Removing the Mortgage Interest Deductibility: Policies and Welfare Effects

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Abstract

This paper studies the short-run welfare effects of several policies that remove the mortgage interest deductibility. To this end, we build a life-cycle model with heterogeneous households calibrated to the U.S. economy, in which homeowners can opt to deduct mortgage interest payments under a progressive income tax schedule. Our results suggest that a majority of households alive today would benefit from an immediate repeal. However, households with large mortgages and high earnings realize pronounced losses under such a policy. More gradual policies can mitigate these losses, but do not receive majority support and the average welfare gains are considerably lower.

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"...I know some of you've heard questions raised about whether there might be some plan to do away with the home mortgage interest deduction, which has played such an important role in helping Americans fulfill their dream of homeownership. I'm afraid that story was just another example of someone trying to read into my remarks things that weren't there."

President Reagan's 1984 address to the National Association of Realtors.

1 Introduction

When the mortgage interest deductibility (MID) was passed into law through the Revenue Act of 1913, it was largely insignificant. Hardly any households paid federal income taxes, and those who did predominantly faced a marginal tax rate of merely one percent (Ventry, 2010). Today, the MID has become a symbol of the "American dream" of homeownership and reduces the cost of housing for millions of Americans.

Yet the mortgage subsidy has become subject to much debate. In public discussions, opponents of the MID argue that it primarily benefits middle-to-high earning households and drains the federal budget (Desmond, 2017). Indeed, total tax expenditures due to the MID are estimated to 63.6 billion dollars in 2017 (JCT, 2017), which is close to the entire annual spending of the Departments of Commerce, Energy, and Justice. These views are generally supported by results in the academic literature, which typically suggest that, in the long run, most American households would be better off without the MID.[1]

In this paper, we study the short-run welfare effects of removing the MID. There are at least two reasons why these should differ notably from the effects in the long run. First, past decisions with respect to housing and mortgages matter in a short-run analysis. The welfare evaluation needs to take into consideration that households have already made long-term housing and financing decisions based on the presumption that they can deduct mortgage interest payments. Second, the timing of policies can also have important welfare consequences. Questions such as "How rapidly should the MID be removed?" and "Should the policy be announced in advance?", become relevant. Both of these aspects are critical for understanding potential reasons why politicians have been reluctant to repeal the MID. The primary purpose of this paper is therefore to study the effects of various implementation policies for removing the MID. Specifically, how is the diverse group of current U.S. households affected by different MID removal policies?

We address this question by building a life-cycle model with overlapping generations

[1] See e.g. Chambers et al. (2009), Floetotto et al. (2016), Gervais (2002), and Sommer and Sullivan (2017).

and incomplete markets in which house and rental prices adjust to clear the housing market. Households differ by their educational attainment, age, and history of earnings shocks. The tenure decision is endogenous and there are transaction costs associated with both buying and selling a house. Households can borrow, but only against their home and subject to an equity requirement.

In the model, we include the main features of the U.S. tax code with respect to housing, namely that imputed rents are not taxed and that property taxes and mortgage interest payments are tax deductible. Furthermore, households can choose between itemized deductions and a standard deduction, where the former includes mortgage interest payments. Both deductions are subtracted from earnings that are subject to a progressive tax schedule. This enables us to replicate two striking and important characteristics of the MID: the fraction of households that itemize deductions increase with the earnings level, and a disproportionately large share of mortgage deductions go to high-earning households.

Although the main contribution of this paper concerns the short-run effects of removing the MID, we also consider the long-run effects of such a removal. This is motivated by the simple observation that there is little need to study short-run dynamics of removing the MID if the welfare effects in the long run are negative. In line with previous studies, we find that an overwhelming majority of households prefer to be born into a world without the MID. This is explained by lower equilibrium prices and taxes. The direct effect of removing the MID is an increase in the user cost of owning a house for households that itemize deductions. To accommodate the lower housing demand of these households, house and rental prices fall. The lower house price enables more households to purchase a house as the necessary down payment decreases. Indeed, without the MID the homeownership rate is six percentage points higher. As such, we corroborate the results in Chambers et al. (2009) and Sommer and Sullivan (2017), calling into question whether the mortgage subsidy really helps to achieve the "American dream" of homeownership. Furthermore, households benefit from the decrease in the average income tax that is made possible as the government saves on MID expenditures. Households at the very top of the earnings distribution is the only group for which the direct negative effect of removing the MID outweighs the benefits of lower equilibrium prices and taxes.

However, the long-run analysis is silent on the welfare effects of households alive today, who have made housing and mortgage choices based on the premise that the MID stays in place. In order to shed light on how these households are affected, we consider several implementation policies for removing the MID. In one policy experiment, we study the effects of an unexpected and immediate repeal. This abrupt policy gives no time for households to adjust their asset holdings before the MID is repealed. Therefore, we also study two alternative removal policies. Under a gradual policy, we analyze the effects of linearly reducing the deductible share of mortgage interest payments over fifteen years. Moreover, we consider an announcement policy in which households can fully deduct their interest payments on mortgages for another fifteen years, after which no payments can be deducted.[2]

In the short-run analysis we find that most households are actually in favor of an immediate and unannounced removal of the MID. However, such a sudden removal policy produces considerable welfare losses for homeowners with high earnings and large mortgages. Out of the three policies, the immediate removal has the highest average welfare gain and it is the only policy that a majority of households benefit from. A third of U.S. households are renters who have no investments in the housing market. They benefit regardless of the policy design, but prefer a more rapid removal where the equilibrium prices and taxes decrease faster. Interestingly, some homeowners are also in favor of an immediate repeal of the MID. These homeowners have low levels of mortgages and/or their tax savings on mortgage interest deductions are small due to the progressivity of the income tax. As a result, they experience either small or no direct costs from eliminating the MID. When the MID is repealed quickly, the benefits from lower equilibrium taxes dominate the direct costs as well as the costs from the fall in housing equity. Under polices where the MID is temporarily extended, house prices still decline instantaneously as households act preemptively to future reductions in the deductibility rate, whereas taxes remain elevated as the government continues to spend large amounts on interest deductions. Hence, few of the homeowners who benefit from an immediate removal experience positive welfare effects from more gradual policies. As a result, we find that this group of homeowners, with small mortgages and/or low earnings, are pivotal for understanding whether the median voter is in favor of a reform or not.

The analysis suggests that a policymaker faces a difficult trade-off. The policy that a majority of households support, is also the one where some homeowners realize the largest welfare losses. Homeowners with large mortgages and high earnings benefit substantially from the possibility to deduct mortgage interest payments and suffer severely from an abrupt repeal of the MID. A policymaker who wishes to mitigate these losses through a more gradual removal, faces the risk that the reform will not pass a public vote.

There is a sizeable literature that studies the effects of the MID on welfare and the user cost of owner-occupied housing.[3] Seminal papers that analyze the importance of the MID in a static setting include Laidler (1969), Aaron (1970), Rosen (1985), Berkovec and Fullerton (1992), and Poterba (1992). More recent papers have used dynamic models with

[2]In Appendix E we also consider a grandfather policy.

[3]Recent empirical work that studies the effects of the MID include Hilber and Turner (2014) and Gruber et al. (2017). We refer to these papers for a more thorough review of the empirical literature.

heterogeneous agents to evaluate the consequences of repealing the MID. This approach was first used in Gervais (2002), followed by other papers such as Chambers et al. (2009), Cho and Francis (2011), Floetotto et al. (2016), and Sommer and Sullivan (2017). As alluded to earlier, these studies generally conclude that, in the long run, a repeal of the MID is welfare improving for a vast majority of households. Typical reasons for this finding include a decrease in taxes (or increased transfers), a lower interest rate, lower house prices, or different combinations of these. Along the same lines, we too find that most households would prefer to be born into a world without the MID.

We contribute to the literature in two important ways. First, we study the short-run effects of removing the MID in a model that features *both* realistic life-cycle profiles and a progressive income tax schedule. Floetotto et al. (2016) also study the short-run impact of an MID repeal using a life-cycle model with overlapping generations. However, in their analysis, mortgage interest deductions are claimed against earnings that are subject to a proportional income tax rate, and all homeowners are implicitly assumed to itemize deductions. In contrast, homeowners in the U.S., and in our model, subtract mortgage interest payments from earnings that are subject to a progressive tax system, and not all mortgage holders itemize deductions. These features are important as they allow our model to replicate the pronounced skewness of MID claims towards high-earning households. To the best of our knowledge, the only other paper that studies the short-run effects of removing the MID is Sommer and Sullivan (2017).[4] They do include a progressive tax system with an endogenous choice between itemizing and claiming the standard deduction. However, in their model a household's age is stochastic. We add to their analysis by modeling the life-cycle of a household explicitly, as after all, tenure choice and indebtedness are intimately connected with age. This allows us to characterize the welfare distribution in great detail and provides intuition of the mechanisms behind the results.

The second contribution of this paper is that we consider and compare the welfare effects of alternative policies for removing the MID. Floetotto et al. (2016) and Sommer and Sullivan (2017) both study the welfare effects of an unexpected and immediate removal of the MID. Similar to our results, these papers find that an immediate reform improves welfare on average, and that a significant share of current homeowners are severely negatively affected. Our analysis of alternative policies enhances the understanding of why the MID has been challenging to repeal, and what type of trade-offs a policymaker faces. Interestingly, our results suggest that the natural candidates for removal policies – the more gradual policies – do not necessarily benefit the average household.

[4] Alpanda and Zubairy (2017) also study the short-run effects of removing the MID, but do so in a DSGE framework that does not allow for the same richness in heterogeneous welfare effects.

The remainder of the paper is organized as follows. In Section 2 we present the model. We explore a simplified version of the model in Section 3 and use it to discuss the net benefit of owner-occupied housing and how this is affected by the MID. The calibration of the baseline economy is presented in Section 4, along with a comparison to both targeted and non-targeted data moments. Section 5 shows and discusses the results of the different policy experiments, while section 6 concludes.

2 Model

To analyze the effects of removing the mortgage interest deductibility, we construct a life-cycle model with overlapping generations and incomplete markets. The model is in discrete time, where one model period corresponds to three years. It features three types of agents: households, rental firms, and a government. Households differ ex-ante by belonging to one of two educational groups; college educated households or non-college educated households. The educational background of a household affects its expected earnings over the life cycle and the uncertainty of earnings. Further heterogeneity arises as a result of aging and idiosyncratic earnings shocks. Rental firms operate in a competitive market with free entry and exit, and provide rental services to households. The government taxes the households and the rental firms in a manner that mimics the U.S. tax system. Importantly, we include the main features of the U.S. tax code with respect to housing, namely that imputed rents are not taxed, and that property taxes and mortgage interest payments are tax deductible. Furthermore, itemized and standard tax deductions are available to households, and are deducted from earnings that are subject to a progressive tax schedule.

There are three assets in the economy: houses, mortgages, and risk-free bonds. Houses are available in discrete sizes, and there are transaction costs associated with both buying and selling a house. The stock of housing is fixed in aggregate, but flexible in its composition.[5] In equilibrium, house and rental prices adjust to clear the housing market. The interest rates of mortgages and bonds are exogenous and the supply of both assets is perfectly elastic.

2.1 Households

Each household i is born with a specific educational attainment e and no assets. A household's educational attainment does not change over the life cycle and determines the nature of the earnings process described in section 4.1. Over the course of the life

[5]The main focus of this paper is the short-run effects of a housing subsidy removal. We therefore find the assumption of a fixed aggregate supply of housing reasonable.

cycle, households are hit by idiosyncratic earnings shocks, which give rise to further heterogeneity. A household retires with certainty after period J_{ret} and cannot live past period J. The probability of surviving between any two ages j and $j+1$ is $\phi_j \in [0,1]$, and the agents discount exponentially at rate $\beta_j = \phi_j \beta$. In each period, a household derives utility from consumption goods c and housing services s through a CRRA utility function with a Cobb-Douglas aggregator

$$U(c,s) = \frac{\left(c^{\alpha} s^{1-\alpha}\right)^{1-\sigma}}{1-\sigma}. \tag{1}$$

There is no bequest motive and the objective of the household is to maximize the expected sum of discounted lifetime utility.[6]

A household enters each period j with bonds b, mortgage m, and housing h, according to the choices made in the previous period. In the current period, earnings y realize, the household pays taxes Γ, and chooses consumption c, housing service s, bonds b', mortgage m', and housing h'. Housing services are either obtained via the agent's owned housing or from a rental company. Each unit of housing costs p_h to buy and p_r to rent. An owned house of size h' produces housing services through a linear technology $s = h'$.[7] These services have to be consumed by the owner of the house, which implies that households cannot be landlords. We model landlords implicitly through a rental market, as landlords are treated as business entities in the U.S. tax code. In addition, since landlords are treated as businesses, they are not directly affected by a removal of the mortgage interest deductibility. Households can use mortgages m', with interest rate r^m, to finance up to an exogenously given share $1-\theta$ of the house value. Bonds b' can be purchased in any non-negative amount, earning interest $r < r^m$.

In the steady-state analysis, the household problem has five state variables: education e, age j, permanent earnings p, house size h, and cash-on-hand x. The first three are exogenous, while the latter two are affected by a household's choices. State x is defined as

$$x \equiv y + (1+r)b - (1+r^m)m + (1-\tau^s)p_h h - \delta^h h - \Gamma, \tag{2}$$

where the fourth term is the value of the house net of transaction costs.[8] The transaction cost of selling a house is modeled as a share τ^s of the house value. The maintenance cost

[6] For simplicity, we assume that all accidental bequests are fully taxed and the tax revenue goes to government spending that does not affect the agents.

[7] We refer to the quantity of h and s as the size of the housing unit, although it should be interpreted more broadly as the quality.

[8] For computational reasons, and without loss of generality, we define cash-on-hand as including the net revenue of selling the house. Households who do not sell their house between any two periods do not incur transaction costs.

$\delta^h h$ is paid by all homeowners, and is proportional to the size of the house.[9,10] Total tax payments Γ is given by

$$\Gamma \equiv \tau^l y + I^w \tau^{ss} y + \tau^c r b + \tau^h p_h h + T(\tilde{y}). \tag{3}$$

Similar to the U.S. tax system, a household pays a local income tax[11], a payroll tax (only paid by working-age households, represented by the dummy variable I^w), a capital gains tax, a property tax on owned housing, and a federal income tax. The federal income tax results from a non-linear tax and transfer system, which is a function of earnings net of deductions $\tilde{y}$. In turn, deductions depend on a household's mortgage, house value, and gross earnings. For a detailed description of the non-linear tax and transfer system see section 2.3, in particular equations (6) and (7).

The household problem includes the discrete choice of whether to rent a home, buy a house, or stay in an existing house. We therefore split up the household problem into these three respective cases, and solve it recursively. The solution to the problem at age J is simple. The household spends all its cash-on-hand on consumption goods and rental services, and dies without any assets, i.e. $h' = m' = b' = 0$. For all ages before J, we characterize the household problem based on how the household chooses to obtain housing services. If the household chooses to rent housing services, the optimization problem is given by

$$\begin{aligned} V_{ej}^R(p, x) = \max_{c,s,b'} & \; U(c, s) + \beta_j \mathbb{E}\left[V_{e,j+1}(p', x', h')\right] \; s.t. \\ & x' = (1 - \tau^l - I^w \tau^{ss}) y' + (1 + (1 - \tau^c) r) b' - T(\tilde{y}') \\ & x = c + p_r s + b' \\ & s \in S \\ & c > 0, h' = 0, b' \geq 0. \end{aligned}$$

The problem is characterized by the Bellman equation, the law of motion for cash-on-hand, the budget constraint, and a number of additional constraints. In this first case, the household rents a home and can therefore not take up a mortgage, implying $h' = m' = 0$. The choice of housing service is restricted to the ordered set of discrete sizes $S = \{\underline{s}, s_2, s_3, ..., \bar{s}\}$.

