (-39%)[16], driven by the combined effect of lower housing prices and a reduced interest rate. On the other hand, lower-income households experience only a modest increase in purchasing power from higher wages (+4.7%), leading them to take advantage of lower rents and allocate more resources to non-durable consumption. As a result, younger households (less than 40 years old) increase their total consumption, defined as $c^{\alpha}d^{1-\alpha}$, and thus welfare.

Another difference is in the revenue side. Notice that under the optimal flat schedule there is a shift in taxation from labor income to housing wealth, while this is no the case in the progressive case. Notice that the effective income tax rate remains virtually the same, and so does the income level parameter that is used to adjust the government balanced budget. This means that – as opposed to flat taxation– the optimal progressive schedule is not bringing new revenues, its a tool to adjust the housing demand and allow for a re-distribution of housing wealth. Renters and poorer households can afford a bigger house due to the lower price and tax rate, while the richest are restricted from buying big houses

[16]This change is before taxes, if we take into account that renters paid taxes in the baseline the fall is higher (-55%).

units by the extremely high tax rates.

E.2 Flat vs. progressive taxation with lump-sum transfers

In section E.1 we have shown the different channels through which a progressive and a flat housing tax operate. To show it we have computed the optimality of the level (τ_h^{lev}) and progressivity (τ_h^{prog}) parameters while adjusting the income-tax level parameter (τ_y^{lev}) to balance the government budget.

To show that our results do not rely on the changes in the income tax function here we compute the same experiments while using a lump-sum taxes/transfers[17] to adjust the government budget. The main results are summarized in Table E2 and in figure E2 we plot the distribution of households over the housing grid.

Table E2: Flat vs. progressive housing taxation under lump sum transfers

		Baseline	Flat	Progressive
Tax Parameters				
τ_h^{lev}	Housing tax level	0.9938	0.90	0.9938
τ_h^{prog}	Housing progressivity	0	0	0.0889
$T/\bar{y}$	Lump sum transfer	0	15.40	0.545
Tax Structure				
Effective housing tax rate (%)		0.62	10	1.788
Share of hhs paying housing Tax		100	100	36.50
Prices				
p_h	Housing price	1	0.777	0.860
p_r	Rental price	0.057	0.103	-
r	Interest rate (%)	5.654	4.403	4.801
w	Wage	1	1.065	1.043
Aggregate Variables				
Production		100	107.1	104.6
Financial wealth		100	93.2	109.8
Real housing stock		100	68.1	79.0
Rental stock		100	23.7	120.0
Net Wealth		100	76.6	83.8
Share of homeowners		73.7	89.8	67.3
Welfare (Δ%)		–	14.12	10.68

We see that the main results still hold. Increases in the flat taxation are used to shift the tax burden towards housing wealth, while the progressive parameter is used as a distributional tool to prevent households from accumulating big houses. Nevertheless, there are also some notable differences. The main one is that the optimal flat tax is now significantly higher (10% vs. the 2.13%) and provides significantly higher welfare gains, even higher than the progressive experiment. The reason is that the lump sum transfers benefit disproportionately the households with the lowest income, as opposed to the previous adjustments in the income tax function through τ_y^0. This is so because the lowest income households are already not paying the income tax. Remember that in the baseline only 77% of the households

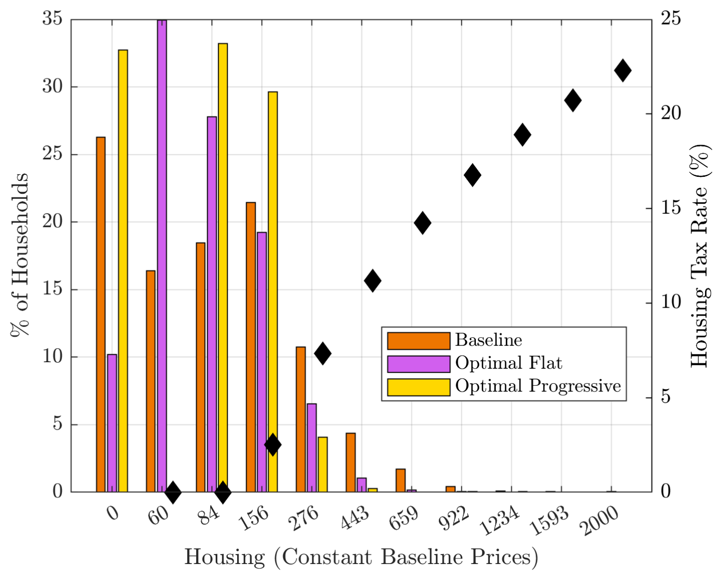
[17] We are not restricting the transfers to be positive. Nevertheless, we restrict the minimum flat tax rate to be zero. If the flat tax rates were to be sufficiently negative it could incentivize renters to get extremely big houses, since we are not restricting their choices to a grid. Thus, we refer to lump sum transfers, as opposed to taxes, just because in both experiments it is optimal to tax housing more than in the baseline and subsidize households through transfers.

