# Implications of U.S. Tax Policy for House Prices, Rents and Homeownership*

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**Abstract**

This paper studies the impact of the preferential tax treatment of housing, including the mortgage interest deduction, on equilibrium house prices, rents, and homeownership. We build a dynamic model of housing tenure choice that features a realistic progressive tax system in which owner-occupied housing services are tax-exempt, and mortgage interest payments and property taxes are tax deductible. We simulate the effect of various tax reform proposals on the housing market, and find that repealing existing tax deductions causes house prices to decline and also increases the homeownership rate. Our results challenge the widely held view that the mortgage interest tax deduction promotes homeownership.

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# 1 Introduction

Housing is the single-most important asset for the vast majority of U.S. households. The market value of the housing stock in the United States was estimated at $24.1 trillion at the end of 2005: this figure is 1.42 times the combined capitalizations of the NYSE, NASDAQ and Amex stock exchanges (Davis and Heathcote, 2007). Because housing accounts for such a large fraction of national wealth, changes in house prices have important macroeconomic effects. The income tax provisions related to mortgage interest and property tax deductions were estimated to provide a $114 billion subsidy to homeowners just in the year 2011 (JCT, 2010). Therefore, federal income tax policy toward owner-occupied housing has first-order effects on housing consumption, homeownership, and housing values.

This paper studies the effects of the preferential tax treatment of housing and evaluates a number of proposed housing finance tax reforms using a dynamic equilibrium model of the housing market with endogenous house prices and rents. Existing studies of the tax treatment of housing have not allowed both house prices and rents to be endogenous (see, for example, Gervais (2002), Díaz and Luengo-Prado (2008), Nakajima (2010), and Chambers, Garriga and Schlagenhauf (2009a,b,c)). We demonstrate that because the U.S. tax code affects both the homeownership decisions of households and the rental property supply decisions of landlords, ignoring equilibrium effects can lead to misleading conclusions about the effects of tax policy on house prices, rents, housing consumption, and homeownership. We show that in equilibrium, when both house prices and rents are allowed to adjust, a reduction in the tax deductions available to homeowners leads to a sizeable decline in house prices, approximately constant rents, and perhaps surprisingly, increased homeownership. The intuition behind this result is that when the housing supply is relatively inelastic, housing subsidies are capitalized into house prices. A decrease in house prices allows low wealth households to become homeowners because the minimum down payment required to purchase a house falls. Moreover, because rents remain constant while house prices decline, homeownership becomes cheaper relative to renting, which further re-enforces the positive effect of eliminating the mortgage interest deduction on the homeownership rate in the economy. Our findings stand in sharp contrast to the widely held view that the preferential tax treatment of housing always promotes homeownership. At the same time, this paper provides a quantitative theory which can explain the empirical results of Hilber and Turner

(2010), who find evidence that preferential tax treatment of homeownership can in fact depress homeownership.[1]

To study the effect of the U.S. tax code on housing market, we build a stochastic life cycle Aiyagari-Bewley-Huggett economy model with an explicit rental market and a market for homeownership. Building on the idea of houses as durable, lumpy consumption goods that provide shelter services and confer access to collateralized borrowing, but can also be used as rental investments, we endogenize the buy vs. rent decision and also allow homeowners to lease out their properties in the rental market. The supply of rental housing is thus determined endogenously within the model, as homeowners weigh their utility from shelter space against rental income, taking into account the tax implications of their decisions. Both house prices and rents are determined in equilibrium through the clearing of markets for rented and owned housing. Mortgages are available to finance purchases of housing, but home-buyers must satisfy a minimum down payment requirement, and moving is subject to lumpy transaction costs. The model includes a realistic progressive tax system that mimics the U.S. tax code, including the itemized tax deductions available to homeowners and landlords that are important determinants of demand for housing and rental supply. More specifically, in the model economy, homeowners can reduce the cost of housing consumption by taking advantage of mortgage interest and property tax deductions, and imputed rents on owner occupied housing are not taxed. At the same time, landlords in the model must pay income taxes on rental income, but they are permitted to deduct operating expenses such as mortgage interest payments, property taxes, maintenance expenses, and depreciation allowances from their gross rental income.

Having estimated the economy to replicate a number of relevant cross-sectional and aggregate moments of the U.S. economy, we conduct a series of counterfactual experiments to quantify the effect of changes in the federal income tax treatment of housing on equilibrium house prices, rents, homeownership, and tax revenue. We quantitatively assess the implications of eliminating the mortgage interest and property tax deductions, and also study the effects of lessening the depreciation allowances available to landlords. We perform each experiment under two different assumptions about government revenue. In the first version,

[1]Hilber and Turner (2010) use the variation in mortgage interest deductions across time and states to estimate their effect on homeownership. The authors find that on average mortgage interest deductions lead to higher house prices and lower homeownership rates, as deductions are capitalized into house prices. The effect is particularly strong when housing supply is relatively inelastic.

we allow government revenue to change when the tax system is altered. In the second version, we impose revenue-neutrality.[2] As discussed above, we find that eliminating mortgage interest or property tax deductions can promote homeownership through lowering of house prices. Moreover, average steady state welfare increases because the tax reform shifts housing consumption from high income households (the main beneficiaries of the tax subsidy in its current form) to lower income families for whom the additional shelter consumption is relatively more valuable. Our results support the much discussed notion that housing tax subsidies embedded in the U.S. tax code lead to an "over-consumption" of housing by the wealthy.

Turning to depreciation allowances for landlords, extending the period over which a rental investment property can be depreciated from the current 27.5 years to 55 years leads to a reallocation of housing from the rental sector to owner-occupiers. As with the other deductions, depreciation allowances are capitalized into house prices. Lowering depreciation allowances increases the cost of rental investment, effectively inducing landlords to partly sell their properties to renters and owner-occupiers for whom the tax treatment is unchanged. In equilibrium, reductions in depreciation allowances for landlords lead to lower house prices, higher rents, and higher homeownership, as renters enter homeownership.

We also show that eliminating deductions can have an asymmetric effect on federal and local governments. From the federal perspective, eliminating deductions leads to increased income tax revenue, as taxable income rises. However, viewed through the lens of a local government, the house price decline associated with eliminating deductions leads to a decline in property tax revenue. In terms of income tax revenue, our analysis also highlights the key role that the house price level plays in determining the total value of mortgage interest and property tax expenditures in the economy. When mortgage interest deductions are eliminated, house prices fall, thus decreasing the value of property tax deductions. Similarly, when property tax deductions are eliminated, the corresponding fall in house prices implies that homeowners need less debt to finance housing consumption. The decline in household mortgage debt further increases taxable income as the value of mortgage interest deductions falls. Our results highlight how eliminating one housing subsidy also affects the total expenditure on the other subsidy.

[2]In the revenue neutral experiments, we change income tax rates so that government tax revenue remains at the baseline level in each counterfactual experiment.

The impact of tax housing tax policies on the housing market has been studied by many authors (for seminal studies, see Laidler (1962), Aaron (1972), and Rosen (1985)). Poterba (1984) argues that the tax provisions for mortgage interest deductibility, in tandem with rising inflation rates, could explain much of the run-up in house prices during the 1970s.[3] The author's results suggest that eliminating mortgage interest deductions is likely to lead a house price decline, but the size of the decline could be close to catastrophic when combined with a high inflation rate.[4] Poterba (1992) explores the tax subsidies for investing in rental property. The author argues that a reduction in marginal tax rates following the 1980s tax reforms and the tax changes that reduced subsidies for investing in rental property (including the depreciation time horizon – examined here, as well as capital gains tax rates and the passive-loss provisions) lowered households' incentive to invest in rental properties, thus affecting the homeownership and investment decisions of millions of U.S. households. More recently, Gervais and Pandey (2008) use the Survey of Consumer Finances (SCF) to measure the change in federal tax liability that would result if mortgage interest was no longer deductible from taxable income. The authors argue that the elimination of mortgage tax deductions would lead households to re-shuffle balance sheets, lowering the amount of interest income taxes collected. In a similar vein, Poterba and Sinai (2008) use SCF data to analyze how several potential tax reforms could affect incentives for housing consumption as well as the distribution of income tax burdens. The authors estimate that repealing the mortgage interest rate deduction in 2003 would have raised taxable income by $72.4 billion in the absence of any portfolio adjustments, but by only $61.9 billion if homeowners responded by drawing down a limited set of financial assets to partially replace the mortgage debt. The above mentioned studies are unable to assess the effect of eliminating mortgage tax deductions on house prices, rents, housing consumption, or homeownership. We use our model to quantitatively study how all of these equilibrium outcomes respond to changes in the tax code.

Other authors have used theoretical dynamic models in the quantitative macroeconomic tradition to study these issues.[5] Gervais (2002) examines the taxation of housing in the

[3]When inflation rate is high, rising inflation rates push up nominal interest rates, increasing homeowners' interest charges. The author also investigates the effect of tax policy toward capital gains.

[4] Poterba (1984) estimates that for an economy with a constant 10 percent inflation rate and 25 percent marginal tax rate, eliminating mortgage interest deductions would lead to an immediate 26 percent decline in house prices.

[5]Berkovec and Fullerton (1992) employ a static disaggregated general equilibrium model to study the

context of a dynamic life-cycle economy with housing rental services provided by a rental firm, where the house price is normalized at unity. Contrary to this paper, the author finds that repealing the mortgage interest deduction leads to a decline in homeownership. Gervais' results highlight the key role that house price adjustments play in determining the response of homeownership to changes in the tax code. When the house price level is fixed (as in Gervais 2002), repealing mortgage interest deductions increases the cost of ownership but does not reduce down payment requirements. When the user cost rises while house prices are unchanged, the homeownership rate falls. Our model shows that when house prices are allowed to adjust in response to the elimination of mortgage interest deductions, the homeownership rate actually increases.

Chambers, Garriga and Schlagenhauf (2009c) analyze the connection between the asymmetric tax treatment of homeowners and landlords and the progressivity of income taxation in a general equilibrium framework, where rents and interests rates – but not house prices – are determined endogenously. Our model builds on Chambers, Garriga and Schlagenhauf (2009a,b,c), who document that the majority of rental properties in the U.S. are owned by households, and then propose a framework for modeling the rental investment decisions of households. We extend their model by endogenizing both house prices and rents.[6] Similarly to Chambers, Garriga and Schlagenhauf (2009c), we find that eliminating the mortgage interest deduction has a positive effect on homeownership. However, the mechanism generating the increase in homeownership differs between the two papers. In Chambers, Garriga and Schlagenhauf (2009c), the house price is fixed at unity, so the house price effect generated in our model is not operative. Instead, in their model under the assumption of revenue neutrality, eliminating the mortgage interest deduction lowers average tax rates in the economy, and leads to an increase in household income and wealth and lower interest rates. As income and wealth rise while the cost of financing falls and house prices are unchanged, marginal households move from renting to homeownership. Allowing house prices to adjust in equilibrium bolsters these effects in our paper: both the house price and the price-rent ratio fall, thereby reducing down payments and increasing affordability.

implications of tax policy for housing and portfolio choices. They find that when all the tax advantages to homeownership are disallowed, the total quantity of owner occupied housing consumption decreases, and so does the homeownership rate.