[9] It is convenient to require all homeowners to pay the maintenance cost since house sizes are assumed to be discrete.

[10] The maintenance cost is proportional to the house size and not the house value. In our analysis all house price changes result from adjustments of the MID, and should therefore not affect the maintenance cost.

[11] The local income tax is mainly included to ensure that high-earning households are more prone to itemize deductions.

If the household chooses to buy a house that is of a different size than the one it entered the period with, such that $h' \neq h$, the problem becomes

$$
\begin{aligned}
V_{ej}^{B}(p,x) = \max_{c,h',m',b'} & \; U(c,s) + \beta_j \mathbb{E}\left[V_{e,j+1}(p',x',h')\right] \; s.t. \\
x' &= (1-\tau^l - I^w\tau^{ss})y' + (1+(1-\tau^c)r)b' - T(\tilde{y}') \\
&\quad - (1+r^m)m' + (1-\tau^s-\tau^h)p_h' h' - \delta^h h' \\
x + m' &= c + (1+\tau^b)p_h h' + b' \\
0 &\leq m' \leq (1-\theta)p_h h' \\
h' &\in H \\
c &> 0, s = h', b' \geq 0.
\end{aligned}
$$

Since the household in this case buys a house, the budget constraint allows for the use of a mortgage to finance expenditures. The mortgage amount is restricted by a loan-to-value (LTV) constraint. The parameter τ^b captures the transaction cost of buying a house, which is modeled as proportional to the house value. Moreover, the household's choice of housing is limited to a set H, which is a proper subset of S. In particular, the smallest house size $\underline{\mathrm{h}}$ in H is larger than the smallest available size in S.[12] Above and including that lower bound, both sets are identical.

Finally, if the household decides to stay in the same house as it entered the period with, such that $h' = h$, the problem is given by

$$
\begin{aligned}
V_{ej}^{S}(p,x,h) = \max_{c,m',b'} & \; U(c,s) + \beta_j \mathbb{E}\left[V_{e,j+1}(p',x',h')\right] \; s.t. \\
x' &= (1-\tau^l - I^w\tau^{ss})y' + (1+(1-\tau^c)r)b' - T(\tilde{y}') \\
&\quad - (1+r^m)m' + (1-\tau^s-\tau^h)p_h' h' - \delta^h h' \\
x + m' &= c + b' + (1-\tau^s)p_h h \\
0 &\leq m' \leq (1-\theta)p_h h' \\
c &> 0, s = h' = h, b' \geq 0.
\end{aligned}
$$

In this case, the house size h enters as a state variable in the Bellman equation, since it directly determines the housing choice h' when the house size is not changed. Also, since x is defined such that it includes the value of the house when sold, the budget constraint is corrected for the agent not selling the house. This is done by adding $(1-\tau^s)p_h h$ to the

[12] A minimum size of owner-occupied housing $\underline{\mathrm{h}}$ is also assumed in e.g. Cho and Francis (2011), Floetotto et al. (2016), Gervais (2002), and Sommer and Sullivan (2017). The introduction of $\underline{\mathrm{h}}$ provides another reason for assuming that maintenance costs have to be paid by the owner, as otherwise a house quality could depreciate below this lower limit.

expenditures in the budget constraint.

The solution to the household problem is given by

$$V_{ej}(p,x,h) = \max\left\{V^{R}_{ej}(p,x), V^{B}_{ej}(p,x), V^{S}_{ej}(p,x,h)\right\}, \tag{4}$$

with the corresponding set of policy functions

$$\left\{c_{ej}(p,x,h), s_{ej}(p,x,h), h'_{ej}(p,x,h), m'_{ej}(p,x,h), b'_{ej}(p,x,h)\right\}.$$

In the short-run analysis, where we allow for house price dynamics, households do not have to comply with the LTV constraint as long as they stay in the same house and do not increase their mortgage. Formally, the LTV constraint becomes

$$0 \leq m' \leq \max\left\{(1-\theta)p_h h', m\right\}.$$

This implies that the interval of possible mortgage choices m' is affected by the mortgage level that the agent enters the period with. Hence, in the short-run analysis mortgage is an additional state variable whenever the agent chooses to stay in the same house.

2.2 Rental Market

The rental price p_r is determined in a competitive rental market. This market consists of a unit mass of homogeneous rental firms. Each rental firm is born with some endowment and stays alive for one period only. A rental firm f chooses either to buy a stock of housing h_f at price p_h per unit and rent it out to households, or to invest the value $p_h h_f$ in risk-free bonds. The present value of after-tax profits in the former case is

$$\pi^{Rent}_{f} = (1-\tau^c)\left(p_r h_f - \frac{1}{1+\tilde{r}}\left[\delta^r + \tau^h p'_h + \Delta p'_h\right] h_f\right).$$

Firm f's revenue is given by its rental income $p_r h_f$. The firm can deduct its operating expenses from these revenues before paying taxes at rate τ^c. The operating expenses comprise a maintenance cost $\delta^r > \delta^h$ per unit of housing, a property tax on the value of the rental stock in the next period $\tau^h p'_h h_f$, and any negative price return on the rental stock $\Delta p'_h h_f$, where $\Delta p'_h \equiv p_h - p'_h$.[13] All operating expenses are discounted, as these costs realize in the next period, where the discount rate is given by the after-tax return

[13]The assumption that $\delta^r > \delta^h$ is one common way in the literature to incorporate an advantage of owning (see e.g. Piazzesi and Schneider (2016)). It was first introduced in Henderson and Ioannides (1983), and can be thought of as representing a moral hazard problem between owners of rental units and their tenants. An alternative approach would be to assume that owned housing units provide more housing services than rental units.

on bonds $\tilde{r} \equiv (1 - \tau^c)r$.

In case firm f instead invests in bonds, the present value of after-tax profits is given by

$$\pi_f^{Bonds} = \frac{(1 - \tau^c)}{1 + \tilde{r}} r p_h h_f.$$

Imposing a free entry and exit condition, such that $\pi_f^{Rent} = \pi_f^{Bonds}\ \forall f$, the equilibrium rental price is

$$p_r = \frac{1}{1 + \tilde{r}} \left[\delta^r + r p_h + \tau^h p_h' + \Delta p_h' \right]. \tag{5}$$

Admittedly, the rental market can be modeled in other ways. The advantage of using this approach is that it yields a tractable closed-form solution for the rental price and the net benefit of owning (see equation (11)), which is key to understand how the MID affects the demand for owner-occupied housing.

2.3 Government

The role of the government in the model is to provide retirement benefits to the households, and to tax the agents in a manner that replicates the U.S. tax system. Households pay five different taxes. The local level income tax, the payroll tax, the capital income tax, and the property tax are modeled linearly, as shown in equation (3). In contrast, the federal income tax is given by a function that mimics the U.S. federal tax and transfer system. The income tax function takes earnings net of deductions $\tilde{y}$ as its argument, and is assumed to be continuous and convex, following Heathcote et al. (2017). Specifically,

$$T(\tilde{y}) = \tilde{y} - \lambda \tilde{y}^{1-\tau^p}, \tag{6}$$

where λ governs the tax level, and τ^p determines the degree of progressivity.

The type and amounts of deductions a household takes affect taxable earnings. Before retirement, households can either itemize deductions, opt for the standard deduction, or not deduct at all. Itemized deductions, including mortgage interest payments, are only permissible as long as the sum of these exceeds the standard deduction.[14] During retirement, households can only use the standard deduction or not deduct at all.[15] To

[14]Due to the functional form of our tax and transfer system, opting to itemize deductions even if these are lower than the standard deduction, or even not deducting at all, may be optimal as some households face negative marginal tax rates.

[15]In the U.S., many retirees itemize deductions, but most do so for other reasons than mortgage interest payments since the vast majority of retirees have little or no mortgage. Hence, these households will have small direct effects of repealing the MID. In our model, retirees optimally consume out of their housing wealth by taking up mortgages, as they plan to die with zero wealth. Therefore, if retirees were allowed

summarize, households' taxable earnings are such that $T(\tilde{y})$ is minimized, subject to

$$\tilde{y} \in \begin{cases} \{\max(y - ID, 0), \max(y - SD, 0), y\}, & \text{if } j \leq J_{ret} \text{ and } ID > SD \\ \{\max(y - SD, 0), y\}, & \text{otherwise} \end{cases} \tag{7}$$

$$\text{where } ID = \tau^m r^m m + \tau^h p_h h + \tau^l y.$$

The max operators reflect that taxable earnings must be nonnegative. SD is the common exogenous amount that can be deducted if households opt for the standard deduction, while ID is the sum of itemized deductions, and include mortgage interest payments, property tax payments, and local tax payments. These are among the most important deductions in the U.S. tax code (Lowry, 2014). The parameter τ^m is the mortgage deductibility rate in the economy and is the parameter of interest in this paper. In line with the current U.S. tax code, τ^m is set to one in the benchmark model. In other words, all mortgage interest payments are deductible from earnings when calculating taxable earnings for an itemizing household. From equations (2), (3) and (7), we see that the MID reduces taxable earnings, and hence increases cash-on-hand, provided that the agent itemizes tax deductions.

Rental firms pay two taxes; the property tax on its rental stock, and the capital gains tax on accounting profits. In total, the government's tax revenues from households and rental firms are given by

$$TR = \left(\sum_{e=1}^{2} \sum_{j=1}^{J} \Pi_{ej} \int_0^1 \Gamma_{ije} \, di \right) + \int_0^1 \left(\tau^c r h_f + \tau^h p_h h_f \right) \, df, \tag{8}$$

where i index households, f index rental firms, Π_{ej} is the joint distribution of households' educational attainment and age, and Γ is total taxes as defined in equation (3). We assume that both households and rental firms are of unit measure. The government uses the tax revenue from the payroll tax to finance the retirement benefits. The remaining revenues are allocated to spending that does not affect the other agents.

3 The MID and the Benefit of Owning

To better grasp the mechanisms behind the results in this paper, it is useful to understand why households want to own a house in the model and how this is affected by the MID. In this section, we provide this intuition by comparing a household who owns a house of

to itemize deductions in our model, they would have large negative direct effects of removing the MID. That would clearly be at odds with data, and severely overstate the negative effects of an MID repeal.

size h' to a similar household who instead obtains the equivalent housing service $s = h'$ on the rental market. The ex-post net benefit of owning NB^{Own}, in any period, is given by

$$NB^{Own} = UC^{Rent} - UC^{Own}, \tag{9}$$

where UC^{Rent} is the user cost of renting and UC^{Own} is the user cost of owning. Intuitively, the net benefit of owning is positive whenever owning is less costly compared to renting.

The user cost of renting is given by $p_r s$, i.e. the rental price times the size of the rental unit. The user cost of owning is more complicated, as owned housing is an asset and comes with the possibility of debt financing. To keep the analysis in this section tractable, we make a few simplifying assumptions compared to the full model. First, we abstract from any risk by assuming that prices are constant over time and that earnings next period y' are known. Second, we assume that the interest rate on mortgages r^m is equal to the risk-free rate r. Third, we abstract from the possibility of selling and buying a house, and hence from the transaction costs that occur when doing so. Fourth, we assume that local income taxes are not tax deductible.

Given the modifications to the full model, the user cost of owning includes the sum of four costs. First, there is a maintenance cost of $\delta^h h'$. Second, there is an opportunity cost of equity. If the equity had not been invested in the house, it would have yielded an after tax return of $\tilde{r}(p_h h' - m')$, where $\tilde{r} \equiv (1 - \tau^c)r$ is the net of tax risk-free rate. Third, a homeowner needs to pay a property tax on the house. This property tax cost is modeled as a fixed share of the house value, and is given by $\tau^h p_h' h'$. Last, a homeowner incurs a cost whenever it uses a mortgage to finance its dwelling. The borrowing cost is simply the interest payment on the mortgage rm'.

The costs of owner-occupied housing can be reduced whenever a homeowner chooses to itemize deductions rather than simply opt for a standard deduction. The sum of the itemized deductions amounts to $ID' = \tau^h p_h' h' + \tau^m r m'$, and is subtracted from earnings which in turn are subject to the progressive tax schedule $T(\tilde{y}')$. Importantly, any itemized deductions in excess of the standard deduction reduce the tax liabilities of the homeowner, and therefore lower the effective cost of property taxes and mortgage financing. The total benefit from being able to itemize deductions is given by

$$I^d \int_{SD}^{ID'} T_{\tilde{y}'}(y' - \hat{D}) d\hat{D},$$

where I^d is an indicator variable for itemized tax deductions. The user cost of owning is the present value of the sum of all costs, adjusted for deductions

$$UC^{Own} = \frac{1}{1+\tilde{r}}\left(\delta^h h' + \tilde{r}(p_h h' - m') + \tau^h p_h' h' + rm' - I^d \int_{SD}^{ID'} T_{\tilde{y}'}(y' - \hat{D})d\hat{D}\right). \quad (10)$$

Substituting equations (5) and (10) into (9), we get

$$NB^{Own} = \frac{1}{1+\tilde{r}}\left[(\delta^r - \delta^h)h' + \tau^c r(p_h h' - m') + I^d \int_{SD}^{ID'} T_{\tilde{y}'}(y' - \hat{D})d\hat{D}\right]. \quad (11)$$

The first term is the benefit of owning due to lower depreciation of owned housing compared to rental housing.[16] The second term is the benefit of investing equity in an asset (housing) where the return is not taxed, compared to investing in bonds where the return is taxed at a rate τ^c. This benefit to owner-occupied housing arises because imputed rent is not taxed. The last term consists of the tax benefits of owner-occupied housing due to property tax and mortgage interest deductions. Thus, the above measure of the net benefit of owning encapsulates the main features of the U.S. tax treatment of housing.

To see how the net benefit of owning is affected by the deductibility parameter τ^m, it is useful to take the derivative of equation (11) with respect to mortgages

$$NB^{Own}_{m'} = \frac{1}{1+\tilde{r}}\left[-\tau^c r + I^d T_{\tilde{y}'}(y' - ID')\tau^m r\right]. \quad (12)$$

An increase in the mortgage level, and consequently a reduction in equity, has two effects on the net benefit. On the one hand, the reduction in equity means a smaller benefit resulting from the lack of taxation of imputed rent, which is captured by the first term. On the other hand, since mortgages are tax deductible ($\tau^m = 1$ in the initial steady state), the increased mortgage results in larger deductions and hence a higher net benefit.

Overall, equations (11) and (12) are key to understand how the MID affects the net benefit of owning and, subsequently, the demand for owner-occupied housing. First, the MID increases the net benefit of owning by decreasing the cost of mortgage financing only for those who itemize deductions. In the full model, itemizing households are those with relatively large mortgages, houses, or earnings, or a combination of the three. Second, the net benefit of owning due to mortgage interest deductions is increasing in the marginal tax rate. As illustrated in Figure 2, the marginal tax rate differs substantially between households, leading to significant differences in the user cost of owning between households. Third, the net benefit of owning is positive regardless of the MID, due to the difference in the depreciation rates, the lack of taxation of imputed rents, and property tax deductions.