are effectively paying the income tax, thus shifts in the income tax function do not benefit the poorest households, which are the ones driving our welfare results.

As for the effects in the housing distribution, under the optimal flat tax the price the households decide to shrink their housing units. This lower demand drives down the housing price (-23%) and paired with the higher income due to the lump sum transfers, allows poorer households to access homeownership. Thus, we observe a decrease in the average house size together with higher homeownership rate (+16 p.p.). This increase is driven by higher rental prices and the significant transfers to the poorest households, which allows them to overcome the borrowing constraints.

In the progressive counterfactual, we observe similar effects as before. It is optimal to use it as a distributional tool, instead of using it to have extra revenue. This can be seen in the value of the lump sum transfer under the two experiments. In the flat one it accounts for around 15% of the mean income, while in the progressive experiments it is only 0.5% of the mean income.

Figure E2: Distribution of households over the housing grid



E.3 No subsidies case

In section 5 we have presented three experiments for the optimal housing tax schedule (*Opt H*), the optimal income tax schedule (*Opt Y*) and the optimal *Joint* counterfactual which delivers the optimal combination of both tax schedules. In all of those cases we have allowed for potential subsidies in both the income and housing tax functions. Here we restrict the progressive schedules as to not allow subsidies.

Without subsidies there is more role for housing progressivity in the model. As shown in table E3 the welfare gains from the *Opt H* scenario (9.05%) are much higher than the one from *Opt Y* (1.02%). The reason is that in the baseline the income-poorest households do not pay income taxes, so higher progressivity is not relieving the tax burden of that 23% of the households that were not paying taxes in the baseline. Housing taxation, on the contrary, improves the welfare of the poorest households directly *via* lower tax burden and indirectly through general equilibrium effects: lower housing price and interest rate paired with higher wages.

To clarify the distributional effects, table E4 reports welfare changes for newborns by initial productivity and en-

Table E3: Housing vs Income Taxation Results (without subsidies)

			Optimal Counterfactual		
		Baseline	Income	Housing	Joint
Tax Parameters					
τ_h^{lev}	Housing tax level	0.9938	0.9938	1.0070	0.9719
τ_h^{prog}	Housing progressivity	0	0	0.1494	0.0861
τ_y^{lev}	Income tax level	0.8817	0.9016	0.8817	0.9132
τ_y^{progw}	Income progressivity	0.0996	0.2222	0.0996	0.1778
Tax Structure					
Effective income tax rate (%)		13.471	14.400	13.697	12.924
Share of hhs paying income Tax		77.290	47.928	79.426	55.135
Effective housing tax rate (%)		0.620	0.620	1.437	2.525
Share of hhs paying housing Tax		100	100	33.195	31.405
Prices					
p_h	Housing price	1.000	0.964	0.865	0.792
p_r	Rental price	0.057	0.058	0.0257	0.0277
r	Interest rate (%)	5.654	6.030	4.886	4.699
w	Wage	1	0.983	1.038	1.048
Aggregate Variables					
Production		100	98.0	104.2	105.1
Financial wealth		100	90.4	118.2	97.8
Real housing stock		100	98.2	79.8	71.0
Rental stock		100	85.0	162.1	68.5
Net Wealth		100	94.2	84.0	76.5
Share of homeowners		73.7	75.8	59.0	77.5
Welfare (Δ%)		–	1.02	9.05	12.18

trepreneurial shock.[18] Under the *Opt H* scenario, households with higher initial abilities experience the largest welfare gains, and all ability groups benefit on average. In contrast, *Opt Y* reduces welfare for both high- and low-ability households. Low-ability households do not benefit from the policy because they: 1) gain little, or nothing, from tax reductions; 2) face lower wages; and 3) are burdened by higher interest rates that increase rental and mortgage costs. The decrease in the housing price (-3.6%), increases homeownership but many households postpone the purchase of their first home to avoid taking mortgages.