[6] Sommer et al. (2013) develop a related model with endogenous house prices and rents, and examine the effect of interest rates and down payment requirements on the housing market. This paper does not incorporate progressive taxation or study the effect of taxation on the housing market.

Nakajima (2010) studies optimal capital income taxation in a general equilibrium model with a representative rental firm in the style of Gervais (2002) that incorporates the U.S. preferential tax treatment of owner-occupied housing. As in Gervais (2002), house prices are normalized to one. Díaz and Luengo-Prado (2008) calculate the bias resulting from valuing owner-occupied housing services using rental equivalence as opposed to user cost in a dynamic partial equilibrium model where both house prices and rents follow exogenous processes. The authors find that the tax exemption of owner-occupied housing services is the most important factor that distorts the rental price and the user cost of housing. Our model of the housing market incorporates this important wedge.

This paper is organized as follows. In Section 2, we develop a quantitatively rich stochastic life cycle model of the housing market with fully specified household choices with respect to consumption, saving, and homeownership, and provide the rationale for our modeling assumptions. Section 3 defines the equilibrium of the economy, while Section 4 describes the model's estimation. Section 5 discusses the fit of the benchmark model. In Section 6, we conduct a series of counterfactual tax-policy experiments that are targeted at assessing the effect of reducing housing tax subsidies for homeowners and landlords on house prices, rents and homeownership. Section 7 tests sensitivity of the main results to changes in interest rates and housing supply. Section 8 concludes.

# 2 The Model Economy

The economy introduced in this paper builds on the model exposition in Sommer et al. (2013). We consider an Aiyagari-Bewley-Huggett style economy with heterogeneous households. Households derive utility from nondurable consumption and from shelter services which are obtained either via renting or ownership. Households supply labor inelastically, receive an idiosyncratic uninsurable stream of earnings in the form of endowments, and make joint decisions about their consumption of nondurable goods and shelter services, house size, mortgage size, and holdings of deposits. Young households start their life cycle as renters with zero asset holdings and have limited access to credit because all borrowing in the model is tied to ownership of housing. Idiosyncratic earnings shocks can be partially insured through precautionary savings (deposits), or through collateralized borrowing in the form of liquid home equity lines of credit (HELOCs). Households prefer homeownership to renting,

in part because of the tax advantages to homeownership embedded in the U.S. tax code, but may be forced to rent due to the down payment requirement and the financing cost of homeownership. Purchases and sales of housing are subject to transaction costs and the housing stock is subject to depreciation. An important feature of our model is that houses can be used as a rental investment: they provide a source of income when leased out, and tax deductions available to landlords can be used to offset non-rental income and rental property related depreciation expenses. House prices and rents are determined in equilibrium through clearing of housing and rental markets.

## 2.1 Demography and Labor Income

The model economy is inhabited by a continuum of overlapping generations households with identical preferences. The model period is one year. Following Heathcote (2005) and Castaneda, Díaz-Gimenez and Ríos-Rull (2003), we model the life cycle as a stochastic transition between various labor productivity states that also allows household's expected income to rise over time. The stochastic-aging economy is designed to capture the idea that liquidity constraints may be most important for younger individuals who are at the bottom of an upward-sloping lifetime labor income profile without requiring that household age be incorporated into our already large state space.

In our stochastic life cycle model, households transit from state $w$ via two mechanisms: (i) aging and (ii) productivity shocks, where the events of aging and receiving productivity shocks are assumed to be mutually exclusive. The probability of transiting from a state $w_j$ via aging is equal to $\phi_j = 1/(p_j L)$, where $p_j$ is the fraction of population with productivity $w_j$ in the ergodic distribution over the discrete support $\mathcal{W}$, and $L$ is a constant equal to the expected lifetime. Similarly, the conditional probability of transiting from a working-age state $w_j$ to a working-age state $w_i$ due to a productivity shock is defined as $P(w_i|w_j)$. The overall probability of moving from state $j$ to state $i$, denoted by $\pi_{ji}$, is therefore equal to the probability of transition from $j$ to $i$ via aging, plus the probability of transition from $j$ to $i$ via a productivity shock, conditional on not aging, so that

$$\Pi = \begin{bmatrix} 0 & \phi_1 & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & \phi_{J-1} \\ \phi_J & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} (1-\phi_1) & 0 & 0 & 0 \\ 0 & \ddots & 0 & 0 \\ 0 & 0 & (1-\phi_{J-1}) & 0 \\ 0 & 0 & 0 & (1-\phi_J) \end{bmatrix} P. \tag{1}$$

The fractions $p_j$ are the solutions to the system of equations $p = p\Pi$. A detailed description of this process is available in the Appendix of Heathcote's paper.

Young households are born as renters. In this model, we do not allow for inter-generational transfers of wealth (financial or non-financial) or human capital. Instead, upon death, estates are taxed at a 100 percent rate by the government and immediately resold. All proceeds of these sales are not re-distributed, but are instead used to finance government expenditures that do not affect individuals.

## 2.2 Preferences

Our model economy is inhabited by a continuum of households. Consistent with existing studies of the housing market, each household has a per-period utility function of the form $U(c, s)$, where $c$ stands for nondurable consumption, and $s$ represents the consumption of shelter services. Shelter services can be obtained either via the rental market at price $\rho$ per unit or though homeownership at price $q$ per unit of housing, $h'$. A linear technology is available that transforms one unit of housing stock, $h'$, into one unit of shelter services, $s$. The household's choices about the amount of housing services consumed relative to the housing stock owned, $(h' - s)$, determine whether a household is renter $(h' = 0)$, owner-occupier $(h' = s)$, or landlord $(h' > s)$. Landlords lease $(h' - s) =: l$ to renters at rental rate $\rho$.

## 2.3 Assets and market arrangements

There are three assets in the economy: houses $(h \geq 0)$, deposits $(d \geq 0)$ with an interest rate $r$, and collateral debt $(m \geq 0)$ with a mortgage rate $r^m$. Households may alter their individual holdings of the assets $h, d$, and $m$ to the new levels $h', d'$, and $m'$ at the beginning of the period after observing their within-period income shock $w$.

Houses are big items that are available in $K = 18$ discrete sizes, $h \in \{0, h(1), ..., h(K)\}$.

Households may choose not to own a house ($h' = 0$), in which case they obtain shelter through the rental market. Agents also make a discrete choice about shelter consumption. Households can rent a small unit of shelter, $\underline{s}$, which is smaller that than the minimum house size available for purchase, $\underline{s} < h(1)$. Renters are also free to rent a larger amount of shelter. To maintain symmetry between shelter sizes available to homeowners and renters, we assume that all levels of shelter consumption must match a point on the housing grid, so $s \in \{\underline{s}, h(1), ..., h(K)\}$. The total housing stock, $H$, is fully owned by households and its size does not change over time.[7] Our set-up with endogenous house prices and inflexible housing supply thus represents an alternative to a production economy where land – the input factor into the housing production – is in fixed supply.

Houses are costly to buy and sell. Households pay a non-convex transactions costs of $\tau^b$ percent of the house value when buying a house, and pay $\tau^s$ percent of the value of the house when selling a house. Thus, the total transactions costs incurred when buying or selling a house are $\tau^b qh'$ and $\tau^s qh$. The presence of transactions costs reduces the transaction volume in the economy, and generates sizable inaction regions with regard to the household decision to buy or sell. Therefore, only a part of the total housing stock is traded every period. The total housing supply and demand are thus determined endogenously, and are respectively upward and downward sloping functions of the house price. Similarly, the demand and supply of property in the rental market are endogenously determined, with rental supply determined by the individual demands for housing and shelter, $h' - s$.

Homeowners incur maintenance expenses, which offset physical depreciation of housing properties, so that housing does not deteriorate over time. Under this assumption, the total stock of housing, $H$, in the economy is fixed. The actual expense depends upon the value of housing, so that the total current maintenance costs facing an agent who has just chosen housing capital equal to $h'$ is given by $M(h') = \delta^h qh'$. In addition to the maintenance cost, we follow Chambers, Garriga and Schlagenhauf (2009a) and assume that landlords incur a fixed cost, $\phi$, caused by the burden of maintaining and managing a rental property.

Homeownership confers access to collateralized borrowing at a constant markup over the risk-free deposit rate, $r$, so that $r^m = r + \kappa$. Borrowers must, however, satisfy a minimum equity requirement. In a steady state where the house price does not change across time,

[7] Section 7.2 tests sensitivity of the main results to changes in the stock of housing.

the minimum equity requirement is given by the constraint

$$m' \leq (1-\theta)qh', \tag{2}$$

with $\theta > 0$. The equity requirement limits entry to the housing market, since households interested in buying a house with a market value $qh'$ must put down at least a fraction $\theta$ of the value of the house. By the same token, households who wish to sell their house and move to a different size house or become renters must repay all the outstanding debt, since the option of mortgage default is not available. The accumulated housing equity above the down payment can, however, be used as collateral for home equity loans.[8]

## 2.4 The Government

This section describes our model of a progressive income tax system. The goal is to develop a parsimonious representation of the U.S. tax system which is progressive and captures the differential tax treatment of homeowners, landlords, and renters. Let $y$ represent the sum of labor earnings ($w$), interest income ($rd$), and rental income net of tax deductible expenses ($TRI$),

$$y = w + rd + TRI. \tag{3}$$

Prior to defining taxable rental income, $TRI$, which we do below, it is useful to discuss the current U.S. tax treatment of landlords and explain how the key features of the tax code are incorporated into our model. The U.S. tax system treats landlords as business entities. As a result, property owners are required to report all rental income received, but business expense can be used to offset it.[9] When part of a property is owner-occupied, and part of it is rented out, for tax purposes it is generally treated as two pieces of property—the part used as a home and the part used for rental. A tax payer must divide expenses between the personal and rental use.[10] The most notable expense items include but are not limited to

[8] Similarly to Díaz and Luengo-Prado (2008), we abstract from income requirements when purchasing houses. See their paper for further discussion. Chambers et al. (2009b) and Campbell and Cocco (2003) offer a more complete analysis of mortgage choice. See Li and Yao (2007) for an alternative model with refinancing costs.

[9] According to the U.S. tax code, rental income must be reported by all tax payers who meet a minimum standard of involvement with their rental property. This minimum involvement is generally defined as the property being leased out for more than 14 days in a year.