[16] The difference in depreciation rates between rental and owned housing should be interpreted more broadly as capturing the residual benefits of owning that are not modeled specifically.

4 Calibration

We calibrate the model to the U.S. economy. Most of our parameters are calibrated independently, based on data or previous studies, whereas the remaining parameters are calibrated using simulated method of moments.

4.1 Independently Calibrated Parameters

Yearly parameter values estimated from other studies or calculated directly from data are listed in Table 1.

Table 1: Independently calibrated parameters, based on data and other studies

Parameter	Description	Value
σ	Coefficient of relative risk aversion	2
α	Relative weight of consumption in utility	0.8
τ^l	Local income tax	0.05
τ^c	Capital gains tax	0.15
τ^{ss}	Payroll tax	0.153
τ^h	Property tax	0.01
τ^p	Progressivity parameter	0.141
τ^m	Mortgage deductibility	1
r	Interest rate	0.03
κ	Yearly spread, mortgages	0.014
θ	Down-payment requirement	0.20
δ^h	Depreciation, owner-occupied housing	0.03
τ^b	Transaction cost if buying house	0.025
τ^s	Transaction cost if selling house	0.07
B^{max}	Maximum benefit during retirement	22.8

Note: The table presents calibrated parameter values. For relevant parameters the values are annual. When simulating the model, we adjust these values to their three-year (one model period) counterparts.

Demographics

The households enter the economy at age 23. The probability of a household dying between two consecutive periods is taken from the Life Tables for the U.S. social security area 1900-2100 (see Bell and Miller (2005)). We use the observed and projected mortality rates for males born in 1950. In the model, the retirement age is set to 65, and we assume that all households are dead by age 98.

The relative sizes of the two educational groups are calibrated according to Bauman and Ryan (2016). They report the share of the population above age 25 that has a

Bachelor's degree or more to be 33 percent, which we use as the share of college graduates in the model economy.

Preferences

In the CRRA utility function we set the coefficient of relative risk aversion σ to 2, which is widely used in the literature. The consumption expenditure share is determined by α, while $1-\alpha$ is the share of expenditures on housing services. Using data from the Consumer Expenditure Survey (CES) between 2004 and 2015, we find the share of housing services in total expenditures to be 23 percent on average, where we define housing services as including shelter and utilities while excluding telephone services and other lodging. The same measure when using data from the National Income and Product Accounts (NIPA), for the years 2008 to 2015, is 18 percent. Based on these two data sources, we set α equal to 0.8, which is broadly in line with findings in Piazzesi et al. (2007).

Tax System

The local income tax rate τ^l is set to 0.05, which is the average state and local income tax rate for itemizers (Lowry, 2014). The capital gains tax τ^c is set to 0.15, to match the maximum rate that applies to long-term capital gains for most taxpayers. In the U.S., the payroll tax is levied equally on both the employer and the employee, and amounts to 15.3 percent of earnings (Harris, 2005). Since there is no explicit production sector in our model, we let the full tax burden fall on the worker by setting τ^{ss} to 0.153. The 2013 American Housing Survey (AHS) shows that the median amount of real estate taxes per $\$1,000$ of housing value is approximately 10 dollars.[17] Following this estimate, we set the property tax parameter τ^h to 0.01, which is also similar to the value used in Sommer and Sullivan (2017). The parameter determining the progressivity of the federal income tax rates τ^p, is set to roughly match the distribution of households exposed to the different statutory marginal tax rates. We set this parameter value to 0.141, which is close to that in Heathcote et al. (2017).

The mortgage deductibility rate τ^m is our parameter of interest. In the analysis we alter this parameter from one to zero, where the benchmark economy is characterized by full deductibility (τ^m=1).

Market Setting

The interest rate is estimated from market yields on the 30-year constant maturity nominal Treasury securities, deflated by year-to-year headline Consumer Price Index (CPI). The

[17] See table C-10-OO in the 2013 American Housing Survey.

average real rate over the period 1997 to 2015 is 3.3 percent (Federal Reserve Statistics Release, H15, and the Bureau of Labor Statistics, Databases & Tables, Inflation & Prices). We set the real interest rate r to 0.03. Using the Federal Reserve's series of the contract rate on 30-year fixed-rate conventional home mortgage commitments over the period 1997 to 2015, we find that the average yearly spread to the above Treasuries is 1.4 percentage points. Consequently, we choose a yearly spread for mortgages κ of 0.014, implying a mortgage interest rate r^m of 0.044.

Between 1978 and 1992, the average down payment of first-time buyers in the U.S. ranges from 11.4 to 20.5 percent of the house value (U.S. Bureau of the Census, Statistical Abstract of the United States (GPO), 1987, 1988, and 1994). However, a private mortgage insurance is required if the down payment is less than 20 percent of the house value. Therefore, the minimum down-payment requirement θ is set to 0.20 in the model.

The depreciation rate of owned housing is set to 3 percent. This follows from the estimate of the median depreciation rate of owned housing, gross of maintenance, in Harding et al. (2007). The transaction costs of buying and selling a house are taken from Gruber and Martin (2003). They use the median transaction costs from CES data and estimate the costs of buying and selling to be 2.5 and 7 percent of the house value, respectively.

Labor Income

The modeling and estimation of the labor income process is similar to Cocco et al. (2005). We estimate deterministic life-cycle profiles of earnings and include idiosyncratic earnings risk in terms of permanent and transitory shocks. At each age j, household i receives exogenous earnings y_{ij}. For a household in a given education group, log earnings before retirement are

$$\log(y_{ij}) = \alpha_i + g(j) + n_{ij} + \nu_{ij} \quad \text{for } j \leq J_{ret}, \tag{13}$$

where α_i is a household fixed effect with distribution $N(0, \sigma_\alpha^2)$. The function $g(j)$ represents the hump-shaped life-cycle profile of earnings. The remaining two terms, ν_{ij} and n_{ij}, capture the idiosyncratic earnings risk. The former is an i.i.d. transitory shock with distribution $N(0, \sigma_\nu^2)$. The latter, n_{ij}, allows households' earnings to permanently deviate from the deterministic trend, and is assumed to follow a random walk

$$n_{ij} = n_{i,j-1} + \eta_{ij} \quad \text{for } j \leq J_{ret}, \tag{14}$$

where η_{ij} is an i.i.d. shock, distributed $N(0, \sigma_\eta^2)$.[18] All shocks are assumed to be uncorrelated with each other. Note that log earnings can be thought of as the sum of a permanent component, $\log(p_{ij}) = \alpha_i + g(j) + n_{ij}$, and a transitory component ν_{ij}.

During retirement there is no earnings risk. Households receive benefits given by

$$\log(y_{ij}) = \min\left(\log(R) + \log(p_{i,J_{ret}}),\ \log(B^{max})\right) \quad \text{for } j \in]J_{ret}, J], \tag{15}$$

where R is a common replacement rate for all households and B^{max} is the maximum amount of benefits a household can receive. For simplicity, retirement benefits are a function of permanent wages in the last period before retirement only.

Equations (13) and (14) are estimated using PSID data for the survey years 1970 to 1992. The estimation is conducted separately for the educational groups *no college* and *college*. Thus, we allow for different deterministic trends and variances across educational attainment. The deterministic life-cycle profile $g(j)$ is estimated by regressing log household earnings on dummies for age, marital status, and family composition. We control for household fixed effects by running a linear fixed effect regression. Furthermore, a third-order polynomial is fitted to the vector of age dummy coefficients for smoothing purposes. The resulting life-cycle profiles of earnings are displayed in Figure 1.

The variances of the transitory σ_ν^2 and permanent σ_η^2 shocks are estimated in a similar fashion as in Carroll and Samwick (1997). The variance of the fixed effect shock σ_α^2 is identified as the variance of earnings, net of the deterministic trend value in the first period of working life, that is not explained by the estimated variances of the transitory and the permanent shocks. Table 2 presents the resulting variances.[19]

Table 2: Estimated variances of three-year shocks

Parameter	Description	No college	College
σ_α^2	Fixed effect	0.099	0.091
σ_η^2	Permanent	0.025	0.040
σ_ν^2	Transitory	0.030	0.019

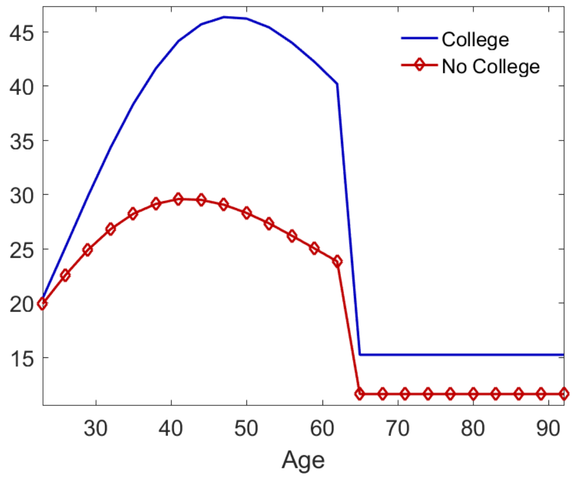
Note: During working age, households receive permanent and transitory earnings shocks. In addition, households obtain a fixed effect shock when they enter the economy. During retirement there is no earnings risk. Estimated using PSID data.

The maximum allowable benefit during retirement, B^{max} in equation (15), is calculated using data from the Social Security Administration (SSA). In the model, the common replacement rate R is slightly above 50 percent and is computed such that the payroll tax

[18] Modeling the permanent component of earnings as a random walk is common in the literature, see for example Carroll (1997), Cocco et al. (2005), and Gourinchas and Parker (2002).

[19] We relegate a detailed description of the data and the method we use to estimate the labor income process to Appendix D.

Figure 1: Life-cycle profiles of earnings (thousands of 1992 dollars)



Note: Deterministic life-cycle profiles of annual earnings for college and non-college educated households, estimated using PSID data. Households deviate from these profiles due to transitory and permanent earnings shocks, the variances of which are shown in Table 2.

revenue fully finances the retirement benefits:

$$\sum_{e=1}^{2}\sum_{j=1}^{J_{ret}}\Pi_{ej}\int_0^1 \tau^{ss} y_{ije}\, di = \sum_{e=1}^{2}\sum_{j=J_{ret}+1}^{J}\Pi_{ej}\int_0^1 \min\left(Rp_{i,J_{ret},e},\ B^{max}\right)\, di. \tag{16}$$

4.2 Estimated Parameters

Table 3 shows the structural parameters calibrated by simulated method of moments, along with a comparison between data and model moments.[20]

For all the target moments and their respective model counterparts we focus on the working-age population, defined as ages 23 to 64. We do this for two reasons. First, it is mainly the working-age population who has sizable LTVs, hence they are the households who are the most directly affected by an elimination of the mortgage interest deductibility. In fact, the median LTV does not exceed zero for any age over 66 in the Survey of Consumer Finances (SCF).[21] Second, the model is unable to replicate the rather low mortgage and LTV levels seen in data among retired households. In the model, retirees who own their houses, increase their mortgages throughout retirement to smooth consumption.

The discount factor β impacts households' savings and borrowing decisions. Hence,

[20]In the *initial* steady state with MID, we impose $p_h = 1$. The rental price is then easily computed from equation (5). The housing market clears automatically as we let the rental companies cater any demand for rental units, and impose that the supply of owner-occupied housing is perfectly elastic. In all other equilibria the aggregate housing stock is fixed at the initial level, but its composition is flexible, and house and rental prices adjust to clear the housing market. For a detailed description of the equilibrium definitions, the computational methods, and the solution algorithms, see the Appendices.

[21]We use the survey years 1989 to 2013 for the SCF.

Table 3: Estimated parameters

Parameter	Description	Value	Target moment	Data	Model
β	Discount factor	0.94	Median LTV	0.48	0.48
δ^r	Depreciation rate, rentals	0.046	Homeownership rate	0.66	0.66
$\underline{h}$	Minimum owned housing size	17	Homeownership rate, no college	0.63	0.63
λ	Level parameter, tax system	1.55	Average marginal tax rates	0.13	0.13
SD	Standard deductions	3.3	Itemization rate	0.40	0.40

Note: Parameters calibrated by simulated method of moments. The third column shows the resulting parameter values from this estimation procedure. The values are annual when applicable. When simulating the model, we adjust these parameter values to their three-year (one model period) counterparts. The fifth column presents the data moments that are targeted. The last column shows the model moments that are achieved by using the parameter values in column three.

this parameter is used to match the median LTV. The target moment is computed using data from the SCF. The depreciation rate of rental housing δ^r affects how favorable owner-occupied housing is relative to rental housing. Therefore, this parameter is used to target the homeownership rate. In order to match the difference in homeownership rates between the two educational groups, the minimum owner-occupied housing size $\underline{h}$ is calibrated to target the homeownership rate of those with no college degree. In the SCF, the overall homeownership rate is 0.66, while the same measure for those without a college degree is 0.63. We use the parameter λ, which governs the level of the convex tax and transfer function $T(\tilde{y})$, to target the average marginal tax rate. The target is taken from Harris (2005).

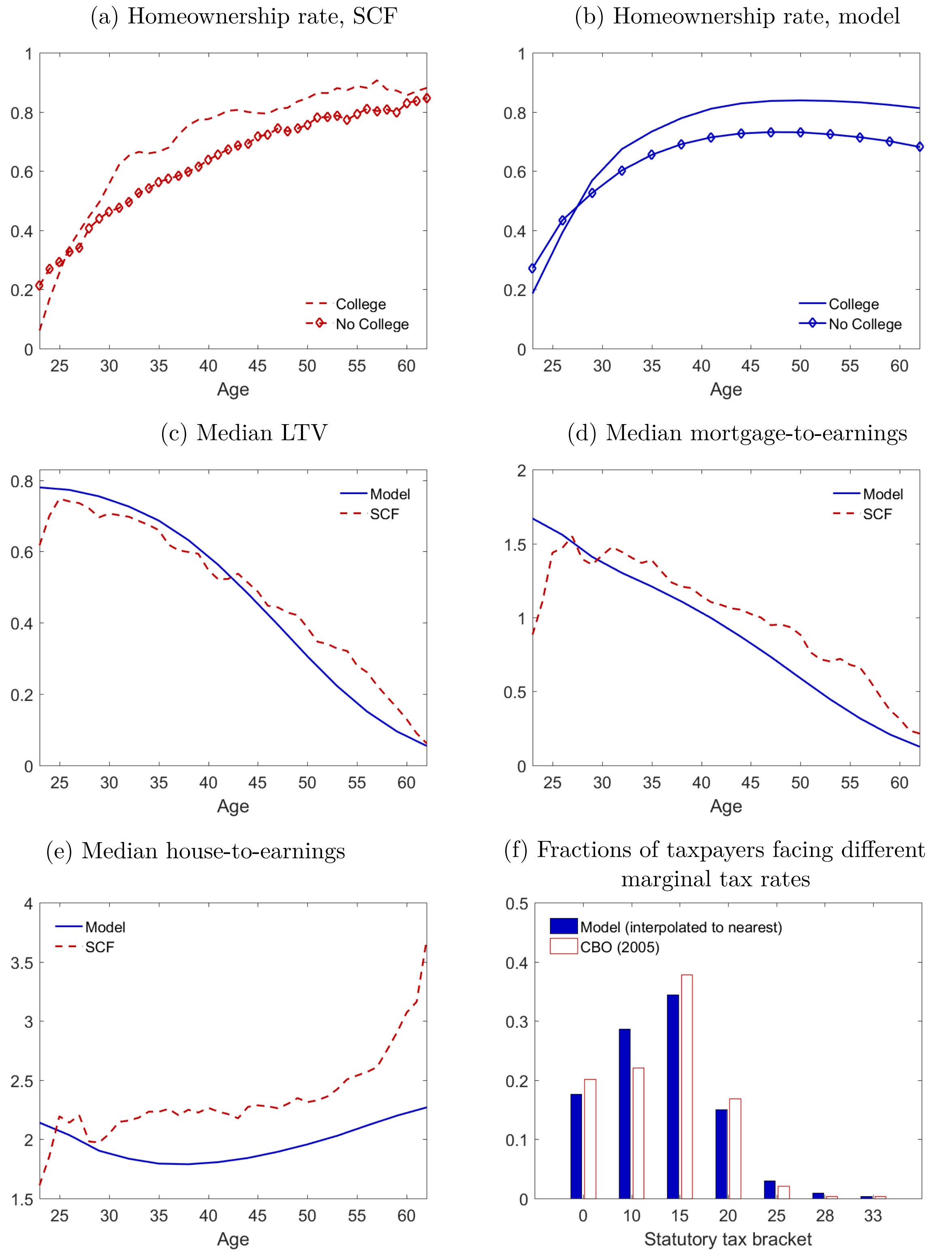
We calibrate the standard deduction to match the fraction of the working-age population that itemize their tax deductions. Using self-reported rates for heads of households aged 26 to 64 in the SCF, the itemization rate is 0.40.[22] Our calibrated standard deduction is about $3,300$ in 1992 dollars, which, CPI-adjusted, is slightly above $5,600$ in 2016 dollars. Reassuringly, this is close to the standard deduction of 6,300 dollars that was available for single filers or married individuals filing separately in 2016.

