

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

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## Abstract

This paper studies the impact of the mortgage interest tax deduction on equilibrium house prices, rents, homeownership, and welfare. We build a dynamic model of the housing market that features a realistic progressive tax system in which owner-occupied housing services are tax-exempt, and mortgage interest payments are tax deductible. We simulate the effect of tax reform on the housing market. Eliminating the mortgage interest deduction causes house prices to decline, increases homeownership, decreases mortgage debt, and improves welfare. Our findings challenge the widely held view that repealing the preferential tax treatment of mortgages would depress homeownership.

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# 1 Introduction

Estimated to provide a \$90 billion subsidy to homeowners just in the year 2013, the mortgage interest deduction is one of the largest tax expenditures in the United States (Joint Committee on Taxation, 2012). This lost revenue amounts to approximately 7 percent of total personal income tax payments. In the ongoing debate over budget deficits and fiscal reform, eliminating the mortgage interest deduction has been a frequently discussed policy change. Proponents of reform point out that the mortgage interest deduction reduces government revenue, is a regressive tax policy, and subsidizes mortgage debt. Opponents argue that repealing the preferential tax treatment of mortgages would depress homeownership and reduce social welfare. To be sure, since housing is the single-most important asset for the vast majority of households, federal income tax policy has first-order effects on housing consumption, house values, homeownership, and welfare. However, the degree to which the repeal of the mortgage interest deduction would affect these objects is ultimately a quantitative question about the magnitude of the resulting equilibrium change in the after-tax cost of homeownership.

This paper studies the repeal of the mortgage interest deduction using an equilibrium model of the housing market which features endogenous house prices and rents. We quantify the general equilibrium effects of tax reform both in the steady state and along the dynamic transition path that occurs when the mortgage interest deduction is suddenly and unexpectedly eliminated from the tax code. Our heterogeneous-agent, stochastic life cycle framework endogenizes the housing tenure decision and features an explicit rental market and a market for homeownership. Houses are modeled as durable, lumpy consumption goods that provide shelter services and grant access to collateralized borrowing. Mortgage financing is available to home-buyers, although it is subject to a minimum down payment requirement, and house sales and purchases are subject to transaction costs. Housing can also be used as a rental investment, as homeowners are allowed to lease out their properties in the rental market. A progressive tax system mimics the U.S. tax code, and includes the itemized tax deductions available to homeowners and landlords that are important determinants of housing demand and rental supply. A housing construction sector allows for a supply response to tax reform. Having calibrated the model by matching a number of relevant moments of the U.S. economy, we use it to assess the implications of repealing the mortgage interest deduction for

house prices, rents, homeownership and welfare.

The model demonstrates that repealing the regressive mortgage interest deduction decreases housing consumption by the wealthy, increases aggregate homeownership, improves overall welfare, and leads to a decline in aggregate mortgage debt. The mechanisms behind these results are intuitive. When both house prices and rents are allowed to adjust, the repeal of the mortgage interest deduction decreases house prices because, *ceteris paribus*, the after-tax cost of occupying a square foot of housing has risen. Reduced house prices allow low wealth, credit-constrained households to become homeowners because the minimum down payment required to purchase a house falls. At the same time, the elimination of the tax favored status of mortgages, acting in concert with the fall in equilibrium house prices, causes unconstrained households to reduce their mortgage debt. Because rents remain roughly constant as house prices decline, homeownership becomes cheaper relative to renting, which further re-enforces the positive effect of eliminating the mortgage interest deduction on homeownership. Importantly, the expected lifetime welfare of a newborn household rises 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 findings stand in sharp contrast to the widely held view that repealing the preferential tax treatment of mortgages would depress homeownership and reduce welfare.<sup>1</sup>

Having established the positive effect of the repeal of the mortgage interest deduction on steady state homeownership and welfare, we turn to a related, and hotly debated policy question: What are the effects of suddenly, and unexpectedly, eliminating the mortgage interest deduction? This experiment begins with the sudden repeal of the mortgage interest deduction, which surprises households owning houses and holding mortgages that were optimal under the *baseline* tax regime. After the initial shock to the system, house prices and rents follow the rational-expectations transitional path to the new steady state. We find that, on average, households benefit from the repeal, with 58 percent of households alive at the time of the reform experiencing an improvement in their future realized welfare. However, welfare effects vary widely across the population, with winners and losers from the

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<sup>1</sup> Christian A.L. Hilber and Tracy M. Turner (2014) provide empirical evidence that the mortgage interest deduction fails to promote homeownership. This paper includes a thorough survey of the related empirical literature.

reform differing systematically in their housing tenure, mortgage debt, and labor income at the time of the reform. In particular, while renters and middle-income households generally benefit from the repeal, high-income households with large mortgages and high marginal tax rates frequently incur sizable welfare losses over their lifetime.

Commensurate with its important role in the housing market, the impact of housing tax policies has been widely studied (for seminal papers, see David Laidler (1969), Henry Aaron (1970), Harvey S. Rosen (1985), and James M. Poterba (1984, 1992)). More recently, other authors have used theoretical dynamic models in the quantitative macroeconomic tradition to study these issues. By and large, these studies have not allowed both house prices and rents to be endogenous (see Martin Gervais (2002), Antonia Díaz and María José Luengo-Prado (2008), Makoto Nakajima (2010), and Matthew Chambers, Carlos Garriga and Don E. Schlagenhauf (2009*a,c,b*)). 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, homeownership and household welfare. When the house price level is fixed (as in the influential work by Martin 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.

In subsequent work to this paper, Max Floetotto, Michael Kirker and Johannes Stroebel (2016) use this study's framework to endogenize both house prices and rents, and explore the effects of eliminating mortgage interest deductions in an economy with a flat income tax. However, abstracting away from progressive taxation eliminates the key distortion generated by the interaction between progressive taxation and the mortgage interest tax subsidy; namely, the fact that the value of the deduction increases with household income, and the associated marginal tax rates.<sup>2</sup>

Recognizing the importance of the interaction between housing tax subsidies with the progressive tax code, Matthew Chambers, Carlos Garriga and Don E. Schlagenhauf (2009*b*)

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<sup>2</sup>Moreover, the authors study the simultaneous elimination of homeowner and landlord mortgage interest deductions. Section 5.1 discusses the distinction between the tax expenditure on owner-occupier mortgage interest, and the deduction for landlord mortgage interest that is in keeping with the goal of taxing net, rather than gross, business income.

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 interest rates—but not house prices—are determined endogenously. Our model builds on Matthew Chambers, Carlos Garriga and Don E. Schlagenhauf (2009*a,c,b*), 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. Similarly to Matthew Chambers, Carlos Garriga and Don E. Schlagenhauf (2009*b*), 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 Matthew Chambers, Carlos Garriga and Don E. Schlagenhauf (2009*b*), 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, leading to increases in household income and wealth along with 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-to-rent ratio fall, thereby reducing down payments and increasing affordability.

The quantitative model presented in this paper shares a number of features in common with, and builds upon, the one in Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013). This earlier paper studies the effects of interest rates and down payment requirements on the housing market, but does not examine tax policy. The primary methodological similarities between the two papers are found in the basic structure of decisions about housing demand, the exogenous labor income process, and the equilibrium price mechanism. However, the model presented in this paper builds on this preceding work in a number of substantive directions that are particularly salient for evaluating housing tax policy. Of particular importance, this paper features a novel housing supply sector and a detailed model of the U.S. progressive income tax system.<sup>3</sup>

Other recent papers have used alternative frameworks to study the effect of the mortgage interest deduction on the housing market. Of note, David Rappoport (2016) analyzes the

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<sup>3</sup>In contrast, Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013) assume that the housing supply is fixed and that income is taxed at a flat rate.

incidence and efficiency loss from mortgage subsidies in a theoretical model with endogenous housing supply. Similar to this paper, he finds that the mortgage interest deduction hurts first-time home buyers by increasing house prices. While he is unable to quantify the effect on homeownership, the author finds that the mortgage interest deduction generates efficiency losses by increasing household leverage and distorting allocation of credit.

## 2 The Model Economy

Households receive utility from non-durable consumption and shelter services, the latter of which can be obtained either through renting or ownership. Households, who supply labor inelastically, face uninsurable idiosyncratic earning shocks, and make joint decisions about non-durable consumption, shelter services consumption, homeownership, mortgage debt, and savings. The tax system is designed to capture the key aspects of the current U.S tax code as it relates to housing. Namely, income taxes are progressive, and homeowners may take advantage of itemized tax deductions for mortgage interest and property tax payments. Although homeownership is generally preferred to renting, in part because of its tax favored status, low wealth households may be forced to rent because of binding credit constraints and the carrying cost of homeownership. Of particular relevance, a minimum down payment is required to purchase a mortgage-financed home, purchases and sales of housing are subject to transactions costs, and houses require maintenance. As an alternative to providing shelter services to the owner, housing can be used as a rental investment. Rental units provide a source of income when leased out, and serve as an additional channel through which households can partially insure their consumption against labor market risk. The total stock of housing is determined by a supply sector, and house prices and rents are determined in equilibrium through the simultaneous clearing of housing and rental markets.

### 2.1 Demography, Preferences, and Labor Income

The economy is populated by overlapping generations households with preferences given by the per-period utility function  $U(c, s)$ , where  $c$  stands for non-durable consumption and  $s$  represents consumption of shelter services. The population grows proportionally at a constant rate  $n$ , and the model period is one year.

Our approach to modeling labor income over the life cycle is identical to the one developed in Jonathan Heathcote (2005) and utilized in Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013). By way of summary, we specify a stochastic life cycle economy that allows expected household income to rise over time, without the need to incorporate household age into our already large state space. In this framework, households transition between discrete labor income levels over time due to two mutually exclusive stochastic events: (i) “aging” and (ii) productivity shocks.<sup>4</sup>

The probability of transiting from a state  $w$  due to an aging shock is equal to  $\chi = 1/(pL)$ , where  $p$  is the fraction of the population with productivity  $w$ , and  $L$  is a constant equal to the expected lifetime. Additionally, the conditional probability of transiting from a state  $w$  to a state  $w'$  due to a productivity shock is defined as  $P(w'|w)$ . The overall probability of moving from state  $w$  to state  $w'$  is denoted by  $\pi(w'|w)$  and equals the likelihood of transitioning from  $w$  to  $w'$  due to an aging shock, plus the likelihood of making this transition from  $w$  to  $w'$  due to a productivity shock, conditional on not aging. The overall transition probability matrix is

$$\Pi = \begin{bmatrix} 0 & \chi_1 & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & \chi_{J-1} \\ \chi_J & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} (1 - \chi_1) & 0 & 0 & 0 \\ 0 & \ddots & 0 & 0 \\ 0 & 0 & (1 - \chi_{J-1}) & 0 \\ 0 & 0 & 0 & (1 - \chi_J) \end{bmatrix} P, \quad (1)$$

with the fractions  $p$  being the solutions to the system of equations  $p = p\Pi$ .<sup>5</sup>

Households are born as renters with zero asset holdings, and inter-generational transfers of wealth are not allowed. Instead, we assume that upon death, financial and housing assets are taxed at a 100 percent rate by the government, and the housing is immediately resold. All proceeds from this estate taxation are used to finance government expenditures that do not affect households.