Notice that the high welfare gains of the optimal housing policy are paired with a decreasing homeownership rate; which indicates that the bulk of welfare gains is not due homeownership preference. Similar to appendix E.1, both house prices and rental prices drop, exerting opposite effects on homeownership. Eventually the effects from the drop in rental prices dominate in this experiment and homeownership decreases by 15 percentage points.

The biggest difference between the counterfactuals with and without subsidies is in the results for the *Joint* taxation experiment. In the case with subsidies, the optimal tax schedule was to impose a high and flat income tax rate (53%) while using a progressive housing tax to redistribute subsidies towards housing. Without subsidies the optimal schedule relies on the progressivity on both, income and housing, to redistribute resources. Higher income tax rates at the top

[18]Because these shocks are persistent, they are good predictors of households' relative income and wealth over the life cycle.

Table E4: Newborns' Welfare Gains by Labor & Entrepreneurial Ability Rank

(a) Optimal income tax

	θ_1	θ_2	θ_3	θ_4
z_1	-1.00 (5.46)	-0.92 (0.29)	-0.82 (0.11)	-1.65 (0.26)
z_2	0.27 (22.05)	0.44 (1.17)	0.46 (0.45)	-2.13 (1.04)
z_3	3.07 (33.62)	2.91 (1.79)	1.81 (0.68)	-3.54 (1.58)
z_4	1.33 (22.05)	1.10 (1.17)	-1.32 (0.45)	-7.79 (1.04)
z_5	-3.58 (5.46)	-3.90 (0.29)	-5.61 (0.11)	-11.61 (0.26)
z_6	-10.34 (0.58)	-10.62 (0.03)	-11.93 (0.01)	-16.91 (0.03)

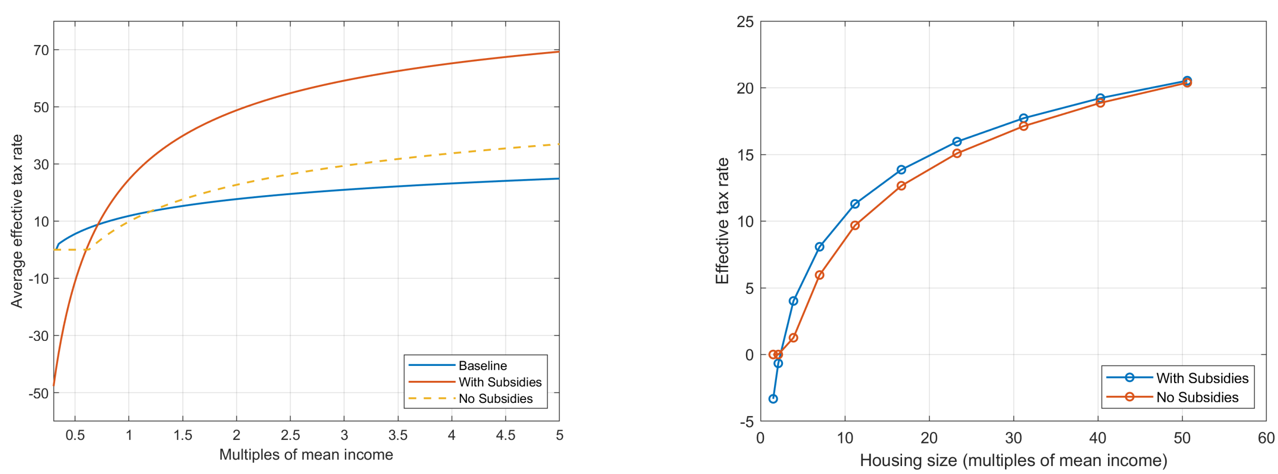
(b) Optimal housing tax

	θ_1	θ_2	θ_3	θ_4
z_1	13.50 (5.46)	12.35 (0.29)	10.37 (0.11)	6.77 (0.26)
z_2	11.91 (22.05)	10.31 (1.17)	8.14 (0.45)	4.95 (1.04)
z_3	9.14 (33.62)	7.71 (1.79)	6.10 (0.68)	3.88 (1.58)
z_4	7.00 (22.05)	6.20 (1.17)	4.99 (0.45)	3.22 (1.04)
z_5	5.84 (5.46)	5.59 (0.29)	4.37 (0.11)	2.73 (0.26)
z_6	1.65 (0.58)	1.59 (0.03)	1.38 (0.01)	0.75 (0.03)

Note: The share of households for each combination of the labor z and entrepreneurial ability θ shock is reported in parenthesis.

and high taxes on big housing units allow to further decrease housing demand, and thus lowering the housing price by more than 20%. Meanwhile, only relying on the housing tax instruments (*Opt H*) decreased the housing price by 13.5%.