4.3 Model Fit

As evident in Table 3, the calibration enables the model to successfully hit the target moments. However, the reliability of our results depends not only on how well the model performs with respect to aggregate measures. It also depends on the distributions and life-cycle profiles of relevant variables.

[22]In this case we do not include households aged 23-25. These ages correspond to the first model period, where households by construction cannot deduct property taxes or mortgage interest payments. Hence, the itemization rate is artificially low in the model for this age group.

Figure 2: Comparison of model versus data: non-targeted profiles and distributions



Note: Model refers to the results from the initial steady state with MID. In panel (f) data is from Harris (2005), otherwise data is taken from Survey of Consumer Finances (SCF), survey years 1989-2013. In panel (f) we interpolate the marginal tax rates to their nearest tax brackets, as the income tax schedule is continuous in the model.

The life-cycle profiles of homeownership, LTV, and mortgage-to-earnings are key indicators of the heterogeneity in exposure to the mortgage interest deductibility. Comparisons to SCF are displayed in Figure 2. The model performs well with respect to these variables, both in terms of magnitudes and life-cycle patterns. The model also produces a decent fit of the median house-to-earnings, which is a measure of exposure to price changes in the housing market.

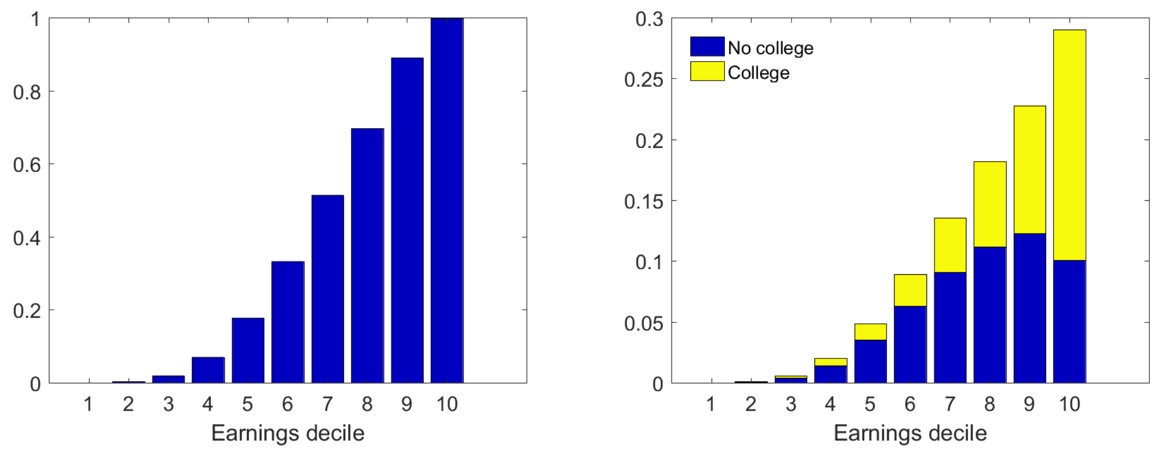
The distribution of marginal tax rates among households is also of importance when analyzing heterogeneous effects, as mortgage interest payments are deducted from a progressive tax schedule. Figure 2 displays the fractions of the working-age population exposed to the different statutory marginal tax rates in data (Harris, 2005) versus in the model. Although we are not able to exactly replicate the distribution, overall the earnings process and the tax schedule produce a satisfactory result.

Data of U.S. tax returns show that the fraction of households that itemize deductions is increasing in earnings and that there is a strong skewness in MID claims.[23] For example, only five percent of those earning less than $15,000 (25 percent of all returns) itemized deductions in 2011, and they claimed merely two percent of all mortgage interest deductions. This stands in sharp contrast to comparable numbers for those earning more than $100,000 (top 14 percent). They claimed 51 percent of the total mortgage interest deductions, and almost ninety percent itemized deductions. As seen in Figure 3a and Figure 3b, our model is able to replicate these important patterns: high earners itemize the most and claim a disproportionately large share of the mortgage interest deductions.

Figure 3: Itemizers and MID claims in the initial steady state, across earnings deciles

(a) Fractions that itemize

(b) Fractions of mortgage interest deductions



Note: Working-age households only.

[23]The data is publicly available on the IRS webpage. We use data from "SOI tax stats - individual statistical tables by size of adjusted gross income", tables 1.4 and 2.1.

5 Results

5.1 What are the Long-Run Effects of Removing the MID?

What would be the level of house prices in the U.S. if households were not able to deduct mortgage interest payments? Does the MID promote homeownership? What fraction of American households would prefer to be born into a world without the MID, and how much would they gain or lose on average?

These questions regarding the long-run implications of removing the MID are all addressed in this section. Although the focus of this paper is on the short-run dynamics of repealing the MID, the answers to these questions are also relevant for our purpose. Indeed, it is difficult to motivate a study of the short-run dynamics if the long-run welfare effects are negative. Moreover, key mechanisms in the long run are also at work in the short run. These mechanisms are easier to identify in the long-run analysis. The long-run results are also interesting in their own right. Our model is the first to our knowledge that allows house and rental prices to adjust in a model which includes both realistic life-cycle profiles and a progressive income tax schedule when studying the MID.[24]

In order to study the long-run effects of removing the MID, we compare the initial steady state with MID, to a new steady state in which the possibility to deduct mortgage interest payments is repealed.[25] Specifically, we study the long-run effects of changing the deductibility parameter τ^m from the initial value of one to zero, while imposing tax neutrality. The income tax level parameter λ is adjusted so that the net tax revenues for the government are unchanged between the steady states.[26]

Prices and Aggregates

Table 4 presents a comparison of the two steady states for a number of key variables. Overall, the new steady state without MID is characterized by lower house and rental prices, higher homeownership, reduced indebtedness, and lower taxes. To better understand the underlying mechanisms behind these results, Figure 4 shows the life-cycle profiles before and after the repeal of the MID for the mean house size, the homeownership rate, and the mean mortgage level. The mean house size and mortgage level are both conditional on owning. The life-cycle profiles are displayed for three distinct groups of households. In the

[24]Chambers et al. (2009) use a life-cycle model with overlapping generations and a progressive income tax schedule to e.g. study the effects of removing the MID. Compared to our study, they do not allow for both house and rental prices to fall, but instead adjust the rental price and the interest rate. Moreover, in their model all households automatically opt for itemized deductions, and the mortgage interest deductibility is removed for both owner-occupied housing and landlord-owned properties.

[25]In the analysis we focus on the working-age population, for the same reasons as stated in section 4.2.

[26]For a detailed description of the equilibrium definitions, the computational methods, and the solution algorithms, see the Appendices.

Table 4: Long-run effects on prices and aggregates of removing the MID

	MID	No MID	Difference	Relative difference (%)
House price	1	0.952	-0.048	-4.8
Rental price	0.236	0.230	-0.006	-2.3
Homeownership rate	0.66	0.72	0.06	9.0
Fraction ever-owner	0.81	0.85	0.04	4.6
Mean owned house size	22.99	21.79	-1.19	-5.2
Mean LTV	0.48	0.47	-0.01	-2.2
Mean mortgage	10.78	9.36	-1.42	-13.2
Mean bond holdings	1.29	1.24	-0.05	-3.9
Mean marginal tax rate	0.1502	0.1485	-0.0017	-1.14

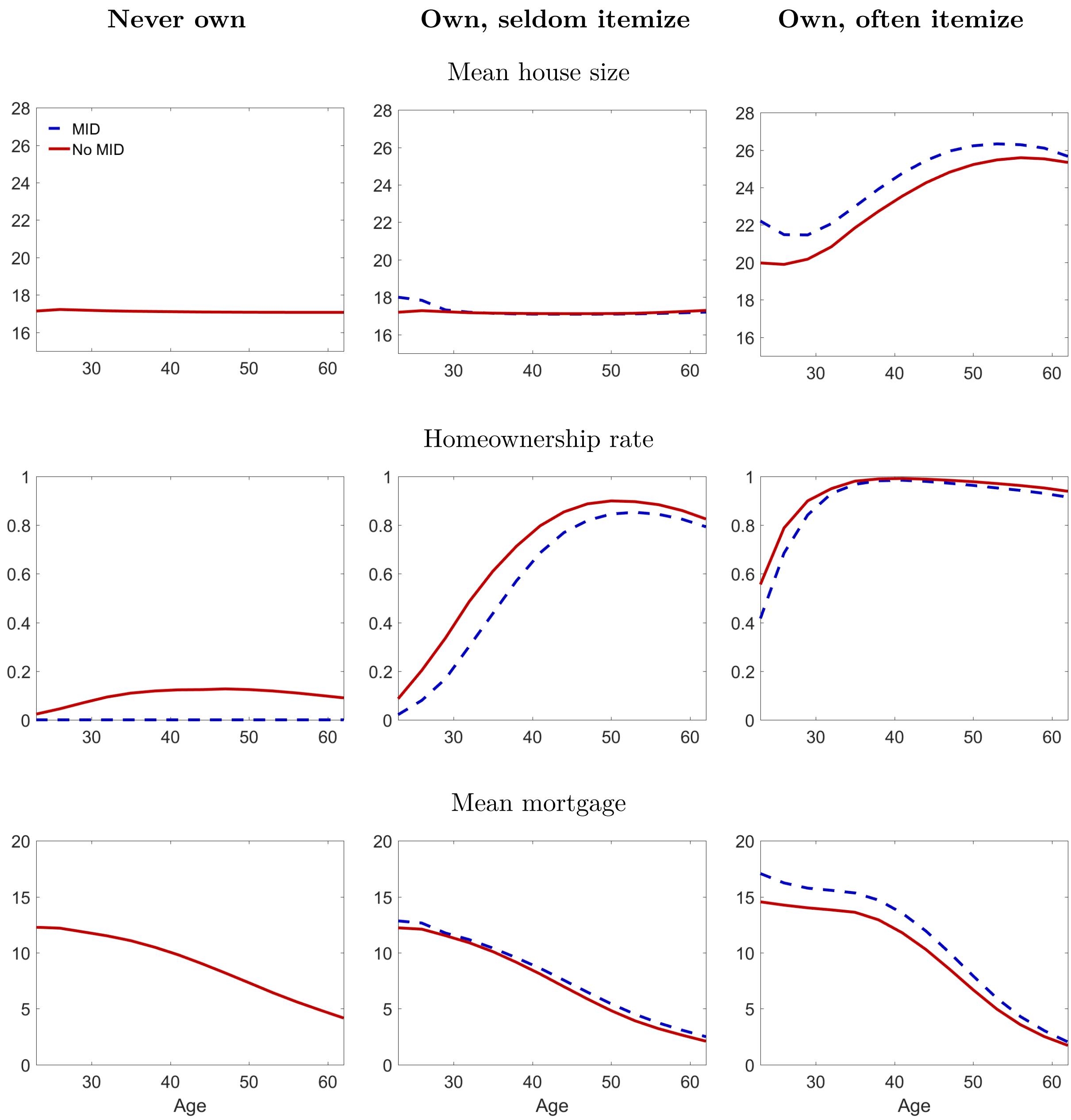
Note: The second column shows prices and aggregate measures in the initial steady state with MID, whereas the third column shows the corresponding values in the steady state without MID. "Fraction ever-owner" is the fraction of households that can expect to own a house at some point during their life. Other aggregates are computed for working-age households. The mean house size, LTV, and mortgage level are conditional on owning. The mean marginal tax rate is gross of deductions.

first column, we see the households who never own a house over the life cycle in the initial steady state (*Never own*). The second column shows the households who at some point own a house in the initial steady state, but itemize fewer than three periods during their life (*Own, seldom itemize*). In the last column, we see the households who at some point own a house in the initial steady state and itemize at least three periods during their life (*Own, often itemize*). Results are similar if we study each educational group separately and if we alter the number of itemizing periods used to divide between *seldom* and *often*.

The price decrease is driven by a downward shift in demand for housing among homeowners who often itemize. These households experience an increase in the user cost of owning, as discussed in section 3. If the house price is held constant, households in this group would wait longer until they buy their first house, and buy smaller houses. When we allow the house price to fall, it reduces the necessary down payment for purchasing a given house. The fall in the required down payment is important for the extensive margin, but has a negligible effect on the intensive margin. As a result, in the new steady-state equilibrium homeownership increases for the group of households that often itemize, whereas they demand smaller houses as seen in the first row and third column of Figure 4.

In the second row in Figure 4, we see that the lower house price has important consequences for the homeownership rate also for the two other groups. A significant share of the group of households who never own a house in the initial steady state are homeowners in the new steady state. Indeed, the fraction of households that can expect to

Figure 4: Long-run comparison of housing, homeownership, and mortgages



Note: Life-cycle profiles in the model economy with MID (blue dashed line) and without MID (red solid line). Mean house size and mortgages are conditional on owning. The labels of the three groups (columns) refer to the status of households in the initial steady state with MID. Specifically: i) Never own: households who never own a house over the life cycle; ii) Own, seldom itemize: households who at some point own a house, but itemize fewer than three periods during their life; iii) Own, often itemize: households who at some point own a house and itemize at least three periods during their life.

own a house at some point in life increases by about four percentage points (see *fraction ever-owner* in Table 4). Moreover, those who own a house but seldom itemize in the initial steady state, choose to buy their first house earlier in the new steady state. Overall, the homeownership rate increases by approximately six percentage points to around 72 percent.