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<sup>4</sup>Unlike in a deterministic life cycle model, where income has a deterministic age component, in a stochastic life cycle model, the age component is random.

<sup>5</sup>See the Appendix of Heathcote’s paper for a detailed description of this process.

## 2.2 Assets and Market Arrangements

Each household enters a time period with three assets: houses ( $h \geq 0$ ), deposits ( $d \geq 0$ ), and mortgages ( $m \geq 0$ ). Households earn an interest rate  $r$  on their holdings of deposits, and service their mortgage debt at a constant mortgage interest rate spread  $\kappa$  over the risk-free rate  $r$ , so that the mortgage rate is given by  $r^m = r + \kappa$ . After observing the within-period idiosyncratic earnings shock, each household can adjust their asset holdings to the new optimal levels  $h'$ ,  $d'$ , and  $m'$ .

Houses are large structures that are available in discrete sizes  $h \in \{0, h(1), \dots, h(K)\}$ , and can be purchased at a market price  $q$  per unit of housing. A linear technology exists that transforms one unit of owned housing stock,  $h'$ , into one unit of shelter services,  $s$ . Households can choose not to own a house and to instead purchase housing services,  $s$ , in the rental market. Households may rent a small unit of shelter,  $\underline{s}$ , that is smaller than the minimum house size that is available for purchase, so  $\underline{s} < h(1)$ . Renters can, however, also rent any of the larger shelter sizes on the housing grid, so that for renters,  $s \in \{\underline{s}, h(1), \dots, h(K)\}$ . The household's choices about the amount of housing services consumed relative to the housing stock owned,  $(h' - s)$ , determine whether the household is a renter ( $h' = 0$ ), owner-occupier ( $h' = s$ ), or landlord ( $h' > s$ ). Landlords lease  $(h' - s)$  units of shelter to renters at rental rate  $\rho$ , so the supply of rental property in the market is endogenously determined. The structure of household choices over housing and shelter described below follows the framework developed by Matthew Chambers, Carlos Garriga and Don E. Schlagenhauf (2009*a,c,b*), which was subsequently extended by Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013) to include equilibrium prices and rents.

Houses are costly to buy and sell. Households pay a non-convex transaction 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 transaction costs incurred when a house is sold are the sum of  $\tau^b q h'$  and  $\tau^s q h$ . The presence of transaction costs generates sizable inaction regions with respect to the household decision to buy or sell, so only a fraction of total housing stock is traded in any given period.

Homeowners incur maintenance expense which offset physical depreciation of housing properties, so housing does not deteriorate over time. The actual expense is proportional to the value of owned housing, so that  $M(h) = \delta^h q h'$ . In addition to maintenance expenses, we



follow Matthew Chambers, Carlos Garriga and Don E. Schlagenhauf (2009a) in assuming that landlords also incur a fixed cost in each time period,  $\phi$ , which captures the burden of managing and maintaining a rental property.

Housing purchases can be financed through mortgage borrowing in the form of home equity lines of credit (HELOCs). However, since all borrowing in the model is tied to ownership of housing, borrowers must satisfy a minimum down payment requirement in order to qualify for a loan. In a steady state where house prices are constant, mortgage debt ( $m'$ ) is limited by the following constraint,

$$m' \leq (1 - \theta)qh', \quad (2)$$

where  $0 < \theta < 1$  represents the minimum equity requirement, as a proportion of house value. The down payment requirement serves as a barrier to entry into homeownership for some households, as aspiring homebuyers must put down at least a fraction  $\theta$  of the house value,  $qh'$ . Similarly, households who wish to move to a different size house or become renters must repay all the outstanding debt, as the option to default on their outstanding mortgage obligation is not available. That said, accumulated housing equity above the down payment requirement allows for household borrowing in the model, since it can be used as collateral for home equity loans.<sup>6</sup>

Following Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013), in an environment where house prices are no longer constant, the credit constraint is modified as follows,

$$m' I^{\{(m' > m) \cup (h' \neq h)\}} \leq (1 - \theta)qh'. \quad (3)$$

Thus, when house prices fluctuate over time, consistent with the structure of a standard mortgage contract, existing homeowners are not required to reduce their outstanding mortgage debt balance in response to a house price decline, as long as they do not sell their properties. In contrast, when house prices rise, the homeowners can increase their mortgage loan borrowing by accessing their pre-approved home equity line of credit.<sup>7</sup>

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<sup>6</sup>Similarly to Antonia Díaz and María José Luengo-Prado (2008), we abstract from income requirements when purchasing houses. See their paper for further discussion. Matthew Chambers, Carlos Garriga and Don E. Schlagenhauf (2009c) and John Y. Campbell and Joao F. Cocco (2003) analyze mortgage choice in detail, while Wenli Li and Rui Yao (2007) build a model with refinancing costs.

<sup>7</sup>In a steady state where house prices are not allowed to fluctuate, Equation 3 simplifies to Equation 2.

## 2.3 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 ( $TRI$ ),

$$y = w + rd + TRI. \quad (4)$$

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 expenses can be used to offset it. 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 taxpayer must divide expenses between the personal and rental use. The most notable expenses include, but are not limited to, mortgage interest, repairs, and maintenance. As a result, taxable rental income,  $TRI$ , for a landlord is defined as:

$$TRI = \rho(h' - s) - [r^m m(\frac{h' - s}{h'}) + \tau^h q(h' - s) + \delta^h q(h' - s) + \tau^{LL} q(h' - s)], \quad (5)$$

where  $\rho(h' - s)$  represents the gross rental receipts;  $r^m m(\frac{h' - s}{h'})$  and  $\tau^h q(h' - s)$  are the respective mortgage interest and property tax expenses for rental space,  $h' - s$ ; and  $\delta^h q(h' - s)$  captures the cost of property maintenance. The last term,  $\tau^{LL} q(h' - s)$ , captures the depreciation allowance for rental properties that is available to landlords, with  $\tau^{LL}$  representing 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 3. In addition, landlords may use rental losses to offset income earned from sources other than real estate.<sup>8</sup>

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<sup>8</sup>The U.S. tax code allows landlords to use a maximum of \$25,000 in rental property losses to offset their taxable income from other sources, but phases out this deduction between \$100,000 and \$150,000 of income. Our model of the tax code abstracts away from both the maximum and the phasing out of this deduction.

Taxable income is equal to total income minus allowable deductions,

$$\tilde{y} = y - \psi(j), \quad j \in \{R, O, L\}, \quad (6)$$

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  $\tilde{y} = 0$  if  $y - \psi(j) < 0$ .<sup>9</sup> Renters are permitted to deduct the following amount from their total income,

$$\psi(R) = \xi + e, \quad (7)$$

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

$$\psi(O, L) = [e + \max\{\xi, \tau^m r^m m(\frac{s}{h'}) + \tau^h qs\}], \quad (8)$$

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.<sup>10</sup>

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

$$T(w, \tilde{y}) = \tau^p w + \eta(\tilde{y}), \quad (9)$$

where  $\tau^p w$  is the payroll tax,<sup>11</sup> and where  $\eta(\tilde{y})$  is the progressive income tax function that

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<sup>9</sup>We abstract away from phasing out of deductions with income, as was the case in the U.S. prior to 2010.

<sup>10</sup>The term  $\tau^m$  allows for the possibility that mortgage interest on owner-occupied space is not fully tax deductible.

<sup>11</sup>The average U.S. income tax rate was estimated at close to 10 percent in 2007 (Congressional Budget Office, 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.

allows the marginal tax rate to vary over  $K$  levels of taxable income,

$$\begin{aligned}
\eta_1 & \text{ for } 0 \leq \tilde{y} < b_1 \\
\eta_2 & \text{ for } b_1 \leq \tilde{y} < b_2 \\
& \vdots \\
\eta_K & \text{ for } b_{K-1} \leq \tilde{y} < b_K.
\end{aligned} \tag{10}$$

Implementing the progressive tax system requires creating deduction amounts  $(\xi, e)$  and cutoff income levels  $\{b_k\}_{k=1}^K$  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 in 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

$$\xi = \left(\frac{\bar{w}}{\bar{w}_d}\right)\xi_d. \tag{11}$$

The cutoff income levels for the tax code are converted in the same manner. In Section 4.2, we check the progressivity of the tax system in the model against available data. Finally, as in Antonia Díaz and María José Luengo-Prado (2008), all proceeds from taxation are used to finance government expenditures that do not affect individuals.<sup>12</sup>

## 2.4 The Dynamic Programming Problem

Households enter each time period with a stock of owned housing,  $h \geq 0$ , accumulated deposits,  $d \geq 0$ , and outstanding mortgage debt,  $m \geq 0$ . Each household observes its idiosyncratic wage shock,  $w$ , and, given the current prices  $(q, \rho)$ , solves the problem:

$$v(w, d, m, h) = \max_{c, s, h', d', m'} U(c, s) + \beta \sum_{w' \in \mathcal{W}} \pi(w'|w)v(w', d', m', h') \tag{12}$$

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<sup>12</sup>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.

subject to

$$c + \rho(s - h') + d' - m' + q(h' - h) + I^s \tau^s qh + I^b \tau^b qh' \quad (13)$$

$$\leq w + (1 + r)d - (1 + r^m)m - T(w, \tilde{y}) - \tau^h qh' - M(h') - \phi I^{h' > s}$$

$$m' I^{\{(m' > m) \cup (h' \neq h)\}} \leq (1 - \theta)qh' \quad (14)$$

$$m' \geq 0 \quad (15)$$

$$d' \geq 0 \quad (16)$$

$$h' \geq s \text{ if } h' > 0, \quad (17)$$

by choosing optimal levels of non-durable consumption,  $c > 0$ , consumption of shelter services,  $s > 0$ , as well as current levels of owned housing stock,  $h'$ , deposits,  $d'$ , and mortgage debt,  $m'$ . Turning to the budget constraint shown in Equation 13, 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 ( $h$ ). Transaction costs enter into the budget constraint when housing is sold ( $\tau^s qh$ ) or bought ( $\tau^b qh'$ ), with the binary indicators  $I^s$  and  $I^b$  indicating the events of selling and buying, respectively. Household labor income is represented by  $w$ , and it follows the process  $\pi(w_t | w_{t-1})$  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  $T(w, \tilde{y})$  and  $\tau^h qh'$ , where the function  $T(\cdot)$  is described in Section 2.2, and  $\tau^h$  is the property tax rate.  $M(h')$  represents the maintenance expenses for homeowners which are described in Section 2.2, and  $\phi$  represents the fixed cost incurred by landlords. Finally, Equation 14 represents the collateral requirement.

## 2.5 Housing Supply

Having described the household problem, we close the model by introducing a housing supply sector. A large literature, such as Morris A. Davis and Jonathan Heathcote (2005), focuses on important macroeconomic questions regarding the cyclical behavior of residential con-

struction and GDP by building multi-sector, representative agent growth models. Given our focus on tax policy and household welfare, we instead build a model that focuses on household heterogeneity and equilibrium prices in the housing and rental markets, and adopt a tractable model of housing supply that can be straightforwardly estimated. Our approach is based on two key assumptions. First, it is consistent with the intuitively appealing idea that long-run growth in the U.S. housing stock is to a large degree driven by population growth. Second, it assumes that the dynamics of the aggregate housing stock,  $H$ , are also governed by the responsiveness of residential investment,  $I$ , to changes in house prices. Hence, insofar as house prices respond to changes in the tax treatment of housing, so will housing investment (and therefore the aggregate stock of housing).