[10] A unit is consider a home if used for personal purposes more than the greater of: 14 days, or 10 percent of the total days it was rented to others at fair market value.

mortgage interest paid, taxes, repairs and maintenance, or insurance. As a result, taxable rental income, $TRI$, for a landlord is defined as:

$$TRI = \rho\,(h' - s) - [\tau^m r^m m(\frac{h' - s}{h'}) + \tau^h q(h' - s) + \delta^h q(h' - s) + \tau^{LL} q(h' - s)], \quad (4)$$

where $\rho\,(h' - s)$ represents the gross rental receipts; $\tau^m r^m m(\frac{h'-s}{h'})$ and $\tau^h q(h' - s)$ are the respective mortgage interest and property tax expenses for rental space, $h' - s$; and $\delta^h q(h' - s)$ represents the maintenance expenses. The last term, $\tau^{LL} q(h' - s)$, represents the tax deduction for depreciation of rental property available to landlords (i.e., depreciation allowance), where $\tau^{LL}$ represents the fraction of the total value of the rental property that is tax deductible each year. The amount of the depreciation deduction is specified in the U.S. tax code, and we discuss the exact depreciation rate used in our model in Section 4. In addition, landlords who meet a minimum standard of involvement with their rental property may use rental losses to offset income earned from sources other than real estate.[11]

Taxable income is equal to total income minus allowable deductions,

$$\widetilde{y} = y - \psi(j),\ j \in \{R, O, L\}, \quad (5)$$

where the term $\psi(j)$ represents deductions from total income that differ for renters ($R$), owner-occupiers ($O$), and landlords ($L$). Tax deductions are not refundable, so $\widetilde{y} = 0$ if $y - \psi(j) < 0$.[12] Renters are permitted to deduct the following amount from their total income,

$$\psi(R) = \xi + e, \quad (6)$$

where $\xi$ is the standard deduction, and $e$ is the personal exemption. Homeowners and landlords can either claim the standard deduction, or can forgo the standard deduction and choose to make itemized deductions from their total income. In our model, permissible itemized deductions are mortgage interest payments and property taxes. We assume that agents always choose the option that results in the maximum deduction from total income,

[11] A maximum of $\$25,000$ in rental property losses can be used to offset income from other sources, and this deduction is phased out between $\$100,000$ and $\$150,000$ of income. In our stylized model we abstract away from these features of the tax system. As it turns out, little is lost by ignoring these features, as the "offsetting" motive is not operative in the calibrated baseline model. In the calibrated baseline, no landlord uses her rental expenses to offset her non-rental income.

[12] We are ignoring phasing out of deductions with income, as was the case in the U.S. prior to 2010.

so total deductions for a homeowner (a occupier or a landlord) are

$$\psi(O,L) = [e + max\{\xi, \tau^m r^m m(\frac{s}{h'}) + \tau^h qs\}], \tag{7}$$

where $\tau^m r^m m(\frac{s}{h'})$ and $\tau^h qs$ are the respective mortgage interest and property tax deductions for owner-occupied space.

We follow the U.S. tax code in modeling the progressivity of the tax function. The total taxes paid by an individual are

$$T(w, \widetilde{y}) = \tau^p w + \eta(\widetilde{y}), \tag{8}$$

where $\tau^p w$ is the payroll tax,[13] and where $\eta(\widetilde{y})$ is the progressive income tax function allows the marginal tax rate to vary over $K$ levels of taxable income,

$$\begin{aligned} &\eta_1 \quad for \quad 0 \leq \widetilde{y} < \pi_1 \\ &\eta_2 \quad for \quad \pi_1 \leq \widetilde{y} < \pi_2 \\ &\vdots\vdots\vdots \\ &\eta_K \quad for \quad \pi_{K-1} \leq \widetilde{y} < \pi_K. \end{aligned} \tag{9}$$

Implementing the progressive tax system requires creating deduction amounts $(\xi, e)$ and cutoff income levels $\{\pi_k\}_{k=1}^K$ for use in the model that correspond to those in the U.S. tax system. We convert the dollar values found in the U.S. tax code into units appropriate for our model economy by normalizing using the average wage. Let $\bar{w}_d$ represent the average wage is the U.S., let $\xi_d$ represent the standard deduction specified in the U.S. tax code, and let $\bar{w}$ represent the average wage in the model. The standard deduction in the model is

$$\xi = (\frac{\bar{w}}{\bar{w}_d})\xi_d. \tag{10}$$

The cutoff income levels for the tax code are converted in the same manner. In Section 5.2, we check the generated progressivity of the tax system in the model against available data.

[13]The average U.S. income tax rate was estimated at close to 10 percent in 2007 (CBO, 2010). At the same time, the average federal tax rate was reported at 20 percent. Adopting both the payroll tax and the progressive income tax allows us to capture both the average income tax rate and the average federal tax rate in the calibrated economy.

Finally, as in Díaz and Luengo-Prado (2008), all proceeds from taxation are used to finance government expenditures that do not affect individuals.[14]

## 2.5 The Dynamic Programming Problem

A household starts any given period $t$ with a stock of residential capital, $h \geq 0$, deposits, $d \geq 0$, and collateral debt (mortgage and equity loans), $m \geq 0$. Households observe the idiosyncratic earnings shocks, $w$, and – given the current prices $(q, \rho)$ – solve the following problem:

$$v(w,d,m,h) = \max_{c,s,h',d',m'} U(c,s) + \beta \sum_{w' \in W} \pi(w'|w) v(w',d',m',h') \tag{11}$$

subject to

$$\begin{aligned} & c + \rho\,(s - h') + d' - m' + q(h' - h) + I^s \tau^s q h + I^b \tau^b q h' \\ & \leq w \ + (1+r)d - (1+r^m)\,m - T(w,\widetilde{y}) - \tau^h q h' - M(h') - \phi I^{h'>s} \end{aligned} \tag{12}$$

$$m' \leq (1-\theta) q h' \tag{13}$$

$$m' \geq 0 \tag{14}$$

$$d' \geq 0 \tag{15}$$

$$h' \geq s \ > 0 \ if \ \ h' > 0 \tag{16}$$

$$s > 0 \ if \ \ h' = 0, \tag{17}$$

by choosing non-durable consumption, $c$, shelter services consumption, $s$, as well as current levels of housing, $h'$, deposits, $d'$, and collateral debt, $m'$. The term $\rho\,(s - h')$ represents either a rental payment by renters (i.e., households with $h' = 0$), or the rental income received by landlords (i.e., households with $h' > s$). The term $q(h' - h)$ captures the difference between the value of the housing purchased at the start of the time period $(h')$ and the stock of housing that the household entered the period with $(h)$. Transactions costs enter into the budget constraint when housing is sold $(\tau^s q h)$ or bought $(\tau^b q h')$, with the binary indicators

[14]The treatment of proceeds from taxation is consistent with the treatment of proceeds from sales of estates of deceased agents, previously discussed in Section 2.1.

$I^s$ and $I^b$ indicating the events of selling and buying, respectively. Household labor income is represented by $w$, and it follows the process $\pi_w(w_t|w_{t-1})$ described in Section 2.1. Households earn interest income $rd$ on their holdings of deposits in the previous period, and pay mortgage interest $r^m m$ on their outstanding collateral debt in the last period. The total federal and property tax payments are represented by $T(w, \widetilde{y})$ and $\tau^h q h'$, where the function $T(\cdot)$ is described in Section 2.3, and $\tau^h$ is the property tax rate. $M(h')$ represents the maintenance expenses for homeowners which are described in Section 2.3, and $\phi$ represents the fixed cost incurred by landlords. Finally, equation 13 represents the collateral requirement.

# 3 Definition of a Stationary Equilibrium

In the benchmark economy, we restrict ourselves to stationary equilibria. The individual state variables are deposit holdings, $d$, mortgage balances, $m$, housing stock holdings, $h$, and the household wage, $w$; with $x = (w, d, m, h)$ denoting the individual state vector. Let $d \in \mathcal{D} = \mathbb{R}_+$, $m \in \mathcal{M} = \mathbb{R}_+$, $h \in \mathcal{H} = \{h_1, ..., h_{11}\}$, and $w \in \mathcal{W} = \{w_1, ..., w_7\}$, and let $\mathcal{S} = \mathcal{D}\times\mathcal{M}\times\mathcal{H}\times\mathcal{W}$ denote the individual state space. Next, let $\lambda$ be a probability measure on $(\mathcal{S}, \mathcal{B}_s)$, where $\mathcal{B}_s$ is the Borel $\sigma-$algebra. For every Borel set $B \in \mathcal{B}_s$, let $\lambda(B)$ indicate the mass of agents whose individual state vectors lie in $B$. Finally, define a transition function $P : \mathcal{S}\times \mathcal{B}_s \rightarrow [0, 1]$ so that $P(x, B)$ defines the probability that a household with state $x$ will have an individual state vector lying in $B$ next period.

**Definition (Stationary Equilibrium):** A stationary equilibrium is a collection of value functions $v(x)$, a household policy $\{c(x), s(x), d'(x), m'(x), h'(x)\}$, probability measure, $\lambda$, and price vector $(q, \rho)$ such that:

1. $c(x), s(x), d'(x), m'(x)$, and $h'(x)$ are optimal decision rules to the households' decision problem from Section 2.5, given prices $q$ and $\rho$.

2. Markets clear:

   (a) Housing market clearing: $\int_{\mathcal{S}} h'(x)d\lambda = H$, where $H$ is fixed

   (b) Rental market clearing: $\int_{\mathcal{S}}(h'(x) - s(x))d\lambda = 0$,

   where $\mathcal{S}=\mathcal{D} \times \mathcal{M} \times \mathcal{H} \times \mathcal{W}$.

3. $\lambda$ is a stationary probability measure: $\lambda(B) = \int_{\mathcal{S}} P(x, B)d\lambda$ for any Borel set $B \in \mathcal{B}_s$.

# 4 Calibration

The model is calibrated in two stages. In the first stage, values are assigned to parameters that can be determined from the data without the need to solve the model. In the second stage, the remaining parameters are estimated by the simulated method of moments (SMM). Table 1 and Table 2 summarize the parameters determined in the first stage. These parameters were drawn from other studies or were calculated directly from the data. Table 3 contains the four remaining parameters that we estimate in the second stage based on moments constructed using the data from the American Housing Survey (AHS) and the Census Tables. These moments are listed in Table 4.

Table 1: Exogenous Parameters

| Parameter | Value |
|---|---|
| Autocorrelation $\rho_w$ | 0.90 |
| Standard Deviation $\sigma_w$ | 0.20 |
| Risk Aversion $\sigma$ | 2.50 |
| Down Payment Requirement $\theta$ | 0.20 |
| Selling Cost $\tau^s$ | 0.07 |
| Buying Cost $\tau^b$ | 0.025 |
| Risk-free Interest Rate $r$ | 0.04 |
| Spread $\kappa$ | 0.015 |
| Maintenance Cost Rate $\delta^h$ | 0.015 |
| Payroll Tax Rate $\tau^p$ | 0.076 |
| Property Tax Rate $\tau^h$ | 0.01 |
| Mortgage Deductibility Rate $\tau^m$ | 1.00 |
| Deductibility Rate for Depreciation of Rental Property $\tau^{LL}$ | 0.023 |

## 4.1 Demography and Labor Income

To calibrate the stochastic aging economy, we assume that households live, on average, 50 periods (e.g., $L = 50$). In terms of the process for household productivity, many papers in the quantitative macroeconomics literature adopt simple AR(1) specification to capture the earnings dynamics for working-age households that is characterized by the serial correlation coefficient, $\rho_w$, and the standard deviation of the innovation term, $\sigma_w$.[15] Using data from

[15] Heathcote (2005) discusses alternatives to the AR(1) specification in a technical appendix which is available on the Review of Economic Studies web site.

the Panel Study of Income Dynamics (PSID), work by Card (1994), Hubbard, Skinner and Zeldes (1995) and Heathcote, Storesletten and Violante (2010) indicates a $\rho_w$ in the range 0.88 to 0.96, and a $\sigma_w$ in the range 0.12 to 0.25. For the purposes of this paper, we set $\rho_w$ and $\sigma_w$ to 0.90 and 0.20, respectively, and follow Tauchen (1986) to approximate an otherwise continuous process with a discrete number (7) of states.