The third row in Figure 4 shows that the mean mortgage level decreases in particular for the households that often itemize. The fall in mortgages can be explained by changes in house size demand and the fall in the house price. Since it is the itemizing households that demand smaller houses, they are also the ones that decrease their mortgage levels the most.

Why are U.S. Households Better Off Without the MID?

Table 5 shows that an overwhelmingly large fraction, 97 percent of households, would prefer to be born into the steady state without MID. The percentage in favor is similar for both the college and non-college educated households, with 95 and 98 percent, respectively. On average, the welfare gain of being born into the steady state without MID is equivalent to that of increasing consumption by 0.76 percent in all periods in the initial steady state, as measured by the mean consumption equivalent variation (CEV).

Table 5: Long-run welfare effects of removing the MID, for newborns

	Mean CEV (%)	Fraction in favor
Overall	0.76	0.97
No college	0.81	0.98
College	0.64	0.95

Note: Mean CEV (%) refers to the average consumption equivalent variation in percent, for newborns. For example, the “Overall” average welfare effect of removing the MID is equivalent to a 0.76 percent increase in consumption in all periods, in the initial steady state. Fraction in favor is the fraction of newborns with a CEV greater than or equal to zero. Note that including zero CEV in fraction in favor is not of importance, as all households are affected by the change in MID, either directly or through equilibrium effects.

There are three factors behind the changes in welfare from the initial to the new steady state; the direct effect of no longer having the subsidy, the lower house and rental prices, and the lower income taxes. With respect to the first factor, relatively few households experience significant negative effects. Even with MID in place, 60 percent of households do not itemize deductions, and a large fraction of households seldom or never deduct mortgage interest payments over the life cycle. In addition, as seen in Figure 3b, the amounts of mortgage interest deductions are highly skewed. Households with higher earnings receive a disproportionately large share of the total mortgage interest deductions. Most itemizing households deduct relatively modest amounts of mortgage interest payments. The lower house price in the steady state without MID makes both rental and owner-occupied housing more affordable, which increases welfare. Importantly, the lower house price reduces the equity requirement, which enables more households to become homeowners and allows some households to purchase a house earlier. Finally, the lower income tax in the new steady state benefits all households. Households at the top of the earnings distribution is the only group for which the direct negative effect of removing the MID outweighs the benefits of lower equilibrium prices and taxes.

5.2 What are the Short-Run Effects of Removing the MID?

Our results in the previous section suggest that U.S. households would have been considerably better off in a world in which they cannot deduct mortgage interest payments. However, the long-run analysis does not touch upon another important question; is a repeal of the MID also beneficial for current households? To shed light on this question, we need to consider short-run effects. In a short-run analysis, the timing of a removal policy influences the dynamics of important variables, such as prices and taxes, which affects household welfare.

We study three different policies for removing the MID, as depicted in Figure 5a.[27] Under an *immediate* policy, the mortgage interest deductibility is removed at once, i.e. $\tau_t^m = 0$ for all $t \geq 1$. This abrupt policy leaves no room for households to adjust their asset allocations before the MID is repealed. Therefore, we also consider two alternative policies in which the MID is removed less rapidly. Under a *gradual* policy, households can deduct mortgage interest payments for another 15 years (5 model periods), but the deductible share of interest payments is reduced stepwise over that period such that $\{\tau_t^m\}_{t=1}^{t=\infty} = \{1, 0.8, 0.6, 0.4, 0.2, 0, 0, ...\}$. We also study an *announcement* policy in which households are informed that all interest payments can be deducted for another 15 years before the MID is removed permanently, i.e. $\{\tau_t^m\}_{t=1}^{t=\infty} = \{1, 1, 1, 1, 1, 0, 0, ...\}$.

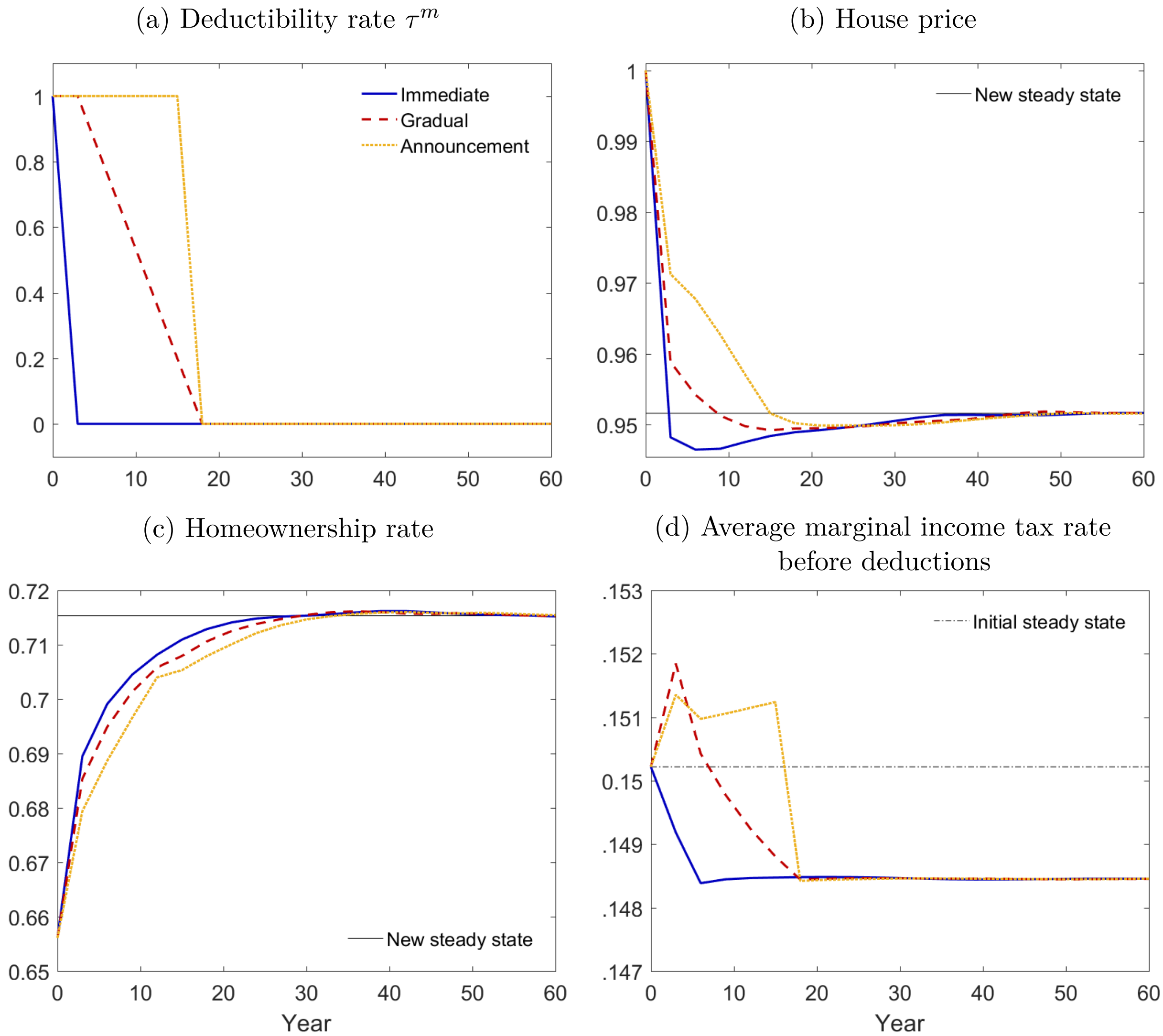
For all policies, we solve for the sequences of house and rental prices, $\{p_{ht}, p_{rt}\}_{t=1}^{t=T}$, and a sequence of the parameter governing the average income tax, $\{\lambda_t\}_{t=1}^{t=T}$, such that for all $t \in \{1, ..., T\}$, where T is the last transition period, total housing demand equals the initial housing stock and tax neutrality is achieved. All policies are implemented unexpectedly and households have perfect foresight of the transition paths of house and rental prices, as well as the tax parameter.

How do Short-Run Dynamics Depend on the Timing of Policies?

Figure 5 shows the short-run dynamics for the house price, the homeownership rate, and the average marginal income tax rate before deductions, for all three policies. The house

[27] For an analysis of a grandfather policy, see Appendix E.

Figure 5: Short-run dynamics from removing the MID, across policies



Note: Panel (a) shows how the deductibility rate is decreased under the three policy reforms. All policies are implemented unexpectedly and households have perfect foresight of the transition paths of prices and taxes. Panels (b)-(d) show how the house price, the homeownership rate, and the average marginal tax rate before deductions behave in the short run, in response to the paths of the deductibility rate.

price falls markedly already in the first period of the transition under all policies, before converging to the new lower steady-state level. The homeownership rate is slower to converge, and increases over time until it reaches the new steady-state level. The marginal income tax rate that ensures tax neutrality differs notably between the policies, but only for the first five periods.[28]

The house price falls most rapidly under the immediate policy. The price fall under a given removal policy is mainly driven by how young itemizing households respond. As seen

[28] In general, imposing tax neutrality has relatively small effects on the short-run dynamics of variables other than the marginal tax rate itself. It does, however, have consequences for welfare.

in the second row of Figure 2, young households have high LTVs and mortgage-to-earnings when they enter the housing market. These households often itemize deductions and are highly exposed to a removal of the MID. Consequently, the young marginal house buyers respond strongly to changes in the deductibility rate. Under the immediate policy, the housing demand of this group of households drops instantaneously. For the gradual and announcement policies, the response in housing demand is smaller due to the extended possibilities to deduct mortgage interest payments.

Although the instantaneous drop in the house price is the largest under the immediate policy, more than fifty percent of the total price fall occurs in the first transition period for the gradual and announcement policies. The lower present value of future net benefits of owning results in instantly lower demand for owned housing, under all policies. Households take into account their own expected financial situation as well as expected changes in the housing market structure, for all future periods, when deciding to purchase or sell a house. Hence, households react preemptively to future changes in the deductibility rate. The demand effect is reinforced by the transaction costs associated with buying and selling a house. Transaction costs restrain households from frequently re-optimizing their house size, which makes a house purchase a long-term investment.

The short-run dynamics of homeownership are mostly driven by demographics, thus the shape of the paths are similar across policies. Older households do not find it worthwhile to take on the necessary transaction cost of buying a house, as they discount the future more heavily and have fewer periods left in which to enjoy the benefit of owning. Hence, the homeownership rate converges slowly, largely reflecting that younger households, who behave similar to the new steady state, replace older households.

The differences in the income tax levels between the policies are driven by the paths of the deductibility rate and the house price. A lower mortgage deductibility rate decreases the government's tax expenditures, and allows the government to reduce the income tax level. On the other hand, a fall in the house price decreases the property tax payments, which worsens the government's budget. Under the immediate policy, the income tax level can be reduced at once. As in the long-run analysis, the effect on the budget from reduced expenses on interest deductions is stronger than the fall in revenue from property taxes. Under the gradual and announcement policies, the income tax rates initially increase, as the revenue from property taxes falls and the government still spends large amounts on interest deductions. When the MID is fully repealed, the tax rates are close to the new lower steady-state level.

Who are the Winners and Losers in the Short Run?

In order to evaluate the welfare effects of different removal policies, we consider the gains and losses incurred by households alive when the policy is implemented. These welfare effects can differ markedly from the long-run analysis, as many households have made long-term decisions based on the presumption that they can deduct mortgage interest payments. As will be shown in the analysis below, the welfare gains therefore tend to be significantly lower and much more dispersed in the short run.

Similar to the long-run analysis, there are three main factors influencing how a household is affected by a removal policy. First, a household is directly negatively affected by a reduction of the MID if it itemizes deductions and has a mortgage. The larger the mortgage and the higher the earnings, due to the progressive tax schedule, the worse off is the household. Second, a household is affected by the fall in the house price. Homeowners are negatively affected by the decrease in the house price during the transition, since the price fall reduces their housing equity. Renters on the other hand benefit from the lower house and rental prices.[29] Third, all households are affected by changes in the income tax level.

Table 6 presents the welfare gains, as measured by CEV, and the fraction in favor of the three policies, for households that are alive in the first period of the transition.[30] By aggregate measures, the immediate policy is preferred to the two alternative policies. The immediate policy has the highest mean CEV for the working-age households in both educational groups. In fact, it is the only policy that delivers a non-negative mean CEV for both educational groups and benefits a majority of the households.

The aggregate results mask important heterogeneous welfare effects. Figure 6 displays the distribution of welfare changes in the first period of the transition, under the immediate removal policy. Based on this distribution, we allocate households into five groups as indicated by the vertical lines in the figure. The first group contains the households who experience the largest welfare losses in the transition. The second group constitutes the households with less extreme, but still negative CEVs. The third group is made up by a relatively large mass of households that have small but positive CEVs. Most of the households in the right bell of the distribution are allocated to the fourth group, while the households in the right tail, with the largest welfare gains, constitute group five. Table 7 presents key characteristics for the different groups.

[29] As seen in equation (5), the rental price is fully explained by the current and next period's house price.

[30] Again, we focus on the working-age households. Welfare implications are broadly similar if we include retirees.

Table 6: Welfare effects for households alive in the first period of the transition

	Mean CEV (%)			Fraction in favor		
	Im.	Gr.	An.	Im.	Gr.	An.
Overall	0.23	0.10	0.00	0.61	0.47	0.42
No college	0.32	0.15	0.03	0.66	0.51	0.45
College	0.04	-0.01	-0.06	0.50	0.40	0.38

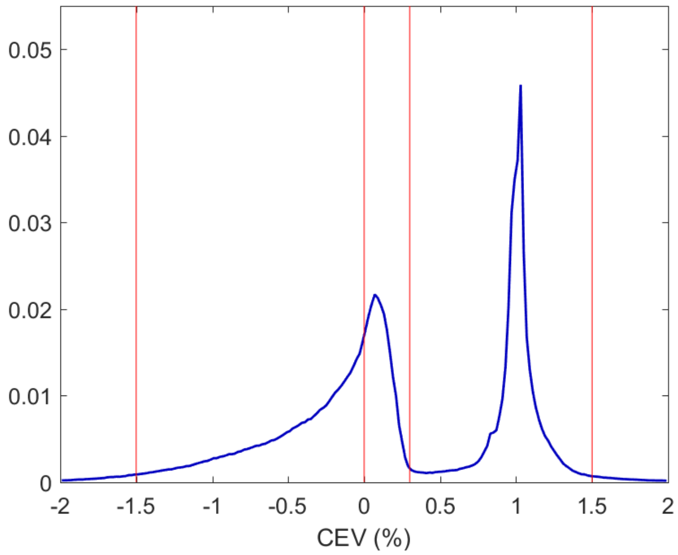
Note: "Im." refers to the immediate removal of the MID, "Gr." to the gradual removal, and "An." to the announcement policy. Mean CEV (%) refers to the average consumption equivalent variation in percent, for all working-age households that are alive in the first period of the transition. For example, the "Overall" average welfare effect of an immediate removal is equivalent to a 0.23 percent increase in consumption, in all remaining periods in the initial steady state. Fraction in favor is the fraction of working-age households with a CEV greater than or equal to zero.

The bimodal shape of the CEV distribution stems from differences in welfare effects between homeowners and renters. The mass around the right peak, groups four and five, consists of renters, while the mass around the left peak, groups one to three, consists of homeowners. Renters are not directly affected by the removal of the MID, but benefit from the lower rental price, lower equity requirements in the housing market, and lower taxes. The renters who experience the largest welfare gains, group 5, have very low earnings and are relatively old. These households benefit substantially from a lower rental price.