Recall that in our model, population grows at constant rate  $n$ , so the total population evolves over time as follows,  $N' = (1 + n)N$ . Residential investment,  $I$ , is proportional to the current stock of housing,  $H$ ,

$$I = f(q, \varepsilon)H, \tag{18}$$

where  $f(q, \varepsilon)$  is the constant elasticity supply function for residential investment,  $H$  is the current stock of housing, and the parameter  $\varepsilon$  represents the elasticity of residential investment with respect to the house price ( $q$ ). A linear technology translates residential investment into housing, so the law of motion for the aggregate stock of housing is a standard capital accumulation equation,

$$H' = H + I. \tag{19}$$

Equation 19 does not include depreciation of housing capital, because homeowners in the model are required to pay maintenance expenses that offset physical depreciation.<sup>13</sup> The supply function satisfies the restriction  $f(q^*, \varepsilon) = n$ , so in steady state equilibrium, the per-capita housing stock remains constant.<sup>14</sup>

Under this specification, and highly relevant for our tax experiments at hand, the aggregate housing stock,  $H$ , responds not only to increases in population but also to the

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<sup>13</sup>That is, a homeowner is not permitted to allow his house to shrink in size by failing to maintain it. Endogenizing expenditures to offset depreciation is not feasible in the current model for two primary reasons. First, this would add another endogenous choice variable to an already high dimensional household choice problem. Second, housing (and shelter) choices are on a discrete grid.

<sup>14</sup>The baseline economy is a stationary equilibrium where market prices are constant at their steady state values  $(q^*, \rho^*)$ , which implies that the per-capita housing stock must remain constant. If the per-capita housing stock was not stationary, the house price would not converge to a stationary value.

counterfactual tax reforms studied in this paper. Specifically, tax reforms that shift the demand for housing interact with the supply function,  $f(q, \varepsilon)$ , to determine the equilibrium price and quantity of housing. Section 3.4 discusses estimation of the supply elasticity,  $\varepsilon$ .

## 2.6 Stationary Equilibrium

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  $d \in \mathcal{D} = \mathbb{R}_+$ ,  $m \in \mathcal{M} = \mathbb{R}_+$ ,  $h \in \mathcal{H} = \{0, h_1, \dots, h_K\}$ , and  $w \in \mathcal{W} = \{w_1, \dots, w_7\}$ , 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. 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 2.4, given prices  $q^*$  and  $\rho^*$ .

2. Markets clear:

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

- (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  $B \in \mathcal{B}_s$ .

## 3 Calibration

The model is calibrated in three stages. In the first stage, a number of parameter values are drawn from other studies or obtained directly from data sources. Tables 1 and 2 summarize the first stage parameters determined in this manner. In the second stage, the housing supply function is parameterized by estimating the supply elasticity parameter. In the third

Table 1: Exogenous Parameters

Parameter	Value
Autocorrelation of Labor Income Shocks ( $\rho_w$ )	0.90
Standard Deviation of Labor Income Shocks ( $\sigma_w$ )	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
Mortgage Interest Rate 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
Population Growth Rate ( $n$ )	0.01

stage, the three remaining structural parameters are calibrated by matching simulated moments from the model to empirical moments. Table 3 shows the three remaining parameters determined in this manner, and also shows the supply elasticity estimate from the second stage. The empirical moments targeted during calibration in the third stage are listed in Table 4.

### 3.1 Demography, Preferences, and Labor Income

We assume that the population grows at rate  $n = 0.01$ .<sup>15</sup> Turning to household preferences, we follow previous studies of housing choice and durable goods (see, for example, Antonia Díaz and María José Luengo-Prado (2008), Satyajit Chatterjee and Burcu Eyigungor (2015), Jesus Fernandez-Villaverde and Dirk Krueger (2011), Nobuhiro Kiyotaki, Alexander Michaelides and Kalin Nikolov (2011), and Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013)) and model household preferences over non-durable consumption,  $c$ , and consumption of shelter services,  $s$ , as non-separable of the form

$$U(c, s) = \frac{(c^\alpha s^{1-\alpha})^{1-\sigma}}{1-\sigma}, \quad (20)$$

<sup>15</sup>The U.S. population grew at an average annual rate of one percent between 1990 and 2016 (U.S. Census).



where the risk aversion parameter,  $\sigma$ , is set to 2.5.<sup>16</sup> The remaining utility function parameters are the Cobb-Douglas weight on non-durable consumption ( $\alpha$ ) and the discount factor ( $\beta$ ). These two parameters are calibrated by matching simulated moments from the model to empirical moments. Section 3.5 discusses our strategy for identifying these parameters. Consistent with Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013), we assume that renters and homeowners enjoy the same per unit utility from consuming housing services, and allow other features of the model—such as the preferential taxation of housing—to endogenously generate a household preference for homeownership over renting.<sup>17</sup>

We calibrate the stochastic aging economy based on Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013) under the assumption that households live, on average, 50 periods (i.e.,  $L = 50$ ). Moreover, we follow many papers in the quantitative macroeconomics literature in modeling the stochastic process for household labor market productivity with an AR(1) process. Based on from the Panel Study of Income Dynamics (PSID), work by David Card (1994), R. Glenn Hubbard, Jonathan Skinner and Stephen P. Zeldes (1995) and Jonathan Heathcote, Kjetil Storesletten and Giovanni L. Violante (2010) suggests a value for the autocorrelation coefficient,  $\rho_w$ , in the range of 0.88 to 0.96, and a value for the standard deviation of the innovation term,  $\sigma_w$ , in the range of 0.12 to 0.25. For the purposes of this paper, we set  $\rho_w$  and  $\sigma_w$  to 0.90 and 0.20, and approximate the labor income process with seven discrete states.

## 3.2 Market Arrangements

Based on data from the Consumer Expenditure Survey (CE), Joseph W. Gruber and Robert F. Martin (2003) report that average selling costs for housing are 7 percent, while average buying costs are approximately 2.5 percent. We use the authors' estimates and set  $\tau^b = 0.025$  and  $\tau^s = 0.07$ . Following Antonia Díaz and María José Luengo-Prado (2008), the housing depreciation/maintenance cost  $\delta^h$  described in Section 2.2 is set to 0.015, which falls within

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<sup>16</sup>An online appendix examines the sensitivity of our results to assuming a lower level of risk aversion ( $\sigma = 1.5$ ). The quantitative responses of the model to the elimination of the mortgage interest deduction are quite similar under the lower level of risk aversion.

<sup>17</sup>A number of existing studies adopt an alternative framework that builds a utility premium for homeownership directly into preferences. This is not the case in our model. Consistent with Antonia Díaz and María José Luengo-Prado (2008) and Kamila Sommer, Paul Sullivan and Randal Verbrugge (2013), ownership is preferred to renting primarily because the imputed rents of homeowners are not taxed, while the rental income of landlords is taxed.

the range of estimates in John P. Harding, Stuart S. Rosenthal and C.F. Sirmans (2007). The landlord fixed cost,  $\phi$ , is calibrated (see Section 3.5).

We calibrate the interest rate on deposits,  $r$ , and the mortgage rate,  $r^m = r + \kappa$ , to 4 percent and 5.5 percent.<sup>18</sup> The interest rate on deposits is calibrated to approximately match the average real interest rate of 3.8 percent on a 30-year constant maturity Treasury bond over the period 1977 to 2008. Similarly, the mortgage interest rate spread,  $\kappa$ , of 1.5 percent matches the spread between the nominal interest rate on a 30-year fixed-rate conventional home mortgage and the nominal yield on a 30-year constant maturity Treasury bond over the same period.<sup>19</sup> Finally, a minimum down payment ( $\theta$ ) of 20 percent is required to purchase a home.<sup>20</sup>

### 3.3 Taxes

Using data from the 2007 American Community Survey, Antonia Díaz and María José 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 mortgage interest to be fully deductible so that  $\tau^m = 1$ . According to the U.S. tax code, a rental structure fully depreciates over a period of 27.5 years, which implies a 3.63 percent annual depreciation rate. However, only structures are depreciable for tax purposes. In our model, the price of a house includes the value of the land that the house is situated on in addition to the value of the structure. Morris A. Davis and Jonathan 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 estimates, we set the depreciation rate of rental property for tax purposes to  $\tau^{LL} = (1 - 0.36) \times 0.0363 = 0.023$ . The payroll tax rate is based on the 2009 level so that  $\tau^p = 0.076$ . Table 2 lists the deduction amounts, marginal tax rates, and cutoff income levels from the 2009 IRS tables for single filing. As discussed in Section 2.3, we convert the dollar values found in the U.S. tax code into units appropriate for our model economy using the median wage in 2009 from the

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<sup>18</sup>An online appendix examines the response of the model to tax reform under a lower interest rate of  $r = 0.02$ . The effects are qualitatively similar, although they are quantitatively more attenuated.

<sup>19</sup>See Federal Reserve Statistical Release, H15, Selected Interest Rates.

<sup>20</sup>In this class of model where there is no loan approval process,  $\theta$  serves as a proxy for the overall tightness of mortgage underwriting standards.

Table 2: Progressive Tax System Parameters

Tax Parameter	
(A) Marginal Rate	Bracket Cutoff
$\eta_1 = 10\%$	\$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
(B) Deduction	Amount
Personal exemption ( $e$ )	\$3,650
Standard deduction ( $\xi$ )	\$5,700

Current Population Survey (CPS).<sup>21</sup>

### 3.4 Estimating the Housing Supply Elasticity

The supply response to housing tax reform in the model is governed by the housing supply function,  $f(q, \varepsilon)$ , which was introduced in Section 2.5. The price elasticity of supply,  $\varepsilon$ , is an unknown parameter that must be estimated. We estimate a constant elasticity supply function,

$$\log(I) = XB + \varepsilon \log(P), \quad (21)$$

where  $I$  is the quantity of residential investment supplied,  $X$  is a vector of variables that affect supply, and  $P$  is the house price. Residential investment is measured using the BEA quantity index for real private residential investment. The house price data series is the real residential property price index for the U.S. from the Bank for International Settlements.<sup>22</sup> All variables are measured at a yearly frequency, and span the years 1975 to 2014.

It is inappropriate to estimate the supply elasticity using a simple OLS regression of residential investment on house prices, because prices are endogenous. The natural solution is to instrument for price using a variable that shifts demand. Following this standard practice, we estimate Equation 21 by instrumental variables, using real disposable personal

<sup>21</sup>The median wage for 2009 in the CPS is \$38,428.