## 4.2 Preferences

Following the literature on housing choice (see, for example, Díaz and Luengo-Prado (2008), Chatterjee and Eyigungor (2009), and Kiyotaki, Michaelides and Nikolov (2011)), the preferences over the consumption of non-durable goods ($c$) and housing services ($s$) are modeled as non-separable of the form

$$U(c,s) = \frac{\left(c^{\alpha} s^{1-\alpha}\right)^{1-\sigma}}{1-\sigma}. \tag{18}$$

The risk aversion parameter, $\sigma$, is set to 2.5. The remaining parameters that characterize preferences are the weight on non-durable consumption of the Cobb-Douglas aggregator, $\alpha$, and the discount factor, $\beta$. These two parameters are estimated in the second stage. Section 4.5 discusses our strategy for identifying these parameters.

Many recent studies assume that renters receive lower utility from a unit of housing services than homeowners. In this model, we assume that renters receive the same utility from housing services as homeowners, and allow other features of model – such as preferential taxation of housing – to endogenously generate a household preference for homeownership over renting.[16]

## 4.3 Market Arrangements

Using data from the Consumer Expenditure Survey (CE), Gruber and Martin (2003) document that selling costs for housing are on average 7 percent, while buying costs are around 2.5 percent. We use the authors' estimates and set $\tau^b = 0.025$ and $\tau^s = 0.07$. In terms of the maintenance cost $\delta^h$ described in Section 2.3, we follow Bureau of Economic Analysis in

[16] Appendix A in Sommer et al. (2013) demonstrates that ownership is preferred to renting primarily because the imputed rents of homeowners are not taxed, while the rental income of landlords is taxed (a result consistent with Diaz and Luengo-Prado, 2008).

using an estimate of 0.015.[17] The landlord fixed cost, $\phi$, is estimated in the second stage (see Section 4.5).

To calibrate the interest rates on deposits $r$, we use the interest rate on the 30-year constant maturity Treasury deflated by year-to-year headline CPI inflation. Using the data from the Federal Reserve Statistical Release, the deflated Treasury rate averaged 3.8 percent for the period between 1977 and 2008.[18] We thus set the real interest rate to 4 percent so that $r = 0.04$. To calibrate the mortgage rate $r^m = r + \kappa$, we set the markup $\kappa$ to represent the spread between the nominal interest rate on a 30-year fixed-rate conventional home mortgage and the interest rate on nominal 30-year constant maturity Treasury. The average spread between 1977 and 2008 is 1.5 percent, so $\kappa$ is set to 0.015. In the baseline model, a minimum down payment of 20 percent is required to purchase a home.[19]

## 4.4 Taxes

Using data from the 2007 American Community Survey, Díaz and Luengo-Prado (2010) compute the median property tax rate for the median house value and report a housing property tax rate of 0.95 percent. Based on information from TAXSIM, they document that on average, 90 percent of mortgage interest payments are tax deductible. We thus set $\tau^h = 0.01$, and allow mortgages to be fully deductible so that $\tau^m = 1$. The U.S. tax code assumes that a rental structure depreciates over a 27.5 year horizon, which implies an annual depreciation rate of 3.63 percent. However, only structures are depreciable for tax purposes, and the value of a house in our model includes both the value of the structure and the land that the house is situated on. Davis and Heathcote (2007) find that on average, land accounts for 36 percent of the value of a house in the U.S. between 1975 and 2006. Based on their findings, we set the depreciation rate of rental property for tax purposes to $\tau^{LL} = (1 - .36) \times .0363 = .023$. The payroll tax rate is based on the 2009 level so that $\tau^p = .076$.[20] Table 2 lists the deduction amounts, marginal tax rates, and cutoff income levels from the 2009 IRS tables for single filing.

[17] Harding, Rosenthal and Sirmans (2007) estimate that the depreciation rate for housing units used as shelter is between 2.5 and 3 percent.

[18] See Federal Reserve Statistical Release, H15, Selected Interest Rates.

[19] Using the American Housing Survey 1993, Chambers, Garriga and Schlagenhauf document that the average down payment is approximately 20 percent.

[20] The 2011 payroll tax cut temporarily reduced the payroll tax rate to 5.6 percent.

Table 2: Progressive Tax System Parameters

| Rate | Bracket Cutoffs |
|---|---|
| $\eta_1 = 10\%$ | $0 - \$8,350$ |
| $\eta_2 = 15\%$ | $\$8,350 - \$33,950$ |
| $\eta_3 = 25\%$ | $\$33,950 - \$82,250$ |
| $\eta_4 = 28\%$ | $\$82,250 - \$171,550$ |
| $\eta_5 = 33\%$ | $\$171,550 - \$371,950$ |
| $\eta_6 = 35\%$ | $>\$371,950$ |
| Personal exemption ($e$) | $\$3,650$ |
| Standard deduction ($\xi$) | $\$5,700$ |

As discussed in Section 2.4, we convert the dollar values found in the U.S. tax code into units appropriate for our model economy by normalizing, using the median wage in 2009 from the Current Population Survey (CPS).[21]

## 4.5 Estimation

After exogenously setting the previously discussed parameters to values based on the data, three structural parameters remain to be estimated: the Cobb-Douglas consumption share, $\alpha$, the discount factor, $\beta$, and the fixed cost of being a landlord, $\phi$. Let $\Phi = \{\alpha, \beta, \phi\}$ represent the vector of parameters to be estimated. We estimate these parameters using the simulated method of moments (SMM). Let $m_k$ represent the $k-$th moment in the data, and let $m_k(\Phi)$ represent the corresponding simulated moment generated by the model. The SMM estimate of the parameter vector is chosen to minimize the squared difference between the simulated and empirical moments,

$$\widehat{\Phi} = \arg\min_{\Phi} \sum_{k=1}^{4} (m_k - m_k(\Phi))^2. \tag{19}$$

Minimizing this function is computationally expensive because it requires numerically solving the agents' optimization problem and finding the equilibrium house price and rent for each trial value of the parameter vector.

The four moments targeted during estimation are the homeownership rate, the landlord rate, the imputed rent-to-wage ratio ($\frac{\rho s}{w}$), and the fraction of homeowners who hold collateral debt. The remainder of this section details the data sources for the targeted moments and

[21]The median wage for 2009 in the CPS is reported at $38,428.

discusses how the parameters ($\Phi$) impact the simulated moments. The share parameter $\alpha$ affects the allocation of income between non-durable consumption and shelter by agents in the model. This motivates our use of the imputed rent-to-wage ratio as a targeted moment. Using data from 1980, 1990, and 2000 Decennial Census of Housing, Davis and Ortalo-Magné (2010) estimate the share of expenditures on housing services by renters to be roughly 0.25, and find that the share has been constant across time and MSA regions. The discount factor, $\beta$, directly impacts the willingness of agents to borrow, so we attempt to match the fraction of owner-occupiers with collateral debt. According to data from the 1994-1998 American Housing Survey (AHS), approximately 65 percent of homeowners report collateral debt balances.[22]

The final two targeted moments are the homeownership rate and landlord rate. According to Census Bureau data, the homeownership rate was approximately 65 percent in the United States between 1970 and 1996 before reaching 69 percent in 2006 and subsequently falling below 66 percent during the second quarter of 2011. To capture the long-term equilibrium level, we thus set the calibration target for homeownership at 0.65. Chambers, Garriga and Schlagenhauf (2009a) use the American Housing Survey data to compute the fraction of homeowners who claim to receive rental income. The authors find that approximately 10 percent of the sampled homeowners receive rental income. Targeting the homeownership and landlord moments implies that we are also implicitly targeting the fraction of households who are renters (0.34) and owner-occupiers (0.56) because the landlord, renter, and owner-occupier categories are mutually exclusive and collectively exhaustive. The homeownership and landlord moments provide information about the magnitude of the landlord fixed cost, $\phi$. As $\phi$ increases from zero, holding the house price and rent constant, landlords who rent out small amounts of shelter are priced out of the market. As a result, in equilibrium, an increase in the landlord fixed cost affects the composition of the landlord pool in the baseline economy.

**Estimated Parameters ($\mathbf{\Phi}$):** Table 3 shows the estimated parameters, and Table 4 demonstrates that the model matches the empirical moments used in estimation well.

[22]The discount pattern $\beta$ governs household borrowing behavior in our model. Since deceased agents in our model are replaced by newborn descendants who do not, however, inherit the asset positions of the dead, we calibrate $\beta$ to ensure that households do not borrow excessively and to generate a realistic borrowing behavior of households in our model economy.

Table 3: Estimated Parameters

| Parameter | Value |
|---|---|
| Discount Factor $\beta$ | 0.985 |
| Consumption Share $\alpha$ | 0.685 |
| Fixed Cost For Landlords $\phi$ | 0.056 |

Table 4: Calibration Targets

| Moment | Data | Model |
|---|---|---|
| Home-ownership rate | 0.65 | 0.65 |
| Landlord rate | 0.10 | 0.10 |
| Expenditure share on housing | 0.25 | 0.25 |
| Fraction of homeowners with collateral debt | 0.65 | 0.65 |

# 5 Properties of the Calibrated Baseline Model

Before using the model to evaluate counterfactual tax policies, it is important to show how the housing market and taxation operate in the baseline model. This section presents evidence on the ability of the model to match moments not targeted during estimation, examines the progressivity of the tax system, and discusses how housing tax expenditures are distributed across households.

## 5.1 Moments not Targeted in the Estimation

As an external text of our model, we report several other key statistics generated by the model that were not targeted in the estimation and compare them to statistics that are either drawn from other studies, or are computed from the 1998 and 2007 waves of Survey of Consumer Finances (SCF). Appendix B shows how we compute these moments in the SCF data.

In terms of cross-sectional moments, the model generates a loan to value ratio for homeowners of 0.29. The corresponding values are 0.35 in both SCF 1998 and SCF 2007. The baseline ratio of house value to total income generated by the model for homeowners is 4.85; again roughly in line with the data (4.43 in SCF 1998 and 5.36 in SCF 2007). In terms of the loan to income ratio for homeowners, the model predicts a ratio of 1.58, while corresponding

SCF statistics are 1.28 for 1998 and 1.41 for 2007. Finally, the net worth to income ratio for homeowners was 3.53 in the model, compared to 3.53 in SCF 1998 and 4.28 in SCF 2007.