Homeowners realize several negative effects in the short run, but the extent to which they are affected varies with household characteristics. By comparing the three groups of homeowners in Table 7, we see that the CEV is decreasing in mortgages, permanent earnings, and the itemization rate. Homeowners with larger mortgages and higher earnings benefit more from itemizing deductions. Consequently, they are relatively worse off when they can no longer deduct mortgage interest payments, as represented by the long, thick tail of negative values in Figure 6. Table 7 also shows that the households with lower CEVs on average own larger houses, which primarily reflects that these households are high earners. In addition, younger homeowners tend to be worse off. This mainly follows from younger homeowners having higher LTVs.

The transition also brings positive effects for homeowners, which for some households outweigh the negative effects. All homeowners benefit from the lower income taxes when the MID is removed, as well as the decreased property tax payments following the house price fall. Group three in Table 7 consists of homeowners in favor of removing the MID. Relative to the other groups of homeowners, fewer households itemize deductions and they have low LTVs. Hence, these households experience no or small negative direct effects of the repeal of the MID. Although their housing equity falls with the lower house price, the benefits of lower income and property taxes dominate.

Figure 6: The distribution of welfare effects under the immediate removal policy



Note: The blue solid line shows the distribution of welfare effects under the immediate policy, for working-age households alive in the first period of the transition. The red vertical lines allocate households into different groups based on their welfare effects. See Table 7 for key characteristics of these groups. For a description of CEV (%) see *Note* below Table 6.

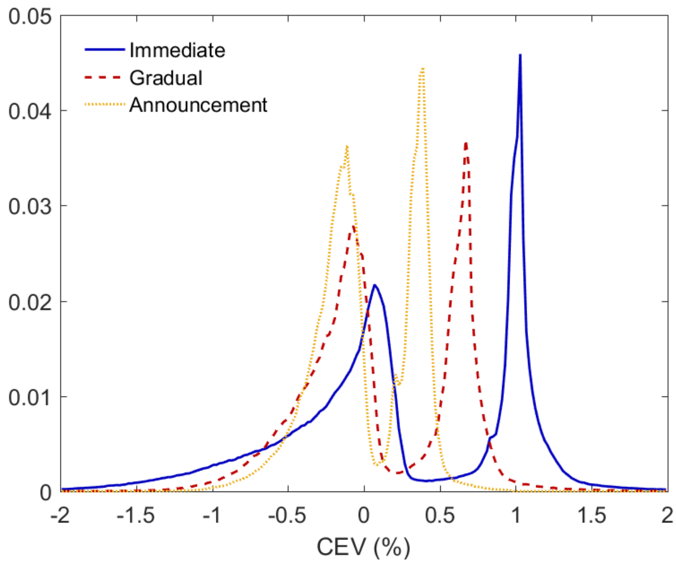
Table 7: Characteristics of winners and losers in the short run

Group:	1	2	3	4	5
CEV range:	< -1.5	$[-1.5, 0[$	$[0, 0.3[$	$[0.3, 1.5[$	≥ 1.5
Mean CEV	-1.83	-0.45	0.11	0.99	1.85
Homeownership rate	1	0.99	0.97	0.01	0
Itemization rate	0.97	0.71	0.39	0.01	0
Age	37	44	48	36	56
Permanent earnings	61	40	35	18	6
House size	40	25	20	20	-
Mortgage	29	12	6	2	-
LTV	0.76	0.56	0.37	0.10	-

Note: Groups 1 to 5 correspond to the five welfare groups defined by the red vertical lines in Figure 6. Thus, welfare effects are those experienced under the immediate removal policy. Other measures correspond to mean values of working-age households in the event the MID is not repealed. House size, mortgage, and LTV are conditional on owning a house.

There are substantial differences in the CEV distributions across policies, as seen in Figure 7. The three main factors causing these differences are variations in the transition paths for allowable mortgage interest deductions, the house and rental prices, and the income tax level.

Figure 7: Distributions of short-run welfare effects, across policies



Note: Distributions of welfare effects of the three policies, for working-age households alive in the first period of the transition. For a description of CEV (%) see *Note* below Table 6.

Households can deduct some or all of their mortgage interest payments for several periods under the gradual and announcement policies. This benefits households with large mortgages and high earnings. Importantly, it also allows households to reduce their mortgages before the deductibility is removed completely. For these reasons, the left tail of the CEV distribution is substantially thinner under these policies. Itemizing households with large mortgages and high earnings prefer the announcement policy, over the gradual and the immediate policies.

The slower fall in the rental and house prices under the gradual and announcement policies affects both renters and homeowners. Renters prefer the immediate policy, since they benefit from a faster decline in prices. Lower prices make rental units more affordable and owned housing more accessible. As a result, the right peak of the distribution shifts to the left under the gradual and announcement policies. For homeowners, the accelerated fall in the house price under the immediate policy reduces housing equity more rapidly. This negative effect is partly offset by two factors. First, a lower house price leads to lower property taxes and thus a decline in the user cost of owning. Second, only those who sell their house early in the transition, where the house price differences are large, are affected by the differences in the house price between the policies.

A lower income tax level benefits all households and shifts the whole CEV distribution to the right. For the first five periods of the transition, the immediate policy has the lowest average income tax, followed by the gradual policy and the announcement policy, respectively. Thus, households benefit the most from income tax changes under the immediate policy. This relative benefit disappears later in the transition as the tax level, under all policies, converges to the new steady-state level.

The main takeaways can be summarized as follows. Renters are not directly affected by removing the MID as they have no investments in the housing market and hold no mortgages. They benefit, however, from a fall in rental and house prices, as well as in income taxes. Hence, they are generally in favor of removing the MID and prefer policies in which prices and taxes fall rapidly. Homeowners with relatively low mortgages and earnings, experience no or small direct effects of removing the MID. They gain little from extended possibilities to deduct mortgage interest payments and prefer faster removal policies. Although the instantaneous fall in housing equity is higher under more sudden policies, the positive effects of lower income and property taxes dominate and push this group of homeowners into positive CEV territory. Under policies where the MID is extended, hardly any of these homeowners experience welfare improvements relative to status quo. Turning to the group of homeowners with large mortgages and high earnings, these households benefit substantially from the possibility to deduct mortgage interest payments. As a result, the costs of removing the MID outweigh the benefits of lower income and property taxes. These homeowners prefer more gradual removal policies where they have time to decrease their mortgages, but they are generally not in favor of removing the MID.

The U.S. housing market structure and tax system explain why more rapid removal policies produce higher support and mean CEV. About 34 percent of all households rent housing services in the U.S. Our results indicate that these households are in favor of removing the MID, and their welfare gains are larger under more immediate removals. Furthermore, the option to itemize deductions and the progressive income tax system create a strongly skewed distribution of mortgage interest deductions. Only 40 percent of working-age households itemize deductions, which is considerably lower than the 66 percent who own a house. Of those who itemize, a disproportionately large share of total mortgage interest deductions are claimed by the highest-earning households. Due to these features of the U.S. tax system, there is a substantial group of homeowners that experience small direct costs from a repeal of the MID, and who benefit from rapid removal policies. These households are pivotal for understanding whether the median voter is in favor of a reform or not.

6 Concluding Remarks

A growing academic literature consistently shows that, in the long run, most American households would be better off without the MID. Much less is known about how a repeal of the MID would affect current households and, in particular, how these effects depend on the design of the removal policy. In this paper, we attempt to fill this gap by studying the short-run effects of several MID removal policies.

Our results show that the welfare effects in the short run are considerably lower on average, and more dispersed, compared to those in the long run. Importantly, we find that both aggregate and distributional welfare measures depend significantly on how the MID is removed and that households differ in their preferred policy design. Interestingly, the natural candidates for removing the MID - the gradual and announced policies - do not necessarily benefit the average American household. Indeed, a majority of households actually prefer and benefit from an immediate removal with large and instantaneous equilibrium effects of lower prices and taxes.

The results have important policy implications. First, when we take the short-run dynamics into account, removing the MID may not be optimal for a policymaker who mainly cares about the households alive today. Second, a policymaker faces a difficult trade-off. An immediate policy, which a majority support, comes at the cost of more pronounced losses for those who are hurt the most from a repeal: relatively young households with large mortgages and high earnings. A policymaker who attempts to mitigate these losses through a more gradual removal, runs the risk that the reform will not pass a public vote.

It is worth mentioning some limitations of our study. First, we do not consider potential demand effects on output from e.g. lower house prices. To the extent that such changes in output can have important feedback effects into house prices, these effects are omitted from the analysis. Second, throughout the analysis we have assumed that households are fully rational and perfectly able to comprehend the benefits associated with removing the MID. As shown in Dal Bó et al. (2017), equilibrium effects tend to be challenging for people to predict. If households do not understand or believe that a repeal of the MID will reduce the tax level, it may be difficult for any removal policy to receive sufficient support. Last, we assume that house prices are linear in house size. Our analysis shows that a removal of the MID reduces demand for larger houses, whereas more households buy smaller homes. Including non-linear price effects may have implications for homeownership and welfare. Although we find these considerations and possible extensions interesting, we leave them as suggested avenues for future research.

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Appendices (for online publication)

A Equilibrium Definitions

A.1 Stationary Equilibria

Households are heterogeneous with respect to their education $e \in \mathcal{E} \equiv \{\text{no college, college}\}$, age $j \in \mathcal{J} \equiv \{1, 2, ..., J\}$, permanent earnings $p \in \mathcal{P} \equiv \mathbb{R}_{++}$, owner-occupied housing $h \in \mathcal{H} \equiv \{0, \underline{h}, ..., \bar{h} = \bar{s}\}$, and cash-on-hand $x \in \mathcal{X} \equiv \mathbb{R}_{++}$. Let $\mathcal{Z} \equiv \mathcal{P} \times \mathcal{H} \times \mathcal{X}$ be the non-deterministic state space with $\mathbf{z} \equiv (p, h, x)$ denoting the vector of individual states. Let $\mathbf{B}(\mathbb{R}_{++})$ be the Borel σ-algebra on $\mathbb{R}_{++}$, and $P(\mathcal{H})$ the power set of $\mathcal{H}$, and define $\mathscr{B}(\mathcal{Z}) \equiv \mathbf{B}(\mathbb{R}_{++}) \times P(\mathcal{H}) \times \mathbf{B}(\mathbb{R}_{++})$. Further, let $\mathbb{M}$ be the set of all finite measures over the measurable space $(\mathcal{Z}, \mathscr{B}(\mathcal{Z}))$. Then $\Phi_{ej}(Z) \in \mathbb{M}$ is a probability measure defined on subsets $Z \in \mathscr{B}(\mathcal{Z})$ that describes the distribution of individual states across agents with education $e \in \mathcal{E}$ and age $j \in \mathcal{J}$. Finally, denote the time-invariant fraction of the population that has education $e \in \mathcal{E}$ and age $j \in \mathcal{J}$ by Π_{ej}.

Stationary Equilibrium with MID

Definition 1. A stationary recursive competitive equilibrium with MID ($\tau^m = 1$) is a collection of value functions $V_{ej}(\mathbf{z})$ with associated policy functions $\{c_{ej}(\mathbf{z}), s_{ej}(\mathbf{z}), h'_{ej}(\mathbf{z}), m'_{ej}(\mathbf{z}), b'_{ej}(\mathbf{z})\}$ for all e and j; prices $(p_h = 1, p_r)$; a quantity of total housing stock $\bar{H}$; government's total tax revenue $\overline{TR}$; and a distribution of agents' states Φ_{ej} for all e and j such that:

1. Given prices $(p_h = 1, p_r)$, $V_{ej}(\mathbf{z})$ solves the Bellman equation (4) with the corresponding set of policy functions $\{c_{ej}(\mathbf{z}), s_{ej}(\mathbf{z}), h'_{ej}(\mathbf{z}), m'_{ej}(\mathbf{z}), b'_{ej}(\mathbf{z})\}$ for all e and j.

2. Given $p_h = 1$, the rental price per unit of housing service p_r is given by equation (5).

3. The quantity of the total housing stock is given by total demand for housing services[31]

$$\bar{H} = \sum_{\mathcal{E}} \sum_{\mathcal{J}} \Pi_{ej} \int_Z s_{ej}(\mathbf{z}) d\Phi_{ej}(Z).$$

4. Government's net tax revenue is given by equation (8).

[31] We assume perfectly elastic supply of both owner-occupied housing and rental units in the initial steady state. This implies supply always equals demand, and we thus have market clearing.

5. The distribution of states Φ_{ej} is given by the following law of motion for all e and $j < J$

$$\Phi_{e,j+1}(\mathcal{Z}) = \int_Z Q_{ej}(\mathbf{z}, \mathcal{Z}) d\Phi_{ej}(Z),$$

where $Q_{ej} : \mathcal{Z} \times \mathscr{B}(\mathcal{Z}) \to [0,1]$ is a transition function that defines the probability that a household with education e at age j transits from its current state $\mathbf{z}$ to the set $\mathcal{Z}$ at age $j+1$.

Stationary Equilibrium without MID

Definition 2. A tax neutral stationary recursive competitive equilibrium without MID ($\tau^m = 0$) is a collection of value functions $V_{ej}(\mathbf{z})$ with associated policy functions $\{c_{ej}(\mathbf{z}), s_{ej}(\mathbf{z}), h'_{ej}(\mathbf{z}), m'_{ej}(\mathbf{z}), b'_{ej}(\mathbf{z})\}$ for all e and j; prices (p_h, p_r); a quantity of total housing stock H; a parameter governing the average income tax level λ; and a distribution of agents' states Φ_{ej} for all e and j such that:

1. Given prices (p_h, p_r) and λ, $V_{ej}(\mathbf{z})$ solves the Bellman equation (4) with the corresponding set of policy functions $\{c_{ej}(\mathbf{z}), s_{ej}(\mathbf{z}), h'_{ej}(\mathbf{z}), m'_{ej}(\mathbf{z}), b'_{ej}(\mathbf{z})\}$ for all e and j.

2. Given p_h, the rental price per unit of housing service p_r is given by equation (5).

3. The housing market clears:

$$\begin{aligned} & H = \bar{H} \\ \text{where} \quad & H = \sum_{\mathcal{E}} \sum_{\mathcal{J}} \Pi_{ej} \int_Z s_{ej}(\mathbf{z}) d\Phi_{ej}(Z) \\ \text{and} \quad & \bar{H} \text{ is the housing stock from the equilibrium with MID.} \end{aligned}$$

4. The government's net tax revenue is the same as in the steady state with MID:

$$\begin{aligned} & TR = \overline{TR} \\ \text{where} \quad & TR \text{ is given by equation (8)} \\ \text{and} \quad & \overline{TR} \text{ is the tax revenues from the equilibrium with MID.} \end{aligned}$$

5. Distributions of states Φ_{ej} are given by the following law of motion for all e and $j < J$

$$\Phi_{e,j+1}(\mathcal{Z}) = \int_Z Q_{ej}(\mathbf{z}, \mathcal{Z}) d\Phi_{ej}(Z),$$

A.2 Transitional Equilibrium

During the transition, mortgage $m \in \mathcal{M} \equiv \mathbb{R}_+$ becomes an additional state variable. Let $\mathcal{Z}_{tr} \equiv \mathcal{Z} \times \mathbb{R}_+$ be the non-deterministic state space with $\mathbf{z}_{tr} \equiv (p, h, x, m)$ denoting the vector of individual states. Let $\mathscr{B}_{tr}(\mathcal{Z}_{tr}) \equiv \mathscr{B}(\mathcal{Z}) \times \mathbf{B}(\mathbb{R}_+)$ and $\mathbb{M}_{tr}$ be the set of all finite measures over the measurable space $(\mathcal{Z}_{tr}, \mathscr{B}_{tr}(\mathcal{Z}_{tr}))$. Then $\Phi_{tr,ejt}(Z_{tr,t}) \in \mathbb{M}_{tr}$ is a probability measure defined on subsets $Z_{tr,t} \in \mathscr{B}_{tr}(\mathcal{Z}_{tr})$ that describes the distribution of individual states across agents with education $e \in \mathcal{E}$ and age $j \in \mathcal{J}$ at time period t.