<sup>22</sup>In real terms, this price series is very highly correlated with the CoreLogic house price index. The estimated supply elasticity is effectively identical using this alternative data series.

income from the BEA national accounts data as an instrument.<sup>23</sup> The  $R^2$  of the first stage regression is 0.695, so personal income is a strong predictor of house prices. The IV estimate of the elasticity parameter, shown in Table 3, is  $\widehat{\varepsilon}_{IV} = 0.9025$ , with a standard error of 0.171.<sup>24</sup>

The estimated price elasticity of supply falls within the relatively wide range of values found in the literature. The empirical framework that is perhaps most similar to ours is James M. Poterba (1984). The author estimates an investment supply function for single family housing structures, and reports elasticity estimates ranging between 0.50 and 2.0. Robert Topel and Sherwin Rosen (1988) estimate a supply function for housing starts, and report a short run elasticity of 1.0, and a long run elasticity of 3.0. Although there is a large empirical literature on housing supply elasticities, many of the existing estimates do not correspond particularly well with the aggregate elasticity in our model. For example, many existing studies focus on small geographic regions, or are based on dependent variables, such as housing starts, that are difficult to translate into units appropriate for our model that features multiple house sizes. As a result of these considerations, we use our own estimate of the elasticity of residential investment with respect to house prices, instead of relying on an external estimate.

### 3.5 Calibrated Parameters

After setting the previously discussed parameters, three structural parameters remain to complete the model: 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 calibrated. The parameter vector is chosen to minimize the squared difference between the simulated and empirical moments,

$$\widehat{\Phi} = \arg \min_{\Phi} \sum_{k=1}^4 \left( m_k - m_k(\Phi) \right)^2, \quad (22)$$

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<sup>23</sup>We estimated alternative specifications of the supply function that included additional explanatory variables ( $X$ ), such as measures of construction costs. These variables had little explanatory power, and did not change the estimated elasticity appreciably. As a result, we set the elasticity using the univariate, IV model.

<sup>24</sup>For comparison purposes, the OLS estimate of  $\widehat{\varepsilon}_{OLS}$  is 1.0024.

Table 3: Parameter Values

Parameter	Value
(A) Obtained by Calibration	
Discount Factor ( $\beta$ )	0.985
Consumption Share ( $\alpha$ )	0.685
Fixed Cost for Landlords ( $\phi$ )	0.056
(B) Estimated by Instrumental Variables	
Housing Supply Elasticity ( $\varepsilon$ )	0.902 (0.171)

Note: Standard error in parentheses.

where  $m_k$  represents the  $k$ -th moment in the data, and  $m_k(\Phi)$  represents the corresponding simulated moment generated by the model. 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. Table 3 shows the three calibrated parameters, and Table 4 demonstrates that the model matches the empirical moments targeted in calibration well.

The four targeted moments are the homeownership rate, the landlord rate, the imputed rent-to-wage ratio ( $\frac{rs}{w}$ ), and the fraction of homeowners who hold collateral debt. The remainder of this section details the data sources for the targeted moments and 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, Morris A. Davis and Francois Ortalo-Magné (2011) 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 gross mortgage debt.<sup>25</sup> These households would be directly affected by the repeal of the mortgage interest deduction. According to data from the 1994-1998 American Housing Survey (AHS), approximately 65 percent of homeowners

<sup>25</sup>The discount factor  $\beta$  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 by households in our model economy.

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 gross mortgage debt	0.65	0.65

report gross mortgage debt balances.

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. Matthew Chambers, Carlos Garriga and Don E. 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.

## 4 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.

Table 5: Moments not Targeted in Estimation

	Waves of the SCF			
	(1) 1998	(2) 2007	(3) 2010	(4) Model
Median House Value-to-Income Ratio	2.44	3.32	2.98	2.54
Median Loan-to-Income Ratio	0.58	0.91	0.93	0.78
Median Loan-to-Value Ratio	0.28	0.31	0.37	0.26

Notes: Columns 1-3 show statistics from the Survey of Consumer Finances. Column 4 shows statistics computed from the model.

## 4.1 Moments not Targeted in Estimation

As an external test of our model, we report several other key statistics generated by the model that were not targeted in the estimation. Table 5 compares frequently reported housing statistics generated by the model against cross-sectional moments computed from the 1998, 2007, and 2010 waves of the Survey of Consumer Finances (SCF).<sup>26</sup> Encouragingly, the moments—median house value-to-income, loan-to-income, and loan-to-value ratios—fall within the range of estimates computed from various waves of the SCF. Moreover, the median house value to income ratio for first-time home buyers generated by our model is 2.7, compared to 2.6 in the 2011 wave of the American Housing Survey (AHS), suggesting that first-time home-buyers in the baseline model are naturally buying the house relative to their income that matches the data. Finally, despite not having a full-fledged deterministic life cycle with explicitly modeled retirement, among retirement-age households (ages 61-70), 59 percent own a home without debt in the 2010 SCF data, compared to 53 percent in our model.

Turning to several relevant aggregate moments, the model predicts the average income tax rate in the economy to be 0.106 vs. 0.093 in the 2007 data (Congressional Budget Office 2010). In the same vein, the average federal tax rate (i.e., income plus payroll tax) in the model is 0.19 and matches well the CBO’s estimate of 0.20 for 2007 (Congressional Budget Office 2010). Finally, in terms of the relative price of shelter, the baseline house price-to-rent ratio in the model is 12.3, which is consistent with U.S. data. Thesia I. Garner and Randal 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

<sup>26</sup>The online appendix shows how we compute these moments in the SCF data.

a mean of approximately 12.<sup>27</sup> Overall, the ability of our model to approximately replicate a number of key moments that were not targeted during calibration is encouraging.

## 4.2 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. Miguel Gouveia and Robert Strauss (1994) estimate the individual average tax rate ( $atr$ ) as a function of total income using United States tax return data. The function is specified as

$$atr = \gamma - \gamma(\zeta y^\nu + 1)^{-1/\nu},$$

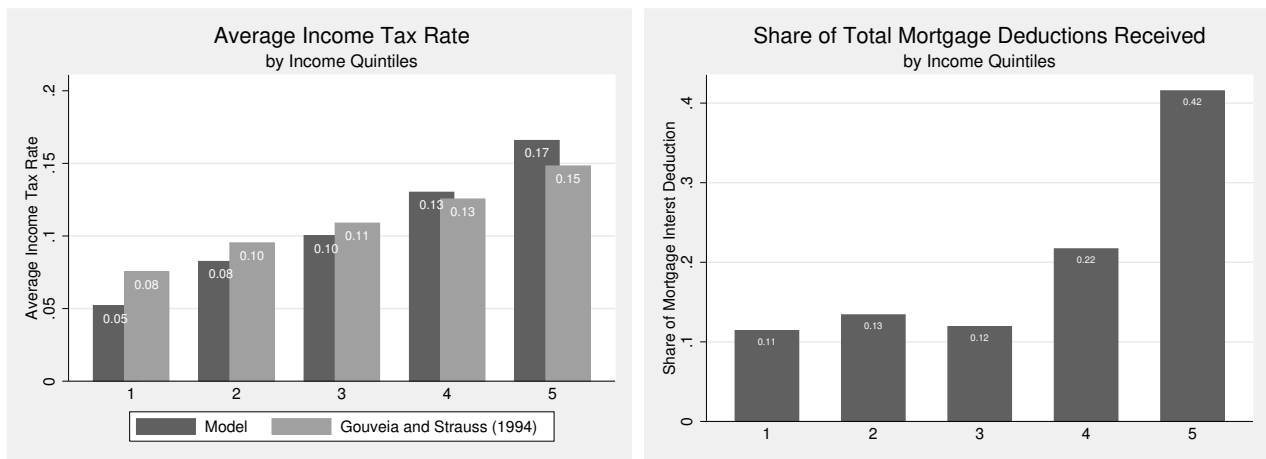
where  $y$  represents total income (in thousands of dollars), with parameters  $\gamma = 0.258$ ,  $\zeta = 0.031$ , and  $\nu = 0.768$  estimated for the year 1989 (the last year for which estimates are available). To test the progressivity of taxation in our baseline model, we use the total income,  $y$ , in Equation 4 (converted to dollars) and simulate the average tax rate of each household in the baseline economy using the Gouveia-Strauss tax function. 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).<sup>28</sup> Figure 1a 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.

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<sup>27</sup>There are many additional sources of data on the price-to-rent ratio. For example, the U.S. Department of Housing and Urban Development and the U.S. Census Bureau report a price-to-rent ratio of 10 in the 2001 Residential Finance Survey (chapter 4, Table 4-2). Morris A. Davis, Robert F. Martin and Andreas Lehnert (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-to-rent ratio ranged between 18.8 and 20 between 1960 and 1995.

<sup>28</sup>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.





(a) Average Income Tax Rates

(b) Share of Mortgage Interest Deductions

Figure 1: Tax Rates and Tax Deductions by Income Quintiles

### 4.3 Distribution of the Mortgage Interest Tax Deduction

Although mortgage interest deductions are in principal available to all homeowners, high income families in the U.S. benefit far more from these tax expenditures than low-income families.<sup>29</sup> Taxpayers with incomes of \$100,000 or more accounted for 11 percent of all tax returns but claimed more than 54 percent of the \$59 billion in mortgage interest deductions taken in the fiscal year of 2004 (Joint Committee on Taxation, 2010).<sup>30</sup> Figure 1b shows the skewed distribution of homeowner mortgage interest tax deductions 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 total mortgage interest tax deductions.

## 5 Repealing the Mortgage Interest Deduction

This section uses the model to simulate the effects of eliminating the mortgage interest deduction on equilibrium outcomes. We focus on the effects of this counterfactual tax reform on objects such as house prices, rents, homeownership, and household welfare. Section 5.1 compares the baseline economy to the new steady state equilibrium reached by the economy

<sup>29</sup>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.

<sup>30</sup>On the other hand, taxpayers earnings up to \$30,000 account for 45 percent of all tax returns but less than 2 percent of total mortgage tax deductions.

after the mortgage interest deduction is repealed. Having established the overall effects of the reform in the steady state, Section 5.2 turns to a detailed discussion of the dynamic transition path from the unexpected reform. The counterfactual experiment begins with the economy in the baseline steady state where mortgage interest is tax deductible. Starting from this initial steady state, the mortgage interest deduction is unexpectedly and permanently repealed. Along the perfect foresight transitional path that ends at the new steady state, all agents correctly forecast the sequence of house prices and rents, and markets clear in each period. Finally, Section 5.3 examines the effects of the reform on steady state tax revenue.

## 5.1 Steady State Outcomes

We start our analysis by exploring the effects of repealing the mortgage interest deduction on steady state housing market equilibrium. Mortgage tax deductions constitute the largest homeownership subsidy under the current tax code: the total tax expenditure toward mortgage interest in 2013 was estimated at \$90 billion (Joint Committee on Taxation, 2012).

In the baseline model, two distinct types of mortgage interest payments are tax deductible. 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 for tax purposes.<sup>31</sup> Eliminating the mortgage interest deduction on rental space would tax landlords on gross rental income, rather than net. Thus, this section discusses the effects of eliminating the mortgage interest tax expenditure on owner-occupied space, while still allowing landlords to deduct mortgage interest payments on leased housing from their gross rental income when calculating taxable rental income.