The housing progressivity changes the distribution over the housing sizes by setting extremely high tax rates on them. Meanwhile, the income progressivity allows to reduce the share of households that pay the income tax from 77% to 55%, which reduces the tax burden on a sizable share of households.



(a) Optimal income tax schedules

(b) Optimal housing tax schedules

Figure E3: Optimal tax schedules with and without subsidies

E.4 Optimal Flat Housing, Progressive Income Tax

In most economies, housing taxation tends to be nearly flat, whereas income taxation is typically highly progressive. However, as demonstrated in Section section 5.2, the optimal tax configuration in our model reverses this pattern—favoring a flat income tax and a progressive housing tax. This raises a natural question: how closely can economies approximate the optimal outcome while maintaining a flat housing tax?

To explore this, we compute the optimal budget-neutral reform under a regime featuring a flat housing tax combined with a progressive income tax. The results, presented in Table table E5, are compared against the jointly optimal reform. The flat housing tax reform entails a substantial tax rate of 9.5% of property value, though its tax burden is mitigated by a 32.3% decline in house prices. Meanwhile, the income tax schedule becomes markedly progressive, with $\tau_y^{prog} = 0.53$.

This configuration yields a welfare gain of 18.36% in consumption-equivalent terms—approximately 2 percentage points below the fully optimal policy, yet about 5% higher than the housing-only reform. Aggregate outcomes broadly mirror those under the joint optimum, though capital stock and output respond more strongly. The sharper decline in aggregate capital, and thus production, is primarily driven by a halving of capital demand among self-employed agents (fig. E4b).

The housing distribution among owners becomes more dispersed: roughly 20% of households occupy the smallest allowable owner-occupied units (slightly above the baseline), and a modest uptick is observed in the share of households residing in mid-to-large housing grid points (fig. E4a). Homeownership is higher than under opt Joint, as in the latter cases subsidies are available to renters, that are absent in *Opt Y,flat H*.

Looking at housing services over age (fig. E5b), we find that both rich (99th percentile of housing services) and poor (25th percentile) young households live in larger houses, while the two profiles differ little after the age of 40. When progressive housing taxation is available, the 25th percentile rises as much as 50% for households below the age of 40.

Looking at housing services over age (fig. E5b), we find the 99th percentile under *Opt Y,flat H*, closely tracks the 99th percentile of *Opt Joint*. Poor and young households though fare sifnificantly worse than under *Opt Joint*, with the p25 forh households in their 30s of housing services being 40% lower, i.e. at same level as baseline. For older households, the p25 of housing services is unchanged across the 3 tax schedules.

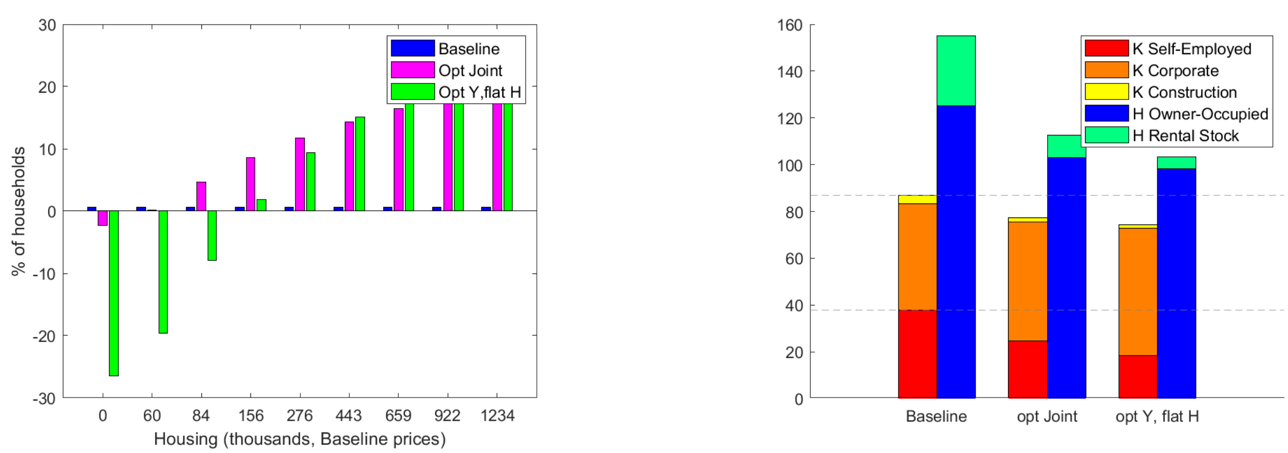
The picture is different when looking at the consumption over age of rich and poor households (fig. E5a. Poor households consume slightly more under the *Opt Y,flat H* tax schedule than under the optimal Joint; since they delay moving to a larger house, they spend more on the consumption good. In contrast, rich households already by age of 30 consume roughly 25% less than they would under the *Opt Joint* policy, with this gap widening to around 33% during midlife and into into retirement.