Definition 3. Given a sequence of mortgage interest deductibility parameters $\{\tau^m_t\}_{t=1}^{t=\infty}$ and initial conditions $\Phi_{tr,ej1}(Z_{tr,1})$ for all e and j, a tax neutral transitional recursive competitive equilibrium is a sequence of value functions $\{V_{ejt}(\mathbf{z}_{tr})\}_{t=1}^{t=\infty}$ with associated policy functions $\{c_{ejt}(\mathbf{z}_{tr}), s_{ejt}(\mathbf{z}_{tr}), h'_{ejt}(\mathbf{z}_{tr}), m'_{ejt}(\mathbf{z}_{tr}), b'_{ejt}(\mathbf{z}_{tr})\}_{t=1}^{t=\infty}$ for all e and j; a sequence of prices $\{(p_{h,t}, p_{r,t})\}_{t=1}^{t=\infty}$; a sequence of quantities of total housing demand $\{H_t\}_{t=1}^{t=\infty}$; a sequence of parameters governing the average income tax level $\{\lambda_t\}_{t=1}^{t=\infty}$; and a sequence of distributions of agents' states $\{\Phi_{tr,ejt}\}_{t=1}^{t=\infty}$ for all e and j such that:

1. Given prices $(p_{h,t}, p_{r,t})$, $V_{ejt}(\mathbf{z}_{tr})$ solves the Bellman equation with the corresponding set of policy functions $\{c_{ejt}(\mathbf{z}_{tr}), s_{ejt}(\mathbf{z}_{tr}), h'_{ejt}(\mathbf{z}_{tr}), m'_{ejt}(\mathbf{z}_{tr}), b'_{ejt}(\mathbf{z}_{tr})\}$ for all e, j, and t.

2. Given $p_{h,t}$ and $p_{h,t+1}$, the rental price per unit of housing service is $p_{r,t}$ for all t.

3. The housing market clears:

$$\begin{aligned} & H_t = \bar{H} \quad \forall t \\ \text{where} \quad & H_t = \sum_{\mathcal{E}} \sum_{\mathcal{J}} \Pi_{ej} \int_{Z_{tr,t}} s_{ejt}(\mathbf{z}_{tr}) d\Phi_{tr,ejt}(Z_{tr,t}) \quad \forall t \\ \text{and} \quad & \bar{H} \text{ is the housing stock from the equilibrium with MID.} \end{aligned}$$

4. The government's net tax revenue is the same as in the steady state with MID:

$$\begin{aligned} & TR_t = \overline{TR} \quad \forall t \\ \text{where} \quad & TR_t \text{ is the total tax revenue in period } t, \forall t \\ \text{and} \quad & \overline{TR} \text{ is the tax revenues from the equilibrium with MID.} \end{aligned}$$

5. Distributions of states $\Phi_{tr,ejt}$ are given by the following law of motion for all e, $j < J$, and t:

$$\Phi_{tr,e,j+1,t+1}(\mathcal{Z}_{tr}) = \int_{Z_{tr,t}} Q_{tr,ejt}(\mathbf{z}_{tr}, \mathcal{Z}_{tr}) d\Phi_{tr,ejt}(Z_{tr,t}),$$

where $Q_{tr,ejt} : \mathcal{Z}_{tr} \times \mathscr{B}_{tr}(\mathcal{Z}_{tr}) \to [0,1]$ is a transition function that defines the probability that a household with education e and age j at time t transits from its current state $\mathbf{z}_{tr}$ to the set $\mathcal{Z}_{tr}$ at age $j+1$ and time $t+1$.

B Computational Method

We discretize the state space by choosing a finite grid for permanent earnings $P_{ej} \equiv \{p_{ej,1}, ..., p_{ej,N_P}\}$ and cash-on-hand $X_e \equiv \{x_{e,1}, ..., x_{e,N_X}\}$.[32] Permanent earnings are education-age specific with $N_P = 9$ grid points. We use education-specific cash-on-hand grids and set the number of grid points N_X to 30. Moreover, we take into account the concavity of the value function by letting the spacing between two grid points increase with the level of cash-on-hand. Housing is assumed to be available in discrete sizes only and we let the grid for housing be $H \equiv \{0, h_1, ..., h_{N_H}\}$ where h_1 is calibrated and $N_H = 14$.

To solve for the value and policy functions, we use a general generalization of the endogenous grid method G^{2}EGM inspired by Druedahl and Jørgensen (2017). The method allows for occasionally binding constraints and non-convexities, while reaping the speed benefits associated with the traditional EGM as in Carroll (2006).

We approximate expectations to solve for the value and policy functions. The transitory earnings shocks are approximated by five Gauss-Hermite quadrature nodes, whereas the permanent earnings shocks are approximated using education-specific Markov chains. We use the method in Tauchen (1986), but allow the support for shocks to fan out over the life cycle (see e.g. Storesletten et al. (2004)). For each education-age combination, we let the outermost grid points be $m_P = 3$ standard deviations from the mean. For simulation purposes, we draw both shocks from their respective continuous distributions. To avoid extrapolation of permanent shocks outside the $m_P = 3$ standard deviation bound, we force permanent income to be on the outermost grid point whenever necessary.

Similar to the traditional EGM, we use grids for the post-decision states to solve for the value and policy functions. The post-decision states in our model are bonds $b' \in \mathbb{R}_+$, mortgages $m' \in \mathcal{M} \equiv \mathbb{R}_+$, and housing $h' \in \mathcal{H}$. For relevant parameter values it is not preferable to hold both mortgages and bonds. For computational convenience, we let b'_y and ltv' be post-decision states instead of b' and m', respectively, where b'_y denotes bonds as a fraction of earnings and ltv' denotes loan-to-value.[33]

Let ϵ be a very small positive number. We choose a finite grid for bonds over earnings $B_y \equiv \{b_{y,1} = 0, b_{y,2} = \epsilon, b_{y,3}, ..., b_{y,N_B}\}$ where $N_B = 80$ and the grid points

[32] We do, however, allow households to have permanent earnings p and cash-on-hand x off grid. We linearly interpolate in cases where p and x are off grid.

[33] Note that both b' and m' can easily be backed-out from b'_y and ltv', for given earnings y, housing h', and house price p_h.

are denser at lower levels of bonds over earnings. The finite grid for loan-to-value is $LTV \equiv \{ltv_1 = 0, ltv_2 = \epsilon, ..., (1-\theta-\epsilon), (1-\theta), (1-\theta+\epsilon), ..., ltv_{N_{LTV}}\}$ where $N_{LTV} = 20$ and θ is the down-payment requirement. Between ltv_2 and $(1-\theta-\epsilon)$ spacing is linear. Spacing is also linear between $(1-\theta+\epsilon)$ and $ltv_{N_{LTV}}$. We allow policy functions for b'_y and ltv' to be off grid by using linear interpolation.

From the definition of the finite grid LTV, we can see how the alternative formulation of post-decision states is particularly convenient in the case of mortgages. First, we ensure that the loan-to-value requirement is on the discretized grid. Second, we can easily specify loan-to-value levels that are very close to the occasionally binding constraints. Both of these features help facilitate more efficient and accurate solutions.

To solve for the equilibrium, we simulate $150,000$ households for J periods in each educational group. When aggregating, each education-age group is assigned a weight Π_{ej}, where the weight reflects the true population density in the U.S. Households are born without assets and receive earnings shocks from continuous distributions at the beginning of each period, before they are taxed and subsequently make their choices. For simplicity, accidental bequests are assumed not to affect other agents.

During the transition, ltv enters as a pre-decision state variable as households do not have to comply with the loan-to-value constraint as long as they stay in the same house and do not increase their mortgage.

All policy reforms are unexpected and we adjust the initial distribution of individual states for changes in the house price and taxes. Specifically, cash-on-hand x needs to be adjusted because (i) the value of the house falls; (ii) the property tax payment falls; (iii) of lower tax deductions due to changes in the MID and lower property taxes; (iv) of changes in the tax level parameter λ. In addition, we need to adjust for changes in the loan-to-value due to a lower house price.

At any time t during the transition, new households enter the economy and replace the households that were of age J in the previous period $t-1$. We assume that newborns are hit by the same sequences of exogenous earnings shocks as the households they replace.

C Solution Algorithm

C.1 Steady State

Solving the initial steady state with MID ($\tau^m = 1$):

1. Impose house price $p_h = 1$ and compute p_r from equation (5).

2. For each education group $e \in \mathcal{E}$, recursively solve for the value and policy functions.

3. For each $e \in \mathcal{E}$, simulate using optimal decision rules.

4. Use simulated values to compute the total housing stock $\bar{H}$ and the government's total tax revenue $\overline{TR}$. From the simulation we also get the distribution of agents' states Φ_{ej} for all e and j.

Let λ_{init} be the parameter value of the income tax level in the initial steady state. Then, solving the new tax neutral steady state without MID ($\tau^m = 0$) can be divided into 2 stages. In the first stage, we solve the steady state without MID given that $\lambda = \lambda_{init}$, i.e. we do not impose tax neutrality:

1. Guess p_h and compute p_r.

2. For each $e \in \mathcal{E}$, recursively solve for the value and policy functions, and simulate using optimal decision rules. Use simulated values to compute the total housing demand H.

3. Compute excess demand for housing $ED_H = H - \bar{H}$.

   (a) If $|ED_H|$ is larger than some tolerance level, update p_h using bisection and go back to step 1.

   (b) If $|ED_H|$ is within the tolerance level, convergence in the first stage is achieved. Denote the equilibrium house price under stage 1 as $\hat{p}_h$.

In the second stage, we solve for the tax neutral steady state:

1. Guess (p_h, λ), where the first guess is $p_h = \hat{p}_h + \epsilon_{p_h}$ and $\lambda = \lambda_{init} + \epsilon_\lambda$.

2. Given p_h, compute p_r.

3. For each $e \in \mathcal{E}$, recursively solve for the value and policy functions, and simulate using optimal decision rules. Use simulated values to compute the total housing demand H and government's total tax revenues TR.

4. Compute excess demand for housing and excess government tax revenue ED_H and $ED_{TR} = TR - \overline{TR}$, respectively.

   (a) If $|ED_H|$ or $|ED_{TR}|$ (or both) are larger than some tolerance levels, update guess for (p_h, λ) using the rule $q' = q + ED_k * \epsilon_q$ where $q \in \{p_h, \lambda\}$ and $k = H$ if $q = p_h$ and $k = TR$ if $q = \lambda$. Go back to step 2.

   (b) If both $|ED_H|$ and $|ED_{TR}|$ are within the tolerance levels, convergence is achieved.

C.2 Transition

Let $\Phi_{init,ej}$ be the distribution of households' states in the initial steady state, and let λ_{new} be the equilibrium λ from the tax neutral steady state without MID. Further, let t denote the transition period, and assume that the economy is in the new steady state in $t = T+1$. Choose T large enough so that by increasing T the transition path is unaltered.[34] The solution algorithm for the transitional equilibrium can be described in 2 stages. In the first stage, we solve for the transitional equilibrium assuming $\lambda_t = \lambda_{new}\ \forall t \in \mathcal{T} \equiv \{1, ..., T\}$:

1. Guess $\{p_{h,t}\}_{t=1}^{t=T}$ and compute $\{p_{r,t}\}_{t=1}^{t=T}$.

2. For each $e \in \mathcal{E}$, recursively solve for the value and policy functions for all ages $j \in \mathcal{J}$ and time periods $t \in \mathcal{T}$. To solve for value and policy functions at time period $t = T$, assume that the value and policy functions in $t = T + 1$ are the ones from the new steady state with tax neutrality.

3. Given the price p_{h1} and λ_1, for each $e \in \mathcal{E}$ and $j \in \mathcal{J}$ adjust the initial distribution $\Phi_{init,ej}$ to reflect unexpected changes in the house price and tax level from the initial steady state.

4. For each $e \in \mathcal{E}$, simulate using the adjusted initial distributions and optimal decision rules. Use simulated values to compute the sequence of total housing demand $\{H\}_{t=1}^{t=T}$.

5. Compute the sequence of excess demand for housing $\{ED_{H,t}\}_{t=1}^{t=T}$, and the Euclidean norm of this sequence.

   (a) If the norm is larger than some tolerance level, update $\{p_{h,t}\}_{t=1}^{t=T}$ using the rule $p'_{h,t} = p_{h,t} + ED_{H_t} * \epsilon_{p_h}$ for all $t \in \mathcal{T}$ and go back to step 1.

   (b) If the norm is within the tolerance level, convergence in the first stage is achieved. Denote the equilibrium house prices under stage 1 $\hat{p}_{h,t}$ for all $t \in \mathcal{T}$.

In the second stage, we solve for the tax neutral transitional equilibrium:

1. Guess $\{(p_{h,t}, \lambda_t)\}_{t=1}^{t=T}$, where the first guess is $p_{h,t} = \hat{p}_{h,t}$ and $\lambda_t = \lambda_{new}$ for all $t \in \mathcal{T}$.

2. Given $\{p_{h,t}\}_{t=1}^{t=T}$, compute $\{p_{r,t}\}_{t=1}^{t=T}$.

3. For each $e \in \mathcal{E}$, recursively solve for the value and policy functions for all ages and time periods, adjust the initial distributions $\Phi_{init,ej}$ to reflect unexpected changes in the house price and tax level from the initial steady state, and simulate using the

[34] We set $T = J$

adjusted initial distributions and optimal decision rules. Use simulated values to compute the sequences of total housing demand $\{H\}_{t=1}^{t=T}$ and government's total tax revenues $\{TR\}_{t=1}^{t=T}$.

4. Compute the sequences of excess demand for housing and excess government tax revenue $\{ED_{H,t}\}_{t=1}^{t=T}$ and $\{ED_{TR,t}\}_{t=1}^{t=T}$, respectively. Compute the Euclidean norm of both sequences.
   (a) If the norm of either sequence is larger than some tolerance level, update guess $\{(p_{h,t}, \lambda_t)\}_{t=1}^{t=T}$ using the rule $q' = q + ED_k * \epsilon_q$ for all $t \in \mathcal{T}$, where $q \in \{p_{h,t}, \lambda_t\}$ and $k = H_t$ if $q = p_{h,t}$ and $k = TR_t$ if $q = \lambda_t$. Go back to step 2.
   (b) If both norms are within the tolerance levels, convergence is achieved.