Table 6 shows the effect of repealing the mortgage interest deduction for owner-occupied space. As the table illustrates, when the mortgage interest deduction is eliminated (column 2), house prices fall by 4.2 percent because, *ceteris paribus*, the cost of ownership has risen. At the same time, rent increases slightly, and the equilibrium house price-to-rent ratio decreases. Since house prices are now lower and ownership is now cheaper relative to renting, the

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<sup>31</sup>The mortgage interest deduction available to landlords is not considered a tax expenditure because it follows the standard practice of allowing a business entity to deduct operating expenses from gross income when computing taxable income. In contrast, the deduction for mortgage interest on a residence is classified as a tax expenditure, because it is a reduction in income tax liability resulting from a “special” tax provision (Joint Committee on Taxation, 2010).

Table 6: The Effect of Eliminating the Mortgage Interest Tax Deduction

	(1) Baseline	(2) Experiment
House price	3.052	2.925
Rent	0.248	0.249
Price-rent ratio	12.320	11.715
Frac. homeowners	0.650	0.702
Fraction renter	0.350	0.297
Fraction owner-occupier	0.549	0.635
Fraction landlord	0.101	0.068
Median $\frac{\text{house value}}{\text{wage}}$	3.815	2.925
Fraction homeowners in debt	0.648	0.634
Average mortgage	2.815	1.931
Consumption equivalent variation ( $cev^*$ )	—	0.757%

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

$cev^*$  is the ex ante consumption equivalent variation.

homeownership rate rises from 65 percent to 70 percent.<sup>32</sup>

The response of homeownership to the repeal of the mortgage interest deduction is determined by quantitative magnitude of two opposing forces. On the one hand, *ceteris paribus*, eliminating the mortgage interest deduction increases the after tax cost of homeownership for households with mortgages. On the other hand, the fall in equilibrium house prices works in the opposite direction, reducing the cost of homeownership. Specifically, the lower house price simultaneously (1) reduces down payments,  $\theta qh'$ , (2) shifts the price-to-rent ratio in favor of buying, and (3) reduces both entry and future per-period ownership costs that are proportional to the value of a home (i.e., transaction costs associated with buying,  $\tau^b qh'$ , as well as maintenance expenses and property taxes,  $qh'(\tau^h + \delta^h)$ ). Our quantitative experiment demonstrates that, on balance, the numerous mechanisms stemming from the house price decline that encourage homeownership more than offset the impact of the lost mortgage interest deduction.

From the perspective of understanding the mechanisms generating the increase in homeownership, and the magnitude of the effect, the crucial households are those who rent in the baseline model. Broadly speaking, renters can be divided into two groups. Approximately one-third of renters are living hand-to-mouth in small apartments, with low wages, and zero

<sup>32</sup>In this counterfactual experiment, the repeal of the mortgage interest deduction increases the aggregate tax burden on households. Section 5.3 discusses the changes in tax revenue, and also conducts an alternative version of the reform that decreases income tax rates to achieve revenue neutrality. Quantitatively, the key results do not change significantly in the revenue neutral reform.

savings. These severely credit constrained households cannot afford to purchase a house. The remaining two thirds of renters are a more diverse group. On average, they earn close to the median wage, and have accumulated savings. Interestingly, the average member of this group could afford to purchase a house, but does not find it optimal to buy because the initial costs,  $qh'(\theta + \tau^b)$ , would consume all of their savings and the majority of their one-period labor income.<sup>33</sup>

When the mortgage interest deduction is eliminated, the top 14 percent of renters in terms of wages and savings—who were on the margin of becoming homeowners—are induced to purchase homes by the drop in house prices. These households face relatively low marginal tax rates, so the loss of the discounted future tax benefits of the mortgage interest deduction are far outweighed by the drop in initial costs,  $qh'(\theta + \tau^b)$ , and the decrease in future per-period costs of ownership that are also proportional to house prices,  $qh'(\tau^h + \delta^h)$ . In addition, as shown in Table 6, households reduce mortgage debt when mortgage interest is no longer tax favored, which mitigates the impact of the lost deduction on the homeownership decision.

Unfortunately, it is difficult to validate the magnitude of this response to the counterfactual tax reform, largely because there is no consensus on the true elasticity of homeownership with respect to house prices, down payments, price-to-rent ratios, or other homeownership costs. As noted in Andreas Fuster and Basit Zafar (2016), the major problem facing empirical work in this area is the absence of exogenous variation in key financial variables. However, Fuster and Zafar’s (2016) new work suggests that the responsiveness of homeownership to reduced down payments—one of the mechanisms at play in our paper—can be quite large. To circumvent the aforementioned endogeneity issues associated with the lack of exogenous variation in down payments, the authors conduct a novel survey designed to directly measure household willingness-to-pay (WTP) for owned housing. Reassuring, they find that renters’ WTP for owned housing increases sharply as minimum down payments decline, supporting our finding that renters on the margin of homeownership are quite responsive to the decline in house prices that accompany the repeal of the mortgage interest deduction. Of course, in our model, the response of homeownership is magnified relative to the hypothetical considered by Andreas Fuster and Basit Zafar (2016), who focus on down payments. In our model,

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<sup>33</sup>Depleting their liquid savings and using up most of their per-period income to buy a house is not an optimal choice for households who face uninsurable earnings shocks as well as sizable non-convex transaction costs associated with selling. Furthermore, as mentioned above, homeownership entails significant recurring costs in the form of maintenance expenses and property taxes.

renters additionally respond to the lower price-to-rent ratio, as well as to a reduction in the entry costs and future per-period costs of homeownership.<sup>34,35</sup>

### 5.1.1 Steady State Welfare Analysis

Interestingly, eliminating the mortgage interest deduction improves the steady state welfare of households. Following a large number of existing studies, steady state welfare is measured using the *ex ante* consumption equivalent variation,  $cev^*$ .<sup>36</sup> We define  $cev^*$  as the constant percentage change in per-period non-housing consumption,  $c$ , that equates the discounted *expected* sum of lifetime utility under the baseline tax system to that under the reformed system. As such,  $cev^*$  provides a quantitative answer to the question: Taking into consideration future earnings uncertainty, would you prefer to be born into a steady state economy with the mortgage interest deduction, or one without it? Measured in consumption equivalent units, welfare increases by 0.757 percent when the mortgage interest deduction is repealed (column (2) of Table 6). It is interesting to note that the reform improves welfare even though it slightly increases the total tax burden on households (total taxes increase by 0.60 percent).<sup>37</sup> 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, average non-durable consumption increases by nearly 2 percent, in part because the repeal of the deduction lowers average household mortgage debt by 31 percent.

Figure 2 depicts the welfare improving shift in shelter consumption and ownership of housing that occurs when the mortgage interest deduction is repealed. The share of the housing stock owned by the top two quintiles of the wage distribution declines appreciably, because the after-tax cost of occupying mortgage-financed housing for households facing high marginal tax rates increases sharply. This housing is reallocated to households in the lower

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<sup>34</sup>The response of homeownership in the model to decreases in the initial cost of owning is consistent with the findings of a number of related quantitative papers that study the effect of down payments on the housing market (Nobuhiro Kiyotaki, Alexander Michaelides and Kalin Nikolov, 2011; Antonia Díaz and María José Luengo-Prado, 2008; Kamila Sommer, Paul Sullivan and Randal Verbrugge, 2013).

<sup>35</sup>In addition, recent work by Neil Bhutta and Benjamin J. Keys (2016) and Atif Mian and Amir Sufi (2011) on home equity extraction supports the idea that new and marginal homeowners are in many cases credit constrained by downpayments.

<sup>36</sup>See, for example, Jay H. Hong and José-Víctor Ríos-Rull (2007) and Makoto Nakajima (2010).

<sup>37</sup>Section 5.3 presents the exact changes in each type of tax revenue, and also presents a revenue neutral version of the reform in which income tax rates are decreased when the deduction is repealed.

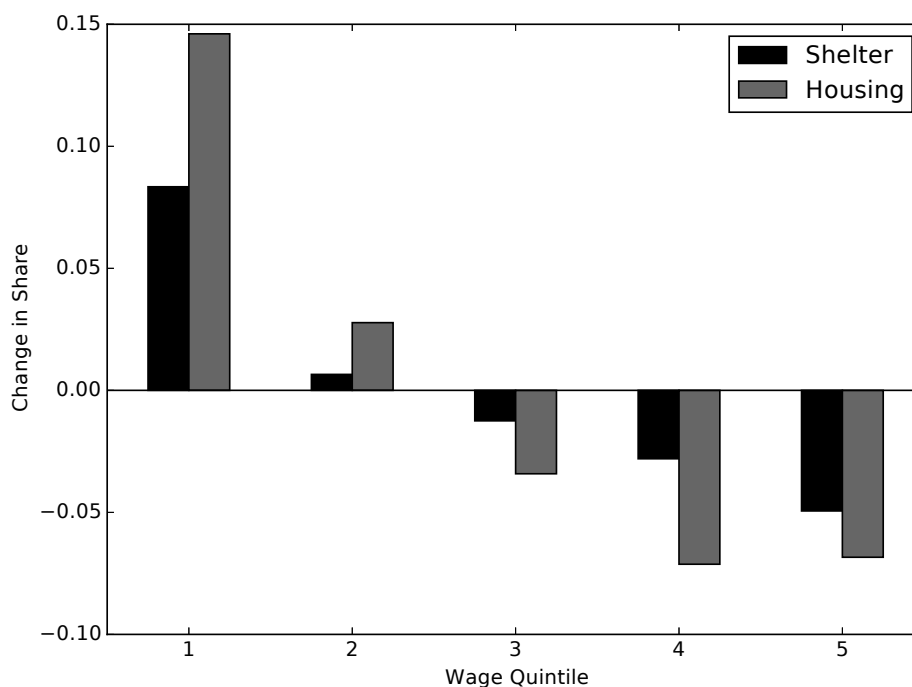


Figure 2: Percent Change in the Share of Steady State Shelter Consumption and Housing Ownership by Wage: Elimination of Mortgage Interest Deduction

quintiles of the wage distribution. Lower equilibrium house prices make starter homes more affordable for previously credit constrained households at the bottom of the wage distribution, and also allow some middle income households to purchase larger houses. Qualitatively, the changes in the equilibrium allocation of shelter across wage quintiles mirror the changes in the allocation of housing, although the magnitudes of the changes are smaller.<sup>38</sup>

## 5.2 Transitional Dynamics

Up to this point, the analysis has been confined to a comparison of two different steady state economies. This comparison reveals that eliminating the mortgage interest deduction—a hotly debated reform—improves overall welfare and increases homeownership. However, evaluating tax reform using only steady state analysis leaves many interesting and policy-relevant questions unanswered. In this section, we turn towards answering the question: What are the dynamic effects of suddenly, and unexpectedly, eliminating the mortgage in-

<sup>38</sup>At the top quintiles of the wage distribution, the housing share is more responsive than shelter because some of the decrease in housing ownership consists of landlords selling rental property to previously credit constrained renters. At the bottom and middle quintiles of the wage distribution, housing is more responsive than shelter because rented shelter accounts for a sizable fraction of shelter consumption.