In contrast, the *Opt Joint* policy delivers a more targeted intervention: it achieves the same reduction in housing demand among wealthy households, but with a substantially smaller impact on their consumption, as detailed in section 5.2.

Table E5: Flat Housing, Progressive Income tax schedule

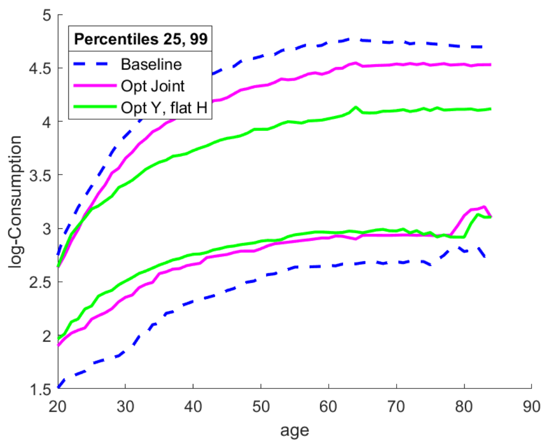
		Baseline	Flat Housing, Prog. Income	Opt. Joint
Tax Parameters				
τ_y^{lev}	Income Tax Level	0.882	0.956	0.488
τ_y^{prog}	Income Tax Prog.	0.1	0.529	0
τ_h^{lev}	H Tax Level	0.994	0.905	1.11
τ_h^{prog}	H Tax Prog.	0	0	0.159
Tax Structure				
Effective income tax rate (%)		13.47	0.953	51.205
Share of hhs paying income tax		78.282	27.372	100
Effective housing tax rate (%)		0.62	9.463	-11.937
Share of hhs paying housing tax		100	100	2.628
Prices				
p_h	Housing price	1	0.677	0.74
p_r	Rental price	0.057	0.097	-
r	Interest rate	5.654	6.399	6.166
w	wage	1	0.967	0.977
Aggregate Variables				
Production		1	0.96	0.978
Capital		1	0.858	0.902
Housing Stock		1	0.667	0.729
Rental Stock		1	0.169	0.337
Share of homeowners		73.577	93.925	90.87
Welfare ($\Delta\%$)		-	18.361	20.384

Figure E4: Flat Housing, Progressive Income tax schedule:
Housing Distribution and Resources Allocation

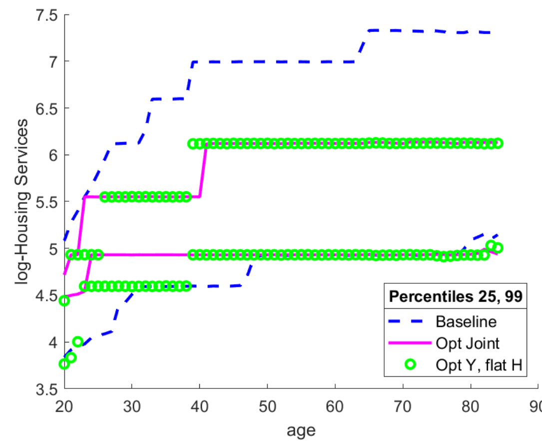


(a) Housing Distribution

(b) Capital and Housing Demand



(a) Consumption-age Profiles



(b) Housing Services-age Profiles

Figure E5: Flat Housing, Progressive Income tax schedule
Consumption and Housing Across Age