In terms of credit constraints, the model predicts that the fraction of liquidity constrained agents is consistent with the available empirical evidence. Following Hall (2011) and Iacoviello and Pavan (2013), we take a model agent to be liquidity-constrained if the holdings of net liquid assets are less than two months (16.67 percent on an annual basis) of income. Using this definition, 28 percent of households are liquidity constrained. Fissel and Jappelli (1990) estimates the share of liquidity constrained individuals to be 20 percent. Iacoviello and Pavan (2013) argue that 20 percent is likely to be a lower bound.

Turning to the aggregate moments, the model predicts the average income tax rate in the economy to be 0.106 vs. 0.093 in the 2007 data (CBO 2010). In the same vein, the average federal tax rate (i.e., income and payroll tax) in the model is 0.19 and matches well the CBO's estimate of 0.20 for 2007 (CBO 2010). Finally, in terms of the relative price of shelter, the baseline house price-rent ratio in the model is 12.3, which is consistent with U.S. data. Garner and Verbrugge (2009), using Consumer Expenditure Survey (CE) data drawn from five cities over the years 1982-2002, report that the house price to rent ratio ranges from 8 to 15.5 with a mean of approximately 12.[23] Overall, the ability of our model to approximately replicate a number of key moments that were not targeted during the calibration is encouraging.

## 5.2 Progressivity of Taxation in the Baseline Model

In this section, we compare the simulated progressivity of the tax system in the baseline model against the available data estimates. Gouveia and Strauss (1994) estimate the individual average tax rate as a function of total income using United States tax return data for tax years 1979 to 1989. The function is specified as

$$atr = b - b(sy^p + 1)^{-1/p},$$

[23]There are many additional sources of data on the price-rent ratio For example, the U.S. Department of Housing and Urban Development and the U.S. Census Bureau report a price-rent ratio of 10 in the 2001 Residential Finance Survey (chapter 4, Table 4-2). Davis et al. (2008) use Decennial Censuses of Housing surveys between 1960 and 1995 to construct a quarterly time series of the rent-price ratio for the aggregate stock of owner-occupied housing in the United States. They find that the price-rent ratio ranged between 18.8 and 20 between 1960 and 1995.

where $y$ represents the total income (in thousands of dollars), with parameters $b = 0.258$, $s = 0.031$ and $p = 0.768$ estimated for the year 1989 (the last year for which estimates are available). To test the progressivity of taxation in our baseline model, we use the total income, $y$, in equation 3 and simulate the average tax rate of each household in the baseline economy using the Gouveia-Strauss tax function.[24] In the second step, we compare these Gouveia-Strauss estimates against the effective tax rates generated in the model. We follow Gouveia and Strauss (1994) in excluding payroll taxes from the computation of the effective tax rates in the model (to ensure that the simulated effective tax rates are directly comparable).[25] Figure 1 compares the average tax rate by income quintiles generated by the baseline model against Gouveia-Strauss estimates. As can be seen in the figure, the model matches the Gouveia and Strauss estimates well, although it tends to understate the effective tax rate for the lowest quintiles.

## 5.3 Who Gets Deductions?

Although mortgage interest and property tax deductions are available to all homeowners, high income families in the U.S. benefit far more from these tax expenditures than low-income families.[26] Taxpayers with incomes of $100,000 or more accounted for 11 percent of all tax returns but claimed more then 54 percent of the $59 billion in mortgage interest deductions taken in the fiscal year of 2004 (JCT, 2010).[27] The distribution of property tax deductions closely parallels that of mortgage tax deductions. For example, homeowners with incomes over $110,999 accounted for half of the value of property tax deductions in 2004, but those earning less than $30,000 receive less than 3 percent (Schwartz, 2010). Figure 2 shows the uneven distribution of homeowner tax expenditures across income quintiles generated by the model. As in the data, the distribution of mortgage tax deductions is vastly uneven, with the top income quintile receiving roughly 40 percent of both mortgage interest and

[24] As described in Section 2.4, we use the CPS 2009 median wage to translate the model units into the dollar amounts that can be directly fed into the Gouveia-Strauss tax function.

[25] The definition of tax in the Gouveia-Strauss paper corresponds to a strict notion of an income tax and excludes sums that pertain to social security obligations

[26] First, deductions become more valuable with rising income; a $1,000 deduction is worth $350 into a taxpayer in the top tax bracket but just $100 to a taxpayer in the lowest bracket. Second, the use of homeowner deductions declines with income because lower income homeowners are less likely to itemize their tax deductions.

[27] On the other hand, taxpayers earnings up to $30,000 account for 45% of all tax returns but less than 2% of total mortgage tax deductions.

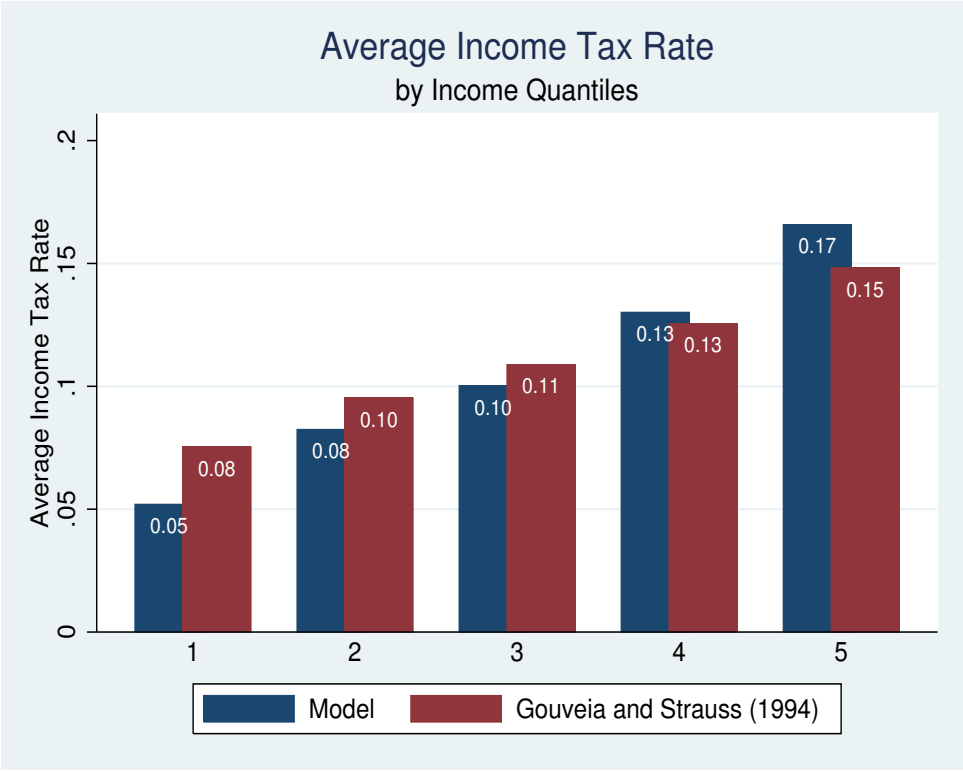


Figure 1: Comparison of the income tax system's progressivity in the baseline model against Gouveia-Strauss (1994) estimates

Notes: We follow Gouveia and Strauss (1994) in excluding payroll taxes from the computation of the average tax rates generated by the model.

property tax deductions.

# 6 Tax Experiments

This section uses the model to simulate the effects of changes in the tax treatment of housing on equilibrium outcomes in the housing market. We focus on the effect of tax policy changes on objects such as house prices, rents, homeownership, government revenue, and household welfare.

## 6.1 The Mortgage Interest Deduction

We start our analysis by exploring the role of the mortgage interest tax deduction – the hallmark of U.S. housing policy – on house prices, rents, and homeownership. Mortgage tax deductions constitute the largest homeownership subsidy under the current tax code: the total tax expenditure toward owner-occupied housing in 2011 was estimated at 93.8

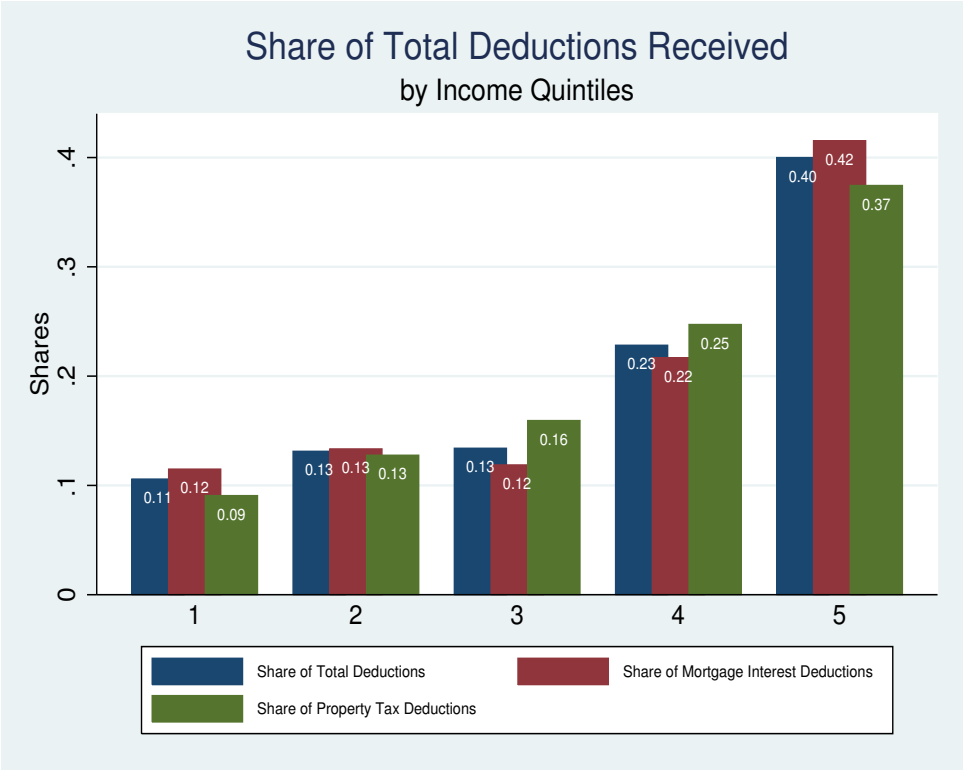


Figure 2: Share of the housing tax deductions by income quintiles

billion (JCT, 2010).

Defined broadly, the mortgage interest tax deduction enters the baseline model in two distinct ways. First, owner-occupiers can reduce their taxable income by claiming this deduction. Second, landlords can use mortgage interest deductions (along with other operating expenses such as maintenance costs and property taxes) to offset gross rental income. Consistent with the tax treatment of business entities, mortgage interest deductions available to landlords are not considered tax expenditures under the U.S. tax code.[28] In the U.S., tax expenditures are defined with reference to a normal income tax structure (also known as "normal income tax law"). Under "normal tax law," individuals are allowed to deduct the interest on debt incurred in connection with a trade or business or an investment, but cannot deduct interest related to personal expenses (JCT, 2010). Thus, the deduction for mortgage interest on a residence is classified as tax expenditure, while the mortgage interest deduction available to landlords is not.[29] Therefore, this section discusses the effects of eliminating

[28]In the U.S., tax expenditures include any reduction in income liabilities that result from special tax provisions or regulations that provide tax benefit to particular tax papers (JCT, 2010).