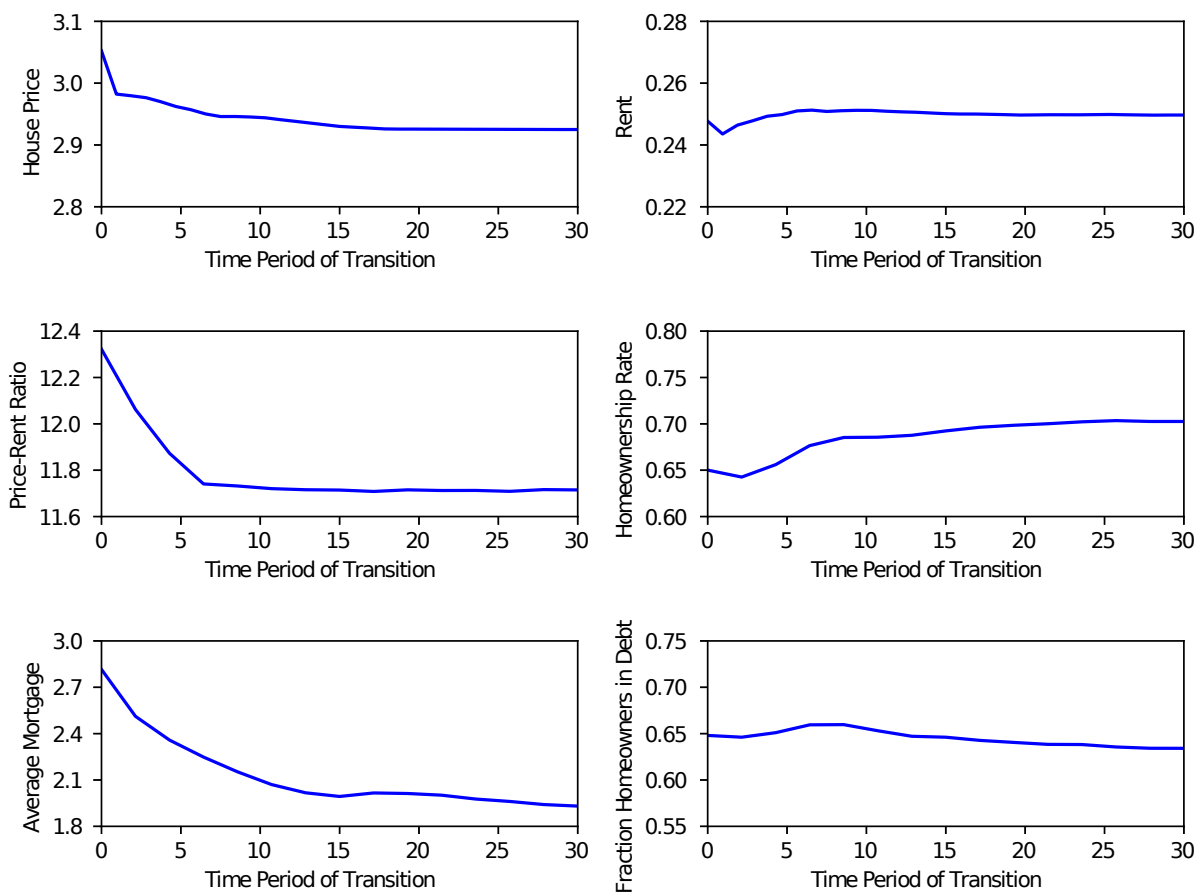


Figure 3: Transitional Dynamics of the Economy after Unexpected, Permanent Elimination of the Mortgage Interest Deduction at  $t = 1$

terest deduction?

### 5.2.1 Evolution of Aggregates Along the Transition

Figure 3 depicts the transitional dynamics of the economy after the unexpected, permanent elimination of the mortgage interest deduction.<sup>39</sup> When the reform is implemented, house prices immediately drop by 2.3 percent, and then smoothly decline to the new steady state equilibrium. The distinguishing feature of house price dynamics over the transition is that price adjustment occurs fairly rapidly: the initial price drop accounts for 56 percent of the total change in house prices observed over the 30 year transition. Within five years, fully

<sup>39</sup>Implementing an unexpected, complete policy change is standard in the quantitative literature. Of course, in actuality this type of reform may be to some extent anticipated by households. Similarly, the change could be phased in more gradually. Policy-makers could also consider compensation schemes to assist those harmed by reform.

73 percent of the house price adjustment has taken place. At the same time, rents decline upon impact, even though—by the end of the transition—rents are slightly higher than their pre-reform level. As a result, the house price-to-rent ratio falls rapidly and monotonically during the first five years of the transition and then gradually declines to its new steady state level.

Compared to the relatively rapid adjustment of house prices, homeownership converges more slowly, holding approximately constant for the first four years after the reform. After this initial sluggish response, the homeownership rate gradually rises from 65 to 70 percent. In terms of the speed of adjustment, 67 percent of this increase occurs within 10 years of the reform. There are two reasons why homeownership responds gradually to the elimination of the mortgage interest deduction. Although the initial decrease in house prices makes ownership more attractive, the simultaneous drop in market rent lessens the incentive for renters to immediately move into homeownership. At the same time, forward-looking renters realize that house prices will continue to fall in the future, even as rents rise, so buying a home later will only become more attractive.

Why does over half of house price adjustment occur immediately when the mortgage interest deduction is repealed? The answer is that the price of a durable good, such as housing, is set at the margin by households who are transacting in the market. When the mortgage interest deduction is suddenly eliminated, households who are on the margin of buying a house—either as a first time buyer, or to upsize—immediately reduce their demand for housing because, *ceteris paribus*, the after-tax cost of owner-occupying a square foot of mortgage-financed housing has risen. Demand by these “transacting households” thus drops discretely. At the same time, the existence of sizable transaction costs prevents existing homeowners from offloading their properties *en masse* in order to move to smaller houses, meaning that the amount of housing for sale stays relatively unchanged in the first period of the transition.<sup>40</sup> As a result, house prices drop significantly as soon as the reform is implemented.

Turning to rent dynamics, with the after-tax cost of occupying square foot of mortgage-financed housing suddenly higher, in a frictionless world, existing homeowners with mort-

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<sup>40</sup>Clearly, homeowners without mortgage balances have no direct incentive to alter their holdings of housing ( $h'$ ), because they are not directly affected by the repeal of the mortgage interest deduction (although they are affected indirectly by capital losses after the reform is implemented).



gages would prefer to own a smaller house. However, in our economy, lumpy transaction costs prevent most of these homeowners from immediately selling their houses and downsizing. Instead, some homeowners choose to reduce housing consumption by leasing out some of their now unwanted property on the rental market. This immediate outward shift in the supply of rental property causes rents to fall in the first period of the transition. Over time, as households adjust to the new tax regime, rental supply contracts, and rents converge to their new equilibrium level.

The bottom panels in Figure 3 show that there is an interesting trend in mortgage borrowing over the transition as markets adjust to the tax reform. The elimination of the tax favored status of mortgages, acting in concert with the fall in equilibrium house prices, causes households to reduce mortgage borrowing. On the intensive margin, as the bottom left panel shows, the average mortgage balance declines by 31 percent over the transition between steady states.<sup>41</sup> On the extensive margin, the bottom right panel shows the evolution of the fraction of households with outstanding mortgage debt. This fraction initially increases marginally as renters transition into homeownership, before declining to the slightly lower equilibrium level by the end of the transition. Taken together, the results show that much of the response of household borrowing to the elimination of the tax favored status of mortgages occurs on the intensive, rather than the extensive, margin.

### 5.2.2 Welfare Analysis Along the Transition

We quantify welfare gains and losses along the transition path using a measure that captures the differential impact of the unexpected elimination of the mortgage interest deduction on households who are heterogeneous in terms of housing ownership ( $h'$ ), financial assets ( $d'$ ,  $m'$ ), and labor earnings ( $w$ ) at the time of the reform. The welfare impact of the tax reform for each person  $i$  alive at the time of the reform is measured by the *ex post* consumption equivalent variation,  $cev_i$ . We define  $cev_i$  as the constant percentage change in per-period non-housing consumption,  $c$ , that equates the discounted sum of lifetime utility *realized* under the baseline tax system to that under the reformed system. As such, for each household alive at the time of the reform,  $cev_i$  provides a quantitative answer to the question: If you had perfect knowledge of the future, would you prefer to experience the tax reform, or not?

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<sup>41</sup>Martin Gervais and Manish Pandey (2008) posit that the elimination of the tax favored status of mortgages would lead to reshuffling of household portfolios away from mortgage debt.

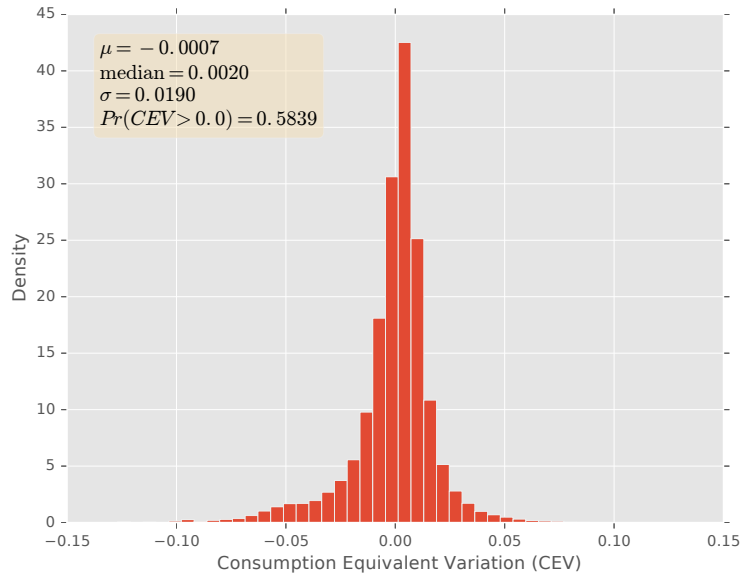


Figure 4: Histogram of Consumption Equivalent Variation ( $cev_i$ )

Figure 4 shows the distribution of  $cev_i$  across households who are alive when the mortgage interest deduction is eliminated. The reform leads to a median welfare gain of 0.20 percent. Moreover, 58 percent of households experience an improvement in their lifetime welfare. However, welfare effects vary widely across the population: a household at the 5th percentile experiences a 3.7 percent welfare loss, while a household at the 95th percentile experiences a 2.3 percent welfare gain.

Since the welfare effects of the tax reform vary widely across the population, it is important to identify the distinguishing features of households that enjoy welfare gains compared to those that incur welfare losses. Table 7 shows that there are systematic differences in housing tenure, mortgage status, and labor income between winners and losers from the reform.<sup>42</sup> In particular, renters, and those without mortgage debt at the time of the reform, tend to enjoy welfare gains while landlords and high income households with mortgages experience the largest welfare losses.

The top section of Table 7 summarizes welfare along the transitional path conditional on homeownership status at the time of the reform. The simulations show that 59 percent of renters benefit from the reform over their lifetime, experiencing a mean welfare gain equal to 0.40 percent of future consumption. On average, renters benefit from the elimination

<sup>42</sup>Throughout this section, unless it is explicitly stated to the contrary, welfare effects are conditioned on the households state immediately before the tax reform is implemented (time period zero in Figure 3).