D Labor Income Process

D.1 Data Sample

Equations (13) and (14) are estimated using PSID data for the survey years 1970 to 1992. Following Cocco et al. (2005), we drop households where the head was i) a nonrespondent, ii) part of the Survey of Economic Opportunities subsample, iii) disabled or retired, iv) a student, or v) a housewife. Due to few female headed households, we focus exclusively on households with male heads.

In line with Guvenen (2009), we further restrict the sample by only keeping households for which i) earnings are strictly positive, ii) annual hours worked by head are between 520 (10 hours per week) and 5110 (14 hours a day, everyday), iii) head's average hourly wage is between \$2 and \$400 in 1993 dollars, where we adjust the bounds backwards using the growth rate in earnings from the Bureau of Labor Statistics, iv) the head is between 20 and 64 years old, and v) the head appears in the sample in at least 15 out of 23 possible survey years.

D.2 Estimation

In order to simulate the exogenous earnings process according to equations (13) and (14), we estimate the deterministic earnings profile $g(j)$ and the variances of the fixed-effect component σ_α^2, the permanent shock σ_η^2, and the transitory shock σ_ν^2, for the two educational groups. Estimating the deterministic wage component $g(j)$ is done in two steps. First, we estimate it on an annual basis, and then we convert it to suit the model period length of three years.

Step 1: Using the yearly observations in the data, we estimate a yearly version of the deterministic component. That is, we estimate $g_a(age)$, where index a stands for annual and $age \in \{20, 21, ..., 64\}$ for no college and $age \in \{22, 23, ..., 64\}$ for college. We regress $\log(y_i)$ on dummies for age (not including the youngest age), marital status, and family composition (number of family members besides head and, potentially, wife). We control for household fixed effects by running a linear fixed effect regression. The constant term from the regression is saved as $\hat{\beta}^{age_{min}}$, where age_{min} is 20 and 22 for no college and college, respectively.

Similar to Cocco et al. (2005), we fit a third-order polynomial to the vector of age dummy coefficients $\hat{\beta}^{age}$ for model purposes. Specifically, we run the regression

$$\hat{\beta}_i^{age} = a + b\, age_i + c\, \frac{age_i^2}{10} + d\, \frac{age_i^3}{100}. \tag{17}$$

The estimate of the *annual* deterministic earnings profile $\hat{g}_a(age)$ is then given by

$$\hat{g}_a(age) = \hat{\beta}^{age_{min}} + \tilde{\beta}^{age},$$

where $\tilde{\beta}^{age}$ are the fitted values from the regression model depicted in (17).

Step 2: We convert annual estimates to three-year periods as follows

$$\hat{g}(j) = \hat{g}_a(j * 3 + 21) \quad \text{for } j \in [1, J_{ret}]. \tag{18}$$

Equation (18) states that the deterministic earnings in period $j = 1$ is the annual deterministic earnings at adult age 24 and the earnings in period $j = J_{ret}$ is the annual earnings at adult age 63. As such, the deterministic earnings in period j is equal to that of the middle adult age of which period j is assumed to represent.

With an estimate of the deterministic earnings profile at hand, the variances of the transitory (σ_ν^2) and permanent (σ_η^2) shocks are estimated in a similar fashion as in Carroll and Samwick (1997). Define $\log(y_{ij}^*)$ as the logarithm of earnings less the household fixed component and the deterministic earnings path

$$\begin{aligned} \log(y_{ij}^*) &\equiv \log(y_{ij}) - \hat{\alpha}_i - \tilde{g}(j) \\ &= n_{ij} + \nu_{ij} \qquad\qquad \text{for } j \in [1, J_{ret}], \end{aligned}$$

where the equality follows from equation (13). Since we have three-year periods in the model, we define $\log(y_{ij})$ as the sum of earnings from the three adult ages that the model period corresponds to. For example, $\log(y_{i1}) = \log(\sum_{age=23}^{25} y_{i,age}^{annual})$. Similarly, $\tilde{g}(j)$ is defined as the sum of the annual deterministic earnings components, for example

$\tilde{g}(1) = \log\left(\sum_{age=23}^{25} \exp(\hat{g}_a(age))\right)$. Next, define household i's d-period difference in $\log(y^*_{ij})$ as

$$\begin{aligned} r_{id} &\equiv \log(y^*_{i,j+d}) - \log(y^*_{ij}) \\ &= n_{i,j+d} + \nu_{i,j+d} - n_{ij} - \nu_{i,j} \\ &= n_{i,j+1} + n_{i,j+2} + ... + n_{i,j+d} + \nu_{i,j+d} - \nu_{i,j}. \end{aligned}$$

In the last step, we recursively apply equation (14). Using that the transitory and permanent shocks are i.i.d., it follows that

$$\begin{aligned} \mathrm{Var}(r_{id}) &= \mathrm{Var}(n_{i,j+1}) + \mathrm{Var}(n_{i,j+2}) + ... + \mathrm{Var}(n_{i,j+d}) \\ &\quad + \mathrm{Var}(\nu_{i,j+d}) + \mathrm{Var}(\nu_{i,j}) \\ &= d\,\sigma^2_\eta + 2\,\sigma^2_\nu. \end{aligned}$$

We estimate these variances by running an OLS regression of $\mathrm{Var}(r_{id}) = r^2_{id}$ on d and a constant term. Then, the coefficient of d is our estimate of the variance of the permanent shock, whereas the constant term divided by two is our estimate of the variance of the transitory shock.

Finally, the estimate of σ^2_α is the residual variance in period $j = 1$ as follows

$$\hat{\sigma}^2_\alpha = \mathrm{Var}\left(\log(y_{i1}) - \tilde{g}(1)\right) - \hat{\sigma}^2_\eta - \hat{\sigma}^2_\nu.$$

D.3 Variable Definitions

Age of head is constructed by taking the first observed age and then adding the number of years between a given survey year and the first survey in which the individual was observed. This is to avoid non-changes and two-year jumps in the age variable between two consecutive survey years. The variable name of age is V20651 in the 1992 PSID survey.

CPI is taken from the BLS. We use the historical CPI for all urban consumers (CPI-U), U.S. city average, all items.

Family composition is the number of family members besides head and, potentially, wife. We define it as family size less adults. Family size is the number of members in the family unit at the time of an interview. Adults are defined as number of major adults (head and wife only). The variable names are V20398 and V20397 in the 1992 PSID survey for family size and adults, respectively.

Head's education is divided into two groups: households with a college degree and households with no college degree. Between 1970 to 1990, we divide the sample into education groups by using the categorical groups defined in the PSID. For example, in the 1990 survey we use the variable name V18898, and define that no college consists of levels 1 to 6, and college comprises levels 7 and 8. After 1990, we use a variable for years of completed education (variable name V21504 in 1992 survey). Then, no college households comprise levels 0 to 15 and households with a college degree comprise levels 16 and 17. We drop observations where individuals have no appropriate answer (NA or don't know) and individuals who before the 1984 survey answered "Could not read or write; DK grade and could not read or write". For simplicity, a household is considered a new entity if its education changes.

Head's annual labor hours are the total annual work hours on all jobs including overtime. The variable name is V20344 in the 1992 PSID survey.

Head's average hourly wage is computed as head's wage divided by head's annual labor hours. We restrict our sample to households where the head's average hourly wage is between \$2 and \$400 (inclusive) in 1993 dollars. We adjust the bounds backwards using the growth rate in average weekly earnings from "Current Employment Statistics" published by the BLS. Series ID: CES0500000030.

Household earnings y_{ij} are the sum of labor income for both head and wife. Earnings are deflated with the CPI using 1992 as the base year. Labor income is defined as the sum of salary income, bonuses, overtime, commissions, the labor part of farm, business, market gardening, roomers and boarders income, and income from professional practice or trade. The variable names are V21484 and V20436 in the 1992 PSID survey for head and wife, respectively.

The maximum allowable benefit during retirement, B^{max} in equation (15), is computed using data from the Social Security Administration (SSA). Specifically, we use the maximum monthly benefit level that was available for a person retiring at age 66 in 1992 (\$1,113) and multiply it by twelve to get a yearly benefit level. We adjust the yearly level for the difference in the SSA's average wage per worker in 1992 (\$22,002) and the average earnings in the model.

E A Grandfather Policy

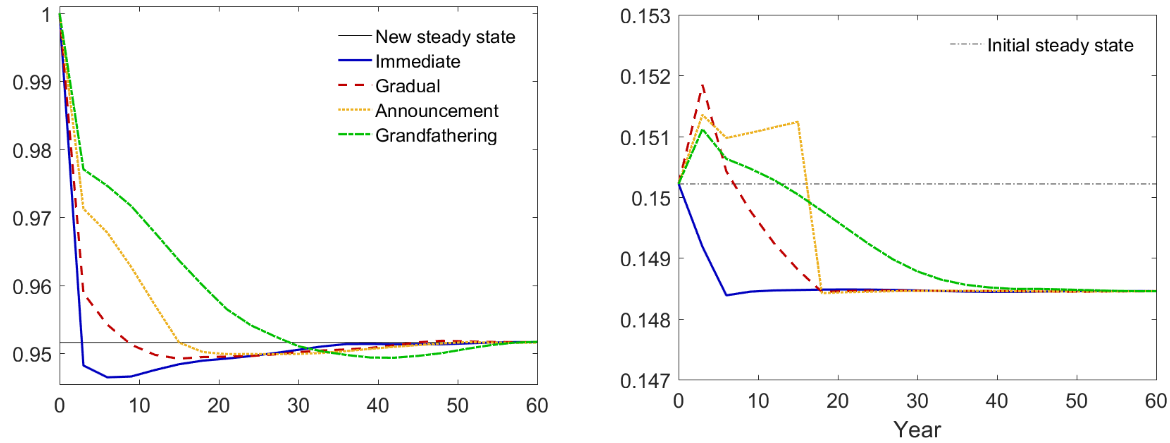
To investigate the effects of a removal policy in which we discriminate between cohorts, we study the effects of a policy where new households are not allowed to deduct mortgage interest payments, while existing households can continue to do so. We refer to this policy as the *grandfather* policy. Figure 8 shows the transition paths for the house price and the average marginal income tax rate.

Naturally, the convergence for the grandfather policy is slower than the alternative

Figure 8: Short-run dynamics from removing the MID for different policies, including grandfathering

(a) House price

(b) Average marginal income tax rate before deductions



Note: All policies are implemented unexpectedly and households have perfect foresight of the transition paths of prices and taxes. Panel (a) and (b) show how the house price and the average marginal tax rate (before deductions) behave in the short run, in response to the changes in the deductibility rate.

policies. It also has a smaller immediate fall in the house price. As only the households that enter the economy are directly affected by the MID removal, the instantaneous fall in housing demand is relatively low. The slower fall in the house price leads to a delayed adjustment of homeownership. Under the grandfather policy the income tax rate increases initially, as the government still spends large amounts on interest deductions and the revenue from property taxes falls. As new cohorts replace older, the income tax level slowly declines towards the lower level of the new steady state.

The grandfather policy is successful in limiting the downside of an MID removal policy, but few homeowners are in favor of the reform. Table 8 presents the average CEV, and the fraction in favor for the four policies. The grandfather policy (Gf.) appears to be a slight improvement compared to the announcement policy, but worse than the gradual.

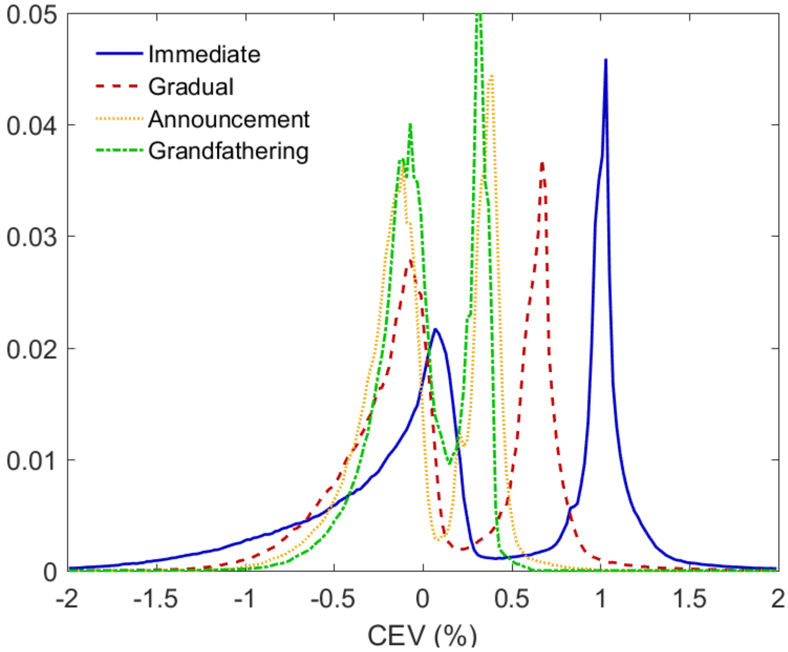
Figure 9 presents the distribution of CEV for the four policies. The bimodal shape of the CEV distribution is apparent also for the grandfather policy. Renters benefit from removing the MID. The lower house and rental prices, together with lower future income taxes dominate the slight instantaneous increase in the income tax. Since the price fall is more gradual, renters' welfare gain is lower than under the alternative policies. Most homeowners on the other hand experience welfare losses from the policy. Homeowners are negatively affected by the fall in the house price and the instantaneous increase in the income tax level. However, since they can still deduct mortgage interest payments, their welfare losses are limited, and the left tail of the distribution is relatively thin.

Table 8: Welfare effects for households alive in the first period of the transition, including the grandfather policy

	Mean CEV (%)				Fraction in favor			
	Im.	Gr.	An.	Gf.	Im.	Gr.	An.	Gf.
Overall	0.23	0.10	0.00	0.01	0.61	0.47	0.42	0.46
No college	0.32	0.15	0.03	0.03	0.66	0.51	0.45	0.49
College	0.04	-0.01	-0.06	-0.03	0.50	0.40	0.38	0.40

Note: Working-age households. "Im." refers to the immediate removal of the MID, "Gr." to the gradual removal, "An." to the announcement policy, and "Gf" to the grandfather policy. For a description of CEV (%) and fraction in favor see *Note* below Table 6.

Figure 9: Distributions of short-run welfare effects across policies, including grandfathering



Note: Distributions of welfare effects for all policies, for working-age households alive in the first period of the transition. For a description of CEV (%) see *Note* below Table 6.

The households that enter the economy in the first period of the transition are the only ones who are not allowed to deduct mortgage interest payments. Since these households are renters, they benefit from the lower house and rental prices, and the lower future taxes. Similar to the steady state, there is a minority of newborns (30 %) who experience welfare losses. These households have relatively high earnings, and hence expect to have large mortgages. As the economy converges, the situation for every new cohort approaches that of being born into the new steady state without MID, where 97 percent of newborns are in favor of a removal.

Overall, the analysis of the welfare effects of the grandfather policy is similar to that of other more gradual policies: since the equilibrium taxes do not decrease quickly, and the house price still falls, few homeowners realize positive welfare effects. In particular, homeowners with low LTVs experience negligible benefits from the continued possibility to deduct mortgage interest payments, while the slight initial elevation of taxes along with falling house prices reduce their welfare. Thus, the grandfather policy is another example of the discussed trade-off. The policy is able to achieve the lowest spread in CEVs, as the homeowners who have large direct exposure to the MID can continue to deduct mortgage interest payments. However, when reducing the magnitudes of the negative welfare effects, the median voter is not in favor of reform.