[29]Repealing mortgage tax deductions (or other operating expense deductions) available to landlords would create asymmetries in the tax treatment of landlords relative to other businesses for which these deductions

the mortgage interest tax expenditure for owner-occupiers, while still allowing landlords to deduct mortgage interest payments on rental properties.

Table 5: The Effect of Eliminating the Mortgage Interest Tax Deduction

| | (1) Baseline | (2) Experiment | (3) Revenue Neutral |
|---|---|---|---|
| House price | 3.052 | 2.901 | 2.909 |
| Rent | 0.248 | 0.249 | 0.249 |
| Price-rent ratio | 12.320 | 11.672 | 11.693 |
| Frac. homeowners | 0.650 | 0.710 | 0.710 |
| Fraction renter | 0.350 | 0.290 | 0.290 |
| Fraction owner-occupier | 0.549 | 0.634 | 0.635 |
| Fraction landlord | 0.101 | 0.076 | 0.075 |
| Median $\frac{house\ value}{wage}$ | 3.815 | 3.045 | 3.053 |
| Fraction homeowners in debt | 0.648 | 0.636 | 0.634 |
| Average mortgage | 2.815 | 1.930 | 1.908 |
| %△ disc. EV of lifetime utility | 0.000 | 0.618 | 0.831 |
| %△ income tax revenue | 0.000 | 3.176 | 1.106 |
| %△ property tax revenue | 0.000 | -4.941 | -4.689 |
| %△ total tax revenue | 0.000 | 1.616 | 0.000 |

Column (2) is the no-mortgage deduction economy.
Column (3) is the same economy as (2), except income tax rates are changed so that the experiment is revenue neutral: tax revenue remains at the baseline level.
%△ indicates percent change relative to baseline model.

Table 5 shows the effect of repealing the mortgage interest deduction for owner-occupied space. As the table illustrates, when the housing supply is inelastic, the value of the mortgage interest deduction is capitalized into house prices. When the mortgage interest deduction is eliminated (column 2), house prices fall by 5 percent because, ceteris paribus, the cost of ownership has risen. At the same time, the rent stays approximately constant so that the equilibrium house price-rent ratio decreases by 5.2 percent. Since required downpayments are now lower and ownership is now cheaper relative to renting, the homeownership rate rises from 65 percent to 71 percent.[30]

Interestingly, column (3) of table 5 shows that the homeownership result also holds when the tax code change is revenue neutral. In the experiment shown in column (3), income tax rates are lowered so that total tax revenue remains at the baseline level when the

are available.

[30]When the house price falls because mortgage interest deductions for owner-occupied space are eliminated, down payments decline, thereby allowing aspiring homeowners to enter the housing market. The decrease in demand for rental space is accompanied by a decrease in rental supply as marginal landlords exit the rental market and the fraction of landlords in the economy falls. Moreover, the composition of the landlord pool shifts toward high income landlords who, as a group, face higher marginal income tax rates.

mortgage interest deduction is removed.[31] The homeownership rates in the economies shown in columns (2) and (3) are very similar because the price-rent ratio is virtually identical in both experiments. Lowering tax rates across the board to preserve revenue neutrality increases the level of house prices only slightly, and has very little impact on the relative cost of owning vs. renting.

The generated effects are consistent with the empirical findings of Hilber and Turner (2010), who exploit variation in the mortgage deduction subsidy across states and time to examine the impact of the mortgage tax deduction on homeownership. In particular, the authors tests whether capitalization of the mortgage tax deduction into house prices offsets the positive effect on homeownership. The authors find that the mortgage tax deductions are on average associated with higher house prices and reduced homeownership. The effect is particularly strong in regions where housing supply is relatively inelastic. In less tightly regulated markets, availability of mortgage interest deductions mostly boosts homeownership attainment of higher income households. The predictions of our model, and in Hilber and Turner (2010), that preferential treatment of homeownership reduces homeownership stand in marked contrast to the commonly accepted notion that mortgage interest deductions are always homeownership-promoting.

Interestingly, our results suggest that eliminating the mortgage interest deduction would improve the welfare of households. The discounted expected value of lifetime utility is 0.62 percent higher in the economy shown in column (2) of table 5 compared to the baseline economy. Perhaps contrary to simple intuition, there is a net welfare gain from eliminating the mortgage interest deduction even though this change in the tax code increases the tax burden on households by 1.616 percent. Why are households better off on average even though their taxes have risen? Welfare rises because lower equilibrium house prices increase homeownership and housing consumption among low income households. These households have a relatively high marginal utility of shelter consumption, so shifting shelter consumption towards them increases aggregate welfare. In addition, eliminating the mortgage interest deduction lowers average household mortgage debt by 31 percent, which allows households to increase average non-durable consumption by nearly 2 percent relative to the baseline. When the mortgage tax deduction is eliminated as part of a revenue neutral tax reform

[31] We impose revenue neutrality by reducing each progressive tax rate by the same amount, until the total tax revenue collected by the government reaches the baseline level.

(column (3) of table 5), the welfare gain is even larger: the discounted expected value of lifetime utility of a newborn household increases by 0.83 percent.

From the perspective of tax revenue, repealing the mortgage interest deduction for owner-occupied space leads to a 3.2 percent increase in income tax revenue because taxable income rises. Conversely, property tax revenue falls because of the decline in equilibrium house prices. With a fixed stock of housing, property tax revenue ($\tau^h qH$) declines by nearly 5 percent. At this point, it is useful to discuss the channels behind the observed increase in taxable income. The direct effect of eliminating the mortgage interest deduction is that taxable income rises because total deductions ($\psi$) fall. However, there is also an indirect effect that expands the federal income tax base. The decline in equilibrium house prices reduces the level of property tax deductions; thus further decreasing the total deductions available to households and thereby re-enforcing the increase in taxable income.

Our results highlight the asymmetric effect of eliminating the mortgage interest deduction on the ability of federal versus local governments to balance budgets.[32] The importance of property taxes as source of revenue for state and local governments is discussed in Section 6.2.

## 6.2 The Property Tax Deduction

Estimated at 22.8 billion for 2011 (JCT, 2010), the deduction for property taxes on real estate represents the second largest tax expenditure related to housing. At the same time, property taxes represent an important source of revenue for state and local government. Property taxes accounted for about 22 percent of state and local government revenue in 2005, according to the National Association of Home Builders.

In line with the size of total dollar expenditure on property taxes relative to mortgage tax deductions, eliminating the property tax deduction for owner-occupied space has a less pronounced effect on the housing market equilibrium than repealing mortgage tax deductions. However, the total effect is notable nonetheless, as it leads to a 2.6 percent drop in the house price, no change in rent, and a 5.2 percent increase in homeownership (Table 6). As in the mortgage interest deduction experiment, column (3) of Table 6 shows that the effects of eliminating the property tax deduction are robust to imposing revenue neutrality on the tax reform. In terms of the mechanism, the same forces are operative as in the mortgage inter-

[32] In the U.S., property taxes are collected by local governments.

Table 6: The Effect of Eliminating the Property Tax Deduction

| | (1) Baseline | (2) Experiment | (3) Rev. Neutral |
|---|---|---|---|
| House price | 3.052 | 2.971 | 2.975 |
| Rent | 0.248 | 0.247 | 0.247 |
| Price-rent ratio | 12.320 | 12.028 | 12.051 |
| Frac. homeowners | 0.650 | 0.684 | 0.683 |
| Fraction renter | 0.350 | 0.316 | 0.317 |
| Fraction owner-occupier | 0.549 | 0.596 | 0.601 |
| Fraction landlord | 0.101 | 0.088 | 0.082 |
| Median $\frac{house\ value}{wage}$ | 3.815 | 3.118 | 3.123 |
| Fraction homeowners in debt | 0.648 | 0.633 | 0.629 |
| Average mortgage | 2.815 | 2.431 | 2.353 |
| %△ disc. EV of lifetime utility | 0.000 | 0.480 | 0.597 |
| %△ income tax revenue | 0.000 | 1.464 | 0.570 |
| %△ property tax revenue | 0.000 | -2.668 | -2.512 |
| %△ total tax revenue | 0.000 | 0.670 | 0.000 |

Column (2) is the no-property tax deduction economy.
Column (3) is the same economy as (2), except income tax rates are changed so that the experiment is revenue neutral: tax revenue remains at the baseline level.
%△ indicates percent change relative to baseline model.
Welfare is measured by the discounted expected value of lifetime utility

est deduction experiment. All else constant, eliminating property taxes for owner-occupied space increases the cost of housing, thus reducing demand. In equilibrium, the fall in house prices lowers down payments ($\theta qh'$), allowing low-income households to become homeowners. Rents remain constant even as house prices decline, so this relative price shift encourages a shift from renting to owning.

Income tax revenue increases by 1.5 percent due to increased levels of taxable income, while property tax revenue ($\tau^h qH$) declines by 2.7 percent due to lowered house prices. As in the mortgage interest tax experiment, equilibrium price effects magnify the increase in government revenue from eliminating the property tax deduction. Ceteris paribus, eliminating the property tax deduction increases income tax revenue because the value of total deductions ($\psi$) falls and taxable income rises. In equilibrium, the marginal decrease in the house price level, however, also reduces average mortgage debt by 14 percent. The equilibrium reduction in mortgage debt further increases taxable income because total household mortgage interest deductions fall.[33]

[33]The changes in household borrowing resulting from changes in tax deductions suggest that accounting for equilibrium interest rate effects may be important. Section 7.1 tests the sensitivity of our results to changes in the interest rate level in the economy.

## 6.3 Combined Effects: Mortgage Interest and Property Tax Deductions

Table 7 shows the effects of simultaneously eliminating the mortgage interest and property tax deductions. Since the mechanisms driving these results are effectively the same as those that operate when each deduction is eliminated in isolation, this section focuses on how eliminating deductions affects housing ownership and shelter consumption. Consistent with the previously discussed counterfactual experiments, jointly eliminating the property tax and mortgage interest deductions decreases house prices and increases homeownership. In

Table 7: The Effect of Jointly Eliminating the Mortgage Interest and Property Tax Deductions

| | (1) Baseline | (2) Revenue Neutral Experiment |
|---|---|---|
| House price | 3.052 | 2.907 |
| Rent | 0.248 | 0.252 |
| Price-rent ratio | 12.320 | 11.516 |
| Frac. homeowners | 0.650 | 0.727 |
| %△ ave. shelter: bottom 25% wage dist. | 0.000 | 4.177 |
| %△ ave. shelter: middle 50% wage dist. | 0.000 | -0.948 |
| %△ ave. shelter: top 25% wage dist. | 0.000 | -2.811 |
| %△ ave. housing: bottom 25% of wage dist. | 0.000 | 4.662 |
| %△ ave. housing: middle 50% of wage dist. | 0.000 | 0.855 |
| %△ ave. housing: top 25% of wage dist. | 0.000 | -9.065 |

Column (2) is the revenue-neutral, no mortgage interest, no-property tax deduction economy, where except income tax rates are changed so that the experiment is revenue neutral:
tax revenue remains at the baseline level.
%△ indicates percent change relative to baseline model.
wage dist. refers to the wage distribution in the model.

addition to changing the aggregate homeownership rate, eliminating the provisions of the federal income tax code that explicitly favor owner occupied housing has a significant effect on the joint distribution of shelter consumption and wages. Relative to the baseline economy, eliminating these deductions leads to a 4.2 percent increase in the shelter consumption of households in the bottom 25 percent of the wage distribution. Since the stock of housing is fixed in this experiment, and in equilibrium all housing must be occupied, the housing consumption of other households in the economy must decrease. In fact, the middle 50 percent of the wage distribution reduces housing consumption by nearly 1 percent, and the top quarter reduces housing consumption by 4.7 percent.