Table 7: Summary Statistics: Welfare Over the Transition

	$\mu(cev_i)$	$\sigma(cev_i)$	Fraction $cev_i > 0$
<hr/>			
Initial housing tenure			
Renter	0.004	0.015	0.589
Occupier	0.001	0.015	0.655
Landlord	-0.027	0.027	0.184
All	-0.001	0.019	0.584
Initial mortgage			
Have mortgage	-0.005	0.020	0.547
No mortgage	0.002	0.020	0.663
Initial wage			
Wage top 15%	-0.009	0.029	0.539
Wage at median	0.001	0.015	0.639
Wage bottom 15%	0.001	0.014	0.531

Notes:  $cev_i$  refers to the ex-post consumption equivalent variation.  $\mu(cev_i)$  and  $\sigma(cev_i)$  represent the mean and standard deviation.

of the mortgage interest deduction for several reasons. Market rent drops suddenly along the transition path (Figure 3), so renters immediately enjoy a lower cost of shelter. At the same time, renters do not hold mortgages, so their current income tax obligations are not affected by the elimination of the deduction. Most importantly, the welfare gains of households who rent at the time of the reform are driven by the decline in house prices over the transition. Lower house prices, through their effect on down payments and other costs of homeownership, allow renters to attain homeownership earlier than they would in the baseline economy where mortgage interest was tax deductible. In addition, lower house prices over the life cycle allow some households to eventually upgrade to larger homes that would have been unaffordable before the repeal of the deduction.

At the opposite end of the welfare spectrum, over 80 percent of households who are landlords at the time of the reform are harmed by its implementation. The average  $cev_i$  for landlords is -2.7 percent, indicating that, on average, landlords are significantly worse off after the reform. Landlords are overwhelmingly harmed by the reform for a number of reasons. First, landlords tend to be high lifetime income households who occupy relatively large houses. The high shelter consumption of landlords tends to be financed by debt, so landlords are directly and highly adversely affected by the higher tax obligations created by

the elimination of the mortgage interest deduction.<sup>43</sup> The negative impact of eliminating the deduction on landlords is further bolstered by progressive taxation, because landlords tend to face high marginal tax rates that make the deduction disproportionately valuable to them. In addition to welfare losses arising directly from the loss of the deduction, landlords incur sizable capital losses on their large property holdings due to the fall in house prices. Furthermore, since landlords typically already own large properties at the time of the reform, there is very limited scope for them to benefit from the house price decline by purchasing a newly affordable, larger house for their own consumption.

It remains to discuss the effect of repealing the mortgage interest deduction on the welfare of owner-occupiers, who account for the majority of the population. The effects on this group lie in between the two extremes experienced by renters and landlords. However, Table 7 shows that 65 percent of occupiers gain from the reform, so the experience of owner-occupiers over the transition resembles that of renters more closely than that of landlords. This is the case because owner-occupiers tend to live in smaller houses than landlords, so the majority of them benefit from the house price declines associated with reform. For these households, the increased affordability and accessibility of bigger homes outweighs the adverse effects of the house price decline and the removal of the option to claim the mortgage interest deduction.

The mean welfare gain for owner-occupiers of 0.10 percent indicates that although 65 percent of these households benefit from the reform, quantitatively the reform is close to welfare-neutral for the average member of the group. However, the overall mean  $cev_i$  masks considerable heterogeneity within the group: the average occupier who benefits from the reform experiences a welfare gain of 0.85 percent, while the average occupier who is harmed by the reform incurs a welfare loss of 1.2 percent. The greatest welfare losses accrue to high-income occupiers who live in large homes, have large mortgages, face high marginal tax rates, and in many ways resemble landlords. This point is illustrated in Figure 5, which shows that households with the largest mortgages at the time of the reform (Quintile 1) are subjected to a 2.9 percent welfare loss by the elimination of the mortgage interest deduction. Owner-occupiers who benefit from the reform are at the other end of the spectrum: they live in more modest homes, have smaller mortgages, and face lower marginal tax rates.

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<sup>43</sup>As explained in Section 5.1, the mortgage interest deduction experiments only eliminate the deduction on owner-occupied housing. Landlords are always allowed to deduct the business expense of mortgage interest paid on rental property.

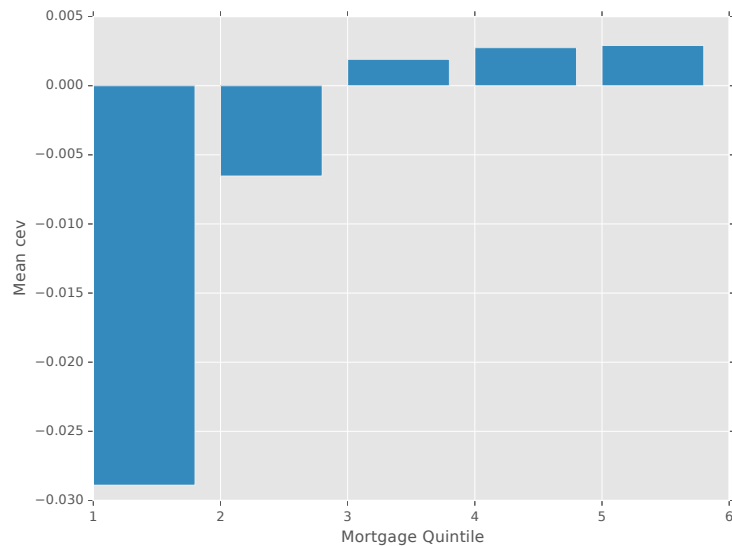


Figure 5: Mean Consumption Equivalent Variation ( $cev_i$ ) by Initial Mortgage Quintile

Notes: Quintile 1 represents the largest mortgages.

A number of different mechanisms are operating on all households who are owner-occupiers at the time of the transition. First, similar to renters, some of these households benefit from the downward trend in house prices over the transition path because it makes upward moves to larger houses possible.<sup>44</sup> Second, the sudden house price decline generates capital losses. Third, owners with mortgages lose the mortgage interest deduction, which increases the carrying cost of financed shelter. Fourth, all households, even those currently without mortgages, lose the option value of claiming the mortgage interest deduction in the future. For any given household, whether the overall welfare effect is positive or negative is a quantitative question about the magnitudes of these, in some cases opposing, forces. The simulations reveal that the majority of households with mortgages (55 percent) still benefit from the reform, even though they immediately lose a tax deduction and incur a capital loss. Indeed, Figure 5 shows that it is only households in the top two quintiles of the mortgage distribution who are, on average, harmed by the reform.

The preceding discussion of the transition path of the economy has focused on variation in welfare effects across households who occupy different states at the time of the reform. However, the path that a household takes after the reform also has a large impact on  $cev_i$ . Figure 6 shows how the initial state and post-reform path interact to determine the welfare

<sup>44</sup>Section 5.1 explains how the elimination of the mortgage interest deduction interacts with progressive taxation to produce a welfare-improving shift of housing from high income to low income households.

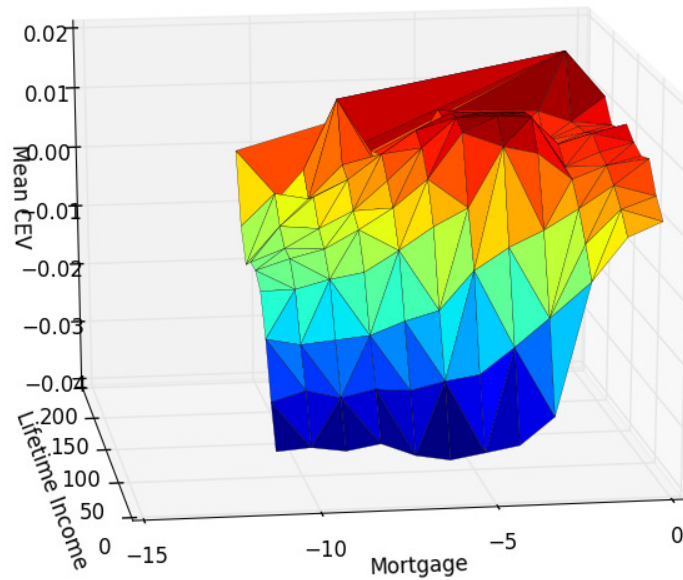


Figure 6: Mean Consumption Equivalent Variation ( $cev_i$ ) by Initial Mortgage and Lifetime Income

impact of the elimination of the mortgage interest deduction. For the purposes of the figure, the initial state is summarized by the mortgage balance at the time of the reform, and the post-reform experience is measured by lifetime income. The bottom left corner of the figure shows that the households most adversely affected by the reform have large mortgages at the time of the reform, and then go on to earn low lifetime incomes over the transition. These unfortunate households face significant tax increases when their mortgage interest payments are no longer deductible, and are burdened by large mortgages on houses that have suddenly depreciated in value. The adverse effects persists over time, because low lifetime income households are unable to quickly pay down their mortgages. The figure also shows that the negative welfare effects on households with mortgages become less severe as lifetime income rises. Ceteris paribus, higher lifetime income over the transition allows households to pay down their mortgages, which are no longer favored by the tax code. The far right edge of Figure 6 shows that the  $cev$  sharply increases as the household mortgage at the time of the reform reaches low levels. This result is consistent with the preceding discussion of the relationship between initial mortgage and the  $cev_i$ . Interestingly, across the entire range of

lifetime income shown in Figure 6, households without initial mortgages benefit from the reform. Overall, the households who realize the largest welfare gains are those who have small or zero mortgage balances at the time of the reform, and also are fortunate enough to earn relatively high incomes in the post-reform periods. These households are best positioned to take advantage of lower house prices by purchasing bigger houses than they would have been able to afford in a world where mortgage interest was tax deductible.

### 5.3 Tax Revenue and Repeal of the Mortgage Interest Deduction

This section discusses the effects of repealing the mortgage interest deduction on tax revenue, and presents a revenue neutral version of the reform. Column (2) of Table 8 shows how steady state tax revenue changes when the mortgage interest deduction is repealed.<sup>45</sup> On the one hand, the reform leads to a 2.6 percent increase in *income* tax revenue because taxable income rises when mortgage interest is no longer deductible. There are two mechanisms behind the observed increase in taxable income. First, taxable income rises because total deductions ( $\psi$ ) fall. Second, 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. On the other hand, *property* tax revenue falls by 7.8 percent because of the decline in equilibrium house prices. In aggregate, the increase in income tax revenue is nearly offset by the sharp drop in property tax revenue, so *total* tax revenue rises slightly by approximately one-half of a percentage point.

Column (3) of Table 8 presents a revenue neutral version of the repeal of the mortgage interest deduction. In this experiment, income tax rates are reduced across-the-board so that total tax revenue remains at the baseline level when the mortgage interest deduction is removed. A slight reduction in tax rates of less than one percent is sufficient to achieve revenue neutrality. The increase in household after-tax income causes both rents and house prices to increase slightly relative to the non-revenue neutral reform shown in Column 2. Since the change in house prices is small, and the price-rent ratio remains unchanged, home-ownership is essentially unchanged relative to the non-revenue neutral tax reform (Column 2). The revenue neutral experiment is only a marginal welfare improvement over the non-revenue neutral experiment, as the welfare measure ( $cev^*$ ) increases from 0.757 percent to

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<sup>45</sup>The results of this reform, excluding the tax revenue effects, were previously presented in Table 6.