The bottom three entries in Table 7 show that changes in the stock of housing owned by

the top and bottom wage groups mirror the changes in shelter consumption.[34] The share of housing owned by the lowest income group increases, and this increase is accommodated by decreases in the stock of housing owned by higher income households. As alluded to earlier in the paper, the optimal response of homeowners to the elimination of tax deductions that favor housing is to sell housing to lower income households. High income households have the largest incentive to do this because the progressive income tax system causes the value of deductions to increase with income. When these deductions are eliminated, high income households have a large incentive to reduce housing ownership and housing consumption.

## 6.4 Depreciation Deductions Available to Landlords

The federal tax code provides subsidies to rental properties vis-à-vis other investment to the extent that it permits the owner of a rental property to take depreciation deductions that exceed the real rate of economic depreciation. In theory, depreciation deductions enable owners of rental housing and other types of commercial real estate to invest in its physical upkeep by freeing funds for investment in capital improvements needed as a result of wear and tear (Schwartz, 2010). The standard method for calculating depreciation is "straight-line" depreciation, which is calculated by dividing the depreciable basis (total development minus land and other non-depreciable expenses) by the number of years of the depreciation period: 27.5 years in the current U.S. tax code.[35] Historically, the depreciation deduction is viewed as the most prominent rental market subsidy, although its importance was vastly curbed in the second half of the 1980s. Prior to the 1986 Tax Reform, the depreciation deduction for rental property became notorious as a vehicle that allowed high earnings households to generate "paper losses" that could be used to offset household non-rental income income for tax purposes (Schwartz, 2010). The Tax Reform Act of 1986 reduced tax rates in the highest income bracket, adopted a conservative depreciation scheme, and prevented households from offsetting very large amounts of non-rental income with "paper" losses from rental investments. After the 1986 Tax Reform, the importance of the depreciation deduction fell

[34]However, shelter consumption of the middle 50 percent of the wage distribution decreases, while housing ownership of the middle 50 percent actually increases. Ownership of housing among the middle 50 percent of the wage distribution increases because the increases in ownership among those at the lower end of this wage group outweigh the decreases in ownership by the higher income households.

[35]Our baseline economy is calibrated using a tax system that is representative of the post 1986 Tax Reform environment.

dramatically: the total depreciation deduction in the first year of acquisition of a rental investment property with a taxable basis of $200,000 fell from $18,421 before 1986 to only $7,273 in 1986 (Schwartz, 2010). Hansmann (1991) argues that the reduced tax subsidies to rental properties (primarily through the depreciation subsidy) contributed to the decline in the prominence of rental properties and increase in the prevalence of condominiums and cooperative housing since the 1986 tax reform.[36]

Table 8: The Effect of Halving the Landlord Depreciation Deduction

| | (1) Baseline | (2) Experiment |
|---|---|---|
| House price | 3.052 | 2.996 |
| Rent | 0.248 | 0.252 |
| Price-rent ratio | 12.320 | 11.883 |
| Frac. homeowners | 0.650 | 0.688 |
| Fraction renter | 0.350 | 0.312 |
| Fraction owner-occupier | 0.549 | 0.606 |
| Fraction landlord | 0.101 | 0.081 |
| Median $\frac{house\ value}{wage}$ | 3.815 | 3.668 |
| Fraction homeowners in debt | 0.648 | 0.633 |
| Average mortgage | 2.815 | 2.605 |
| %△ disc. EV of lifetime utility | 0.000 | -0.376 |
| %△ income tax revenue | 0.000 | 1.142 |
| %△ property tax revenue | 0.000 | -1.855 |
| %△ total tax revenue | 0.000 | 0.566 |

Column (2) is the economy where the depreciation deduction rate for landlords, $\tau\_LL$, is reduced by 50% from the baseline value of $\tau\_LL = 0.023$.
%△ indicates percent change relative to baseline model.

Table 8 shows the effect of doubling the length of the depreciation period from 27.5 to 55 years. In terms of the model parameters, this is implemented by decreasing $\tau^{LL}$ to 0.0125 from its baseline value of 0.023. Table 8 shows that the depreciation deduction continues to have a sizeable impact on equilibrium in the housing market, even though the 1986 Tax Reform reduced the size of this subsidy. When the deduction is reduced, the cost of rental investment rises sharply, leading to a decrease in the supply of rental properties, and a 1.6 percent increase in rents. In addition, the lowered demand for housing by landlords leads to a 1.8 percent decline in house prices. As a result, the homeownership rate rises by

[36]This finding is consistent with the contraction of the rental market: multifamily housing starts decreased every year from 1985 to 1993. As a share of total housing starts, the multifamily sector fell from 33 percent in 1985 to 15 percent in 1991 and 11 percent in 1993. It was not until the second half of the 1990s that multifamily starts began to recover, but they are yet to climb back to the volumes of the 1980s and late 1970s (Schwartz, 2010).

nearly 4 percentage points from its baseline level of 0.65. At the same time, the fraction of landlords in the economy falls from 10 to 8 percent because investing in rental property is less attractive. Moreover, since the tax treatment of owner-occupied space is unchanged, existing homeowners consume more shelter as house prices fall. In this experiment, landlords essentially sell parts of their rental properties to entering renters and existing homeowners, although this does not happen literally because we are comparing different steady states in this experiment. Interestingly, our results suggested that in addition to raising government revenue, lessening depreciation deductions for landlords would be an indirect way for the government to promote homeownership.

Turning to tax revenue effects, increasing the number of years of the depreciation period from 27.5 to 55 years leads to a 1.14 percent increase in income tax revenue and a 1.85 percent decline in property tax revenue. Two channels are jointly operative in generating the increase in income tax revenue. First, when house prices fall, households de-leverage, as less mortgage debt is needed to finance housing purchases. This increases the taxable income of homeowners by decreasing the total value of mortgage interest deductions. Second, lower house prices decrease the magnitude of property deductions.

## 6.5 Replacing the Mortgage Interest Deduction with a Tax Credit

Although the mortgage interest deduction is available to all homeowners, the progressive structure of the U.S. tax code implies that, ceteris paribus, high-income families benefit disproportionately more from these tax incentives than low income households. It has been widely argued that removing the distortionary effect of the progressive tax code on the distribution of the mortgage interest tax subsidy should be at heart of any U.S. tax reform. With this in mind, this section explores the effect of replacing the mortgage interest deduction with an 8.25 percent mortgage interest tax credit. The the tax credit is set at 8.25 percent because this amount holds government revenue constant at the baseline level. The benefits of the hypothetical mortgage tax credit are spread more evenly across households than the benefits of the current mortgage interest deduction because the value of the credit is not related to a household's marginal tax rate.

Table 9 shows the effect of this policy experiment on the housing market equilibrium. When the mortgage interest rate deduction is replaced with a tax credit, the house price

falls by 2.9 percent, the price-rent ratio falls by 3.4 percent, and the homeownership rate rises by approximately 6 percentage points. Additionally, the average discounted lifetime utility of newborn households rises by 0.56 percent. The operating mechanism is the same as the one described in Section 6.3. Under the tax credit, high income households no longer have an incentive to over-invest in housing. As a result, housing is redistributed from high-income households to low-income ones. Since low-income households have a relatively high marginal utility of shelter consumption, shifting shelter consumption towards them increases aggregate welfare.

Table 9: The Effect of Replacing the Mortgage Interest Tax Deduction with an 8.25% Mortgage Interest Tax Credit

| | (1) Baseline | (2) Experiment |
|---|---|---|
| House price | 3.052 | 2.963 |
| Rent | 0.248 | 0.249 |
| Price-rent ratio | 12.320 | 11.901 |
| Frac. homeowners | 0.650 | 0.712 |
| Fraction renter | 0.350 | 0.288 |
| Fraction owner-occupier | 0.549 | 0.617 |
| Fraction landlord | 0.101 | 0.095 |
| Median $\frac{house\ value}{wage}$ | 3.815 | 3.110 |
| Fraction homeowners in debt | 0.648 | 0.688 |
| Average mortgage | 2.815 | 2.376 |
| %△ disc. EV of lifetime utility | 0.000 | 0.562 |
| %△ income tax revenue | 0.000 | 0.657 |
| %△ property tax revenue | 0.000 | -2.914 |
| %△ total tax revenue | 0.000 | 0.000 |

Column (2) is the economy where the mortgage interest deduction has been replaced by an 8.25% tax credit on mortgage interest payments.
%△ indicates percent change relative to baseline model.

# 7 Sensitivity Analysis

## 7.1 Changes in interest rates

Given the recent focus on the effect of the interest rate on the economy, this section examines whether or not the effect of the mortgage interest rate deduction on the housing market varies with the interest rate.[37] Figure 3 shows that our main findings hold across the interest rate

[37]Since the mortgage interest rate $r^m$ is determined by a constant markup, $\kappa$, over the deposit rate $r$, changes in $r$ directly translate into changes in $r^m$; hence changes in $r$ affect both the cost of borrowing and

spectrum: when the mortgage interest deduction is repealed, the house price level and the price-rent ratio fall while the homeownership rate rises at every interest rate level.[38] Interestingly, our model also demonstrates that the interest rate elasticities of house prices and homeownership are relatively unaffected by the tax treatment of mortgage interest: when mortgage interest rate deduction is eliminated, house price, the price-rent ratio and homeownership shift by roughly the same amount at every considered interest rate level. This finding is particularly interesting since simple intuition might suggest that the mortgage interest deduction will have little effect on the housing market when interest rates are low. Ceteris paribus, it is true that as the interest rate falls, the value of the mortgage interest rate deduction to households falls. However, in equilibrium, falling interest rates increase house prices.[39] Higher house prices in turn cause households to hold larger mortgages, and the increased holdings of mortgage debt roughly offset the effect of lower interest rates on the size of the mortgage interest deduction.[40] As a result, in equilibrium, the mortgage interest deduction still has a significant effect on household behavior even when interest rates are low.

## 7.2 Changes in the Stock of Housing

The experiments presented up to this point have been conducted in an environment where the total stock of housing is held constant across economies with different tax codes. However, these experiments demonstrate that house prices respond strongly to changes in the tax treatment of owner occupied housing. This section examines the effects of shifts in the stock of housing on our results.

Table 10 shows the baseline (column 1) and no-mortgage interest deduction (column 2) economies that were first presented in Section 6.1. In addition, column (3) shows an economy where the total stock of housing is decreased by 5 percent when the mortgage

the rate of return on saving.

[38]The simulated interest rate elasticity of house prices from the baseline model is roughly consistent with recent empirical estimates in Glaeser et al. (2010) who estimate that a 200 basis point decrease in real rates at levels examined here is associated with approximately a 16 percent increase in real house prices. In our model, a 200 basis point decrease in interest rate from 4 to 2 percent is associated with a 22 percent increase in house prices.

[39]Lowered interest rates increase the affordability of homeownership by reducing the cost of mortgage financing and also making housing investment more attractive relative to the alternative of holding low-yielding deposits, thereby boosting housing demand and increasing the house price level in the economy.

[40]At 4 percent interest rate, the average mortgage interest deduction is 0.155. When interest rate is lowered to 2 percent, the average size of the mortgage interest deduction in fact rises slightly to 0.157.

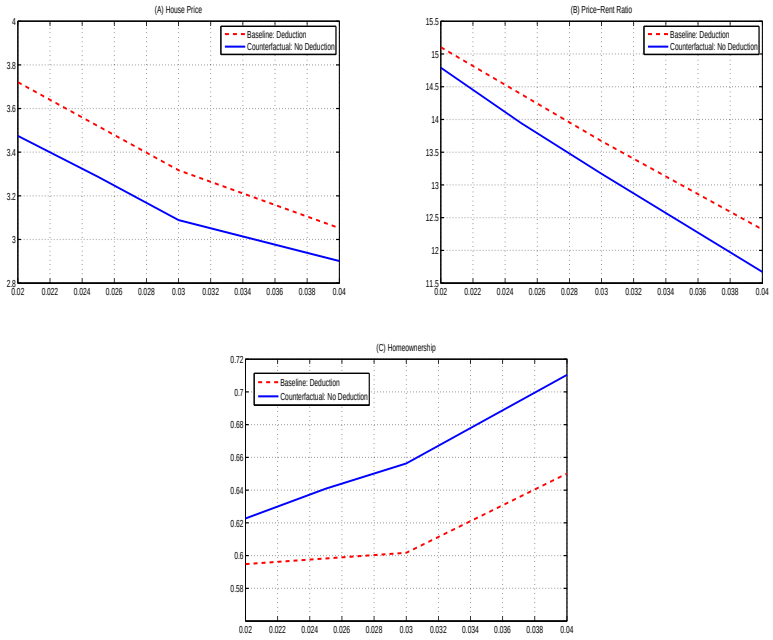


Figure 3: Effect of mortgage interest rate deduction on housing market equilibrium under different interest rates

interest deduction is eliminated. This experiment is designed to capture, in a simple way, the possibility that the stock of housing could shrink if provisions of the tax code that favor housing are eliminated.[41] As expected, the decline in amount of housing in the economy increases the price of housing relative to the experiment shown in column (2). However, the homeownership rate is practically unchanged between columns (2) and (3). This happens because although decreasing the stock of housing increases house prices, it simultaneously increases market rent by nearly the same proportion. As a result, the relative price of owning vs. renting, as captured by the price-rent ratio, is very similar between the experiments that hold the stock of housing fixed (column 2), or allow it to decrease (column 3).[42]

[41] Endogenizing the total stock of housing would require a very large extension of our model to include a construction sector. Since our model is quite detailed in terms of the microeconomic foundations of the housing market, and includes equilibrium prices for housing and shelter, this extension is not currently feasible.

[42] In the interest of brevity, we omit further analysis of how each experiment presented in this paper responds to changes in the stock of housing. However, in all cases, the price-rent ratio mechanism described in this section is operative, and the homeownership results are similarly robust to changes in the stock of housing.

Table 10: The Sensitivity of Mortgage Tax Deduction Reform to Changes in Housing Supply

| | (1) Baseline | (2) No int. ded. | (3) Decrease H |
|---|---|---|---|
| House price | 3.052 | 2.901 | 3.028 |
| Rent | 0.248 | 0.249 | 0.258 |
| Price-rent ratio | 12.320 | 11.672 | 11.740 |
| Frac. homeowners | 0.650 | 0.710 | 0.709 |
| Fraction renter | 0.350 | 0.290 | 0.291 |
| Fraction owner-occupier | 0.549 | 0.634 | 0.642 |
| Fraction landlord | 0.101 | 0.076 | 0.067 |
| Median $\frac{house\,value}{wage}$ | 3.815 | 3.045 | 3.028 |
| Fraction homeowners in debt | 0.648 | 0.636 | 0.632 |
| Average mortgage | 2.815 | 1.930 | 1.965 |
| %△ disc. EV of lifetime utility | 0.000 | 0.618 | -1.392 |
| %△ income tax revenue | 0.000 | 3.176 | 2.844 |
| %△ property tax revenue | 0.000 | -4.941 | -0.798 |
| %△ total tax revenue | 0.000 | 1.616 | 2.144 |

Column (2) is the no-mortgage interest deduction economy.

Column (3) is an economy without a mortgage interest rate deduction, and with a total stock of housing, H, that is 5% less than the stock of housing in the baseline model.

%△ indicates percent change relative to baseline model.

# 8 Conclusion

This paper quantitatively studies the impact of reducing housing tax expenditures on equilibrium house prices, rents, homeownership, and tax revenue using a dynamic stochastic life cycle model of housing choice. To analyze the effects of housing tax expenditures, we build a model with a realistic tax system in which owner-occupied housing services are tax-exempt and mortgage interest payments, property taxes, and landlord's business costs are tax deductible. We examine the effects of eliminating mortgage interest deductions and property tax deductions for owner-occupied space, as well as a reduction in depreciation allowances available to landlords. The simulations indicate that repealing deductions leads to a decline in house prices, but higher homeownership. This result holds for both revenue-neutral and non-neutral experiments. The mechanism driving this result is that because tax deductions are capitalized into house prices, eliminating deductions reduces down payments and, at the same time, shifts the relative cost of owning vs. renting in favor of homeownership. Our results challenge the widely held view that mortgage interest deduction promotes homeownership. We also examine the effect of federal income tax reform on the ability of federal and local governments to balance budgets. We find that repealing tax deductions that favor

owner occupied housing would increase federal income tax revenue, but would simultaneously decrease local government revenue derived from property taxes.

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# 9 Appendix A: Solving the Model (For Online Publication)

## 9.1 Finding Equilibrium in the Housing and Rental Markets

Equilibrium in the housing and rental markets is formally defined by the conditions presented in Section3. In practice, the market clearing rent ($\rho^*$) and house price ($q^*$) are found by finding the $(q^*, \rho^*)$ pair that simultaneously clear both the housing and shelter markets in a simulated economy. The market clearing conditions for a simulated cross section of $N$ agents are

$$\sum_{i=1}^{N} h_i'(q^*, \rho^*|x) = H \tag{20}$$

$$\sum_{i=1}^{N} s_i'(q^*, \rho^*|x) = H. \tag{21}$$

The optimal housing and shelter demands for each agent are functions of the market clearing steady state prices and the agents other state variables ($x$). Solving for the equilibrium of the housing market is a time consuming process because it involves repeatedly re-solving the optimization problem at potential equilibrium prices and simulating data to check for market clearing until the equilibrium prices are found. The algorithm outlined in the following section exploits theoretical properties of the model such as downward sloping demand when searching for market clearing prices. Taking advantage of these properties dramatically decreases the amount of time required to find the equilibrium relative to a more naive search algorithm.

## 9.2 The Algorithm

Let $q_k$ represent the $k$th guess of the market clearing house price, let $\rho_k$ represent a guess of the equilibrium rent, and let $\rho_k(q_k)$ represent the rent that clears the market for housing conditional on house price $q_k$. The algorithm that searches for equilibrium is based on the

following excess demand functions

$$ED_k^h(q_k, \rho_k) = \sum_{i=1}^{N} h_i'(q_k, \rho_k|x) - H \tag{22}$$

$$ED_k^s(q_k, \rho_k) = \sum_{i=1}^{N} s_i'(q_k, \rho_k|x) - H. \tag{23}$$

The equilibrium prices $q^*$ and $\rho^*$ simultaneously clear the markets for housing and shelter, so

$$ED_k^h(q^*, \rho^*) = 0 \tag{24}$$

$$ED_k^s(q^*, \rho^*) = 0. \tag{25}$$

The following algorithm is used to find the market clearing house price and rent.

1. Make an initial guess of the market clearing house price $q_k$.

2. Search for the rent $\rho_k(q_k)$ which clears the market for owned housing conditional on the current guess of the equilibrium house price, $q_k$. The problem is to find the value of $\rho_k(q_k)$ such that $ED_k^h(q_k, \rho_k(q_k)) = 0$. This step of the algorithm requires re-solving the agents' optimization problem at each trial value of $\rho_k(q_k)$, simulating data using the policy functions, and checking for market clearing in the simulated data. One useful property of the excess demand function $ED_k^h(q_k, \rho_k(q_k))$ is that conditional on $q_k$, it is a strictly decreasing function of $\rho_k$. Based on this property, $\rho_k(q_k)$ can be found efficiently using bisection.

3. Given that the *housing* market clears at prices $(q_k, \rho_k(q_k))$, check if this pair of prices also clears the market for *shelter* by evaluating $ED_k^s(q_k, \rho_k(q_k))$.

   (a) If $ED_k^s(q_k, \rho_k(q_k)) < 0$ and $k = 1$, the initial guess $q_1$ is too high, so set $q_{k+1} = q_k - \varepsilon$ and go to step (2). This initial house price guess $q_1$ is too high if $ED_k^s(q_k, \rho_k(q_k)) < 0$ because $ED_k^s(q_k, \rho_k(q_k))$ is decreasing in $q_k$.

   (b) If $ED_k^s(q_k, \rho_k(q_k)) > 0$ set $k = k + 1$ and $q_{k+1} = q_k + \varepsilon$ and go to step (2).

   (c) If $ED_k^s(q_k, \rho_k(q_k)) = 0$, the equilibrium prices are $q^* = q_k$, $\rho^* = \rho_k(q_k)$, so stop.

# 10 Appendix B: SCF Data (For Online Publication)

The Survey of Consumer Finances (SCF) 1998 and 2007 is used to construct the cross-sectional moments cited in the study. The SCF is a triennial survey of the balance sheet, pension, income, and other demographic characteristics of U.S. families. The total housing wealth is constructed as the total sum of all residential real estate owned by a household, and is taken to represent the housing wealth $qh'$ in the model. Secured debt (i.e., debt secured by primary or other residence) is used as a model analog of the collateralized debt, $m'$. The model analogue of the total net worth (i.e., $d' + qh' - m'$) is constructed as the sum of household's deposits in the transaction accounts and the housing wealth (as defined above), net of the secured debt. The total household income reported in the SCF is taken to represent the total household income defined in the model as $y = w + rd' + TRI - \tau^{LL} q(h' - s)$. Data and the SAS code are available upon request, but both can be also found at the SCF website.