Table 8: Revenue Neutral Experiment: Eliminating the Mortgage Interest Tax Deduction

	Eliminate MID		
	(1) Baseline	(2) Experiment	(3) Revenue Neutral
House price	3.052	2.925	2.931
Rent	0.248	0.249	0.250
Price-rent ratio	12.320	11.715	11.715
Frac. homeowners	0.650	0.702	0.702
Consumption equivalent variation ( $cev^*$ )	—	0.757%	0.786%
% $\Delta$ income tax revenue	0.000	2.596%	1.806%
% $\Delta$ property tax revenue	0.000	-7.798%	-7.614%
% $\Delta$ total tax revenue	0.000	0.598%	0.000%

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

Column (3) is the revenue neutral no-mortgage-interest deduction economy.

$cev^*$  is the ex ante consumption equivalent variation.

% $\Delta$  indicates percent change relative to baseline model.

0.786 percent. While the increase in disposable income makes households better off, this welfare benefit is offset to some extent by the accompanying increases in house prices and rents.

## 6 Conclusion

Each year, the mortgage interest deduction reduces U.S. Federal tax revenue by over \$90 billion. This lost revenue amounts to approximately 7 percent of total personal income tax payments. In the ongoing debate over budget deficits and fiscal reform, eliminating the mortgage interest deduction has been a frequently discussed policy change. Proponents of reform point out that the mortgage interest deduction reduces government revenue, is a regressive tax policy, and subsidizes household mortgage debt.

However, there are many unanswered questions about the effects of eliminating the mortgage interest deduction on the housing market. In this paper, we build a model that focuses on understanding, and quantifying, the effects of tax reform on equilibrium house prices, rents, homeownership, and welfare. Although opponents of tax reform claim that repealing the deduction would reduce homeownership, whether or not this is true is ultimately a quantitative question about the magnitude of the resulting equilibrium change in the after-tax cost of homeownership. *Ceteris paribus*, repealing the mortgage interest deduction increases the



cost of financing housing, thereby reducing homeownership. However, our model shows that in equilibrium, house prices fall, allowing credit constrained renters to become homeowners. Moreover, the price-to-rent ratio falls, shifting relative prices in favor of owning. Given the progressive nature of the U.S. income tax code, the results also show that in addition to increasing homeownership, eliminating the mortgage interest deduction shifts housing consumption from high-income to lower-income households, thereby increasing expected lifetime welfare.

The impact of unanticipated tax reform on the welfare of households who are *alive* at the time of the reform (and therefore made decisions about homeownership and mortgage debt under the original tax code) is another significant policy concern. We study this issue by examining the transitional dynamics of the housing market after the sudden repeal of the mortgage interest deduction. As far as social welfare, 58 percent of households alive at the time of the reform are better off under the reformed tax code. However, welfare effects vary widely across the population depending on a household's state at the time of the reform. In particular, homeowners with large mortgages and high incomes frequently incur large welfare losses over their lifetimes.

Finally, our paper is silent on the political feasibility of tax reform, although this is certainly an important and timely additional question. On aggregate, our model suggests that households benefit from tax reform. However, the benefits are largest for young, low-income households, while the costs tend to be highest for older, high-income households. In addition, interest groups representing the real estate industry spend millions of dollars lobbying Congress each year, and these groups strongly support the *status quo* tax regime. Taken together, these facts perhaps cast some doubt on the feasibility of reform, but we leave this as an interesting question for future research.

## References

- Aaron, Henry.** 1970. “Income Taxes and Housing.” *American Economic Review*, 60(5): 789–806.
- American Housing Survey.** 1994-1998, 2011. Data retrieved from U.S. Census, <https://www.census.gov/programs-surveys/ahs.html>.
- Bhutta, Neil, and Benjamin J. Keys.** 2016. “Interest Rates and Equity Extraction During the Housing Boom.” *American Economic Review*, 106(7): 1742–74.
- Campbell, John Y., and Joao F. Cocco.** 2003. “Household Risk Management and Optimal Mortgage Choice.” *Quarterly Journal of Economics*, 118(4): 1449–1494.
- Card, David.** 1994. “Intertemporal Labor Supply: An Assessment.” In *Advances in Econometrics Sixth World Congress.*, ed. Christopher Sims, 49–78. Cambridge University Press.
- Chambers, Matthew, Carlos Garriga, and Don E. Schlagenhauf.** 2009a. “Accounting for Changes in the Homeownership Rate.” *International Economic Review*, 50(3): 677–726.
- Chambers, Matthew, Carlos Garriga, and Don E. Schlagenhauf.** 2009b. “Housing Policy and the Progressivity of Income Taxation.” *Journal of Monetary Economics*, 56(8): 1116 – 1134.
- Chambers, Matthew, Carlos Garriga, and Don E. Schlagenhauf.** 2009c. “The Loan Structure and Housing Tenure Decisions in an Equilibrium Model of Mortgage Choice.” *Review of Economic Dynamics*, 12(3): 444–468.
- Chatterjee, Satyajit, and Burcu Eyigungor.** 2015. “A Quantitative Analysis of the U.S. Housing and Mortgage Markets and the Foreclosure Crisis.” *Review of Economic Dynamics*, 18(2): 165–184.
- Congressional Budget Office.** 2010. “Average Federal Tax Rates in 2007.”
- Davis, Morris A., and Francois Ortalo-Magné.** 2011. “Household Expenditures, Wages, Rents.” *Review of Economic Dynamics*, 14:2: 248–261.

- Davis, Morris A., and Jonathan Heathcote.** 2005. "Housing and the Business Cycle." *International Economic Review*, 46(3): 751–784.
- Davis, Morris A., and Jonathan Heathcote.** 2007. "The Price and Quantity of Residential Land in the United States." *Journal of Monetary Economics*, 54(8): 2595–2620.
- Davis, Morris A., Robert F. Martin, and Andreas Lehnert.** 2008. "The Rent-price Ratio for the Aggregate Stock of Owner-occupied Housing." *The Review of Income and Wealth*, 54: 279–284.
- Díaz, Antonia, and María José Luengo-Prado.** 2008. "On the User Cost and Homeownership." *Review of Economic Dynamics*, 11(3): 584–613.
- Díaz, Antonia, and María José Luengo-Prado.** 2010. "The Wealth Distribution with Durable Goods." *International Economic Review*, 51(1): 143–170.
- Fernandez-Villaverde, Jesus, and Dirk Krueger.** 2011. "Consumption and Saving Over the Life Cycle: How Important Are Consumer Durables?" *Macroeconomic Dynamics*, 15(05): 725–770.
- Floetotto, Max, Michael Kirker, and Johannes Stroebel.** 2016. "Government Intervention in the Housing Market – Who Wins, Who Loses?" *Journal of Monetary Economics*, 80: 106–123.
- Fuster, Andreas, and Basit Zafar.** 2016. "To Buy or Not to Buy: Consumer Constraints in the Housing Market." *American Economic Review*, 106(5): 636–640.
- Garner, Thesia I., and Randal Verbrugge.** 2009. "Reconciling User Costs and Rental equivalence: Evidence from the US Consumer Expenditure Survey." *Journal of Housing Economics*, 18(3): 172–192.
- Gervais, Martin.** 2002. "Housing Taxation and Capital Accumulation." *Journal of Monetary Economics*, 49(7): 1461–1489.
- Gervais, Martin, and Manish Pandey.** 2008. "Who Cares about Mortgage Interest Deductibility?" *Canadian Public Policy*, 34(1): 1–23.

- Gouveia, Miguel, and Robert Strauss.** 1994. “Effective Federal Individual Income Tax Functions: An Exploratory Empirical Analysis.” *National Tax Journal*, 47(2): 317–39.
- Gruber, Joseph W., and Robert F. Martin.** 2003. “Precautionary Savings and the Wealth Distribution with Illiquid Durables.” *Federal Reserve Board International Finance Discussion Paper No. 773*.
- Harding, John P., Stuart S. Rosenthal, and C.F. Sirmans.** 2007. “Depreciation of Housing Capital, Maintenance, and House Price Inflation: Estimates from a Repeat Sales Model.” *Journal of Urban Economics*, 61(2): 193–217.
- Heathcote, Jonathan.** 2005. “Fiscal Policy with Heterogeneous Agents and Incomplete Markets.” *Review of Economic Studies*, 72(1): 161–188.
- Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante.** 2010. “The Macroeconomic Implications of Rising Wage Inequality in the United States.” *Journal of Political Economy*, 118(4): 681–722.
- Hilber, Christian A.L., and Tracy M. Turner.** 2014. “The Mortgage Interest Deduction and Its Impact on Homeownership Decisions.” *Review of Economics and Statistics*, 96(4): 618–637.
- Hong, Jay H., and José-Víctor Ríos-Rull.** 2007. “Social Security, Life Insurance and Annuities for Families.” *Journal of Monetary Economics*, 54(1): 118–140.
- Hubbard, R. Glenn, Jonathan Skinner, and Stephen P. Zeldes.** 1995. “Precautionary Saving and Social Insurance.” *Journal of Political Economy*, 103(2): 360–399.
- Joint Committee on Taxation.** 2010. “Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014.”
- Joint Committee on Taxation.** 2012. “Estimates of Federal Tax Expenditures for Fiscal Years 2011-2015.”
- Kiyotaki, Nobuhiro, Alexander Michaelides, and Kalin Nikolov.** 2011. “Winners and Losers in Housing Markets.” *Journal of Money, Credit and Banking*, 43(2-3): 255–296.

- Laidler, David.** 1969. "Income Tax Incentives for Owner-Occupied Housing." In *The Taxation of Income from Capital*, ed. Arnold C. Harberger and Martin J. Bailey, 50–76. Brookings Institution.
- Li, Wenli, and Rui Yao.** 2007. "The Life-Cycle Effects of House Price Changes." *Journal of Money, Credit and Banking*, 39(6): 1375–1409.
- Mian, Atif, and Amir Sufi.** 2011. "House Prices, Home Equity-based Borrowing, and the US Household Leverage Crisis." *American Economic Review*, 101(5): 2132–2156.
- Nakajima, Makoto.** 2010. "Optimal Capital Income Taxation with Housing." Federal Reserve Bank of Philadelphia Working Papers 10-11.
- Poterba, James M.** 1984. "Tax Subsidies to Owner-occupied Housing: An Asset-market Approach." *The Quarterly Journal of Economics*, 99(4): 729–752.
- Poterba, James M.** 1992. "Taxation and Housing: Old Questions, New Answers." *American Economic Review*, 82(2): 237–242.
- Rappoport, David.** 2016. "Do Mortgage Subsidies Help or Hurt Borrowers?" Board of Governors of the Federal Reserve System (U.S.) Finance and Economics Discussion Series 2016-081.
- Rosen, Harvey S.** 1985. "Housing Subsidies: Effects on Housing Decisions, Efficiency, and Equity." *Handbook of Public Economics*, 1: 375–420.
- Sommer, Kamila, Paul Sullivan, and Randal Verbrugge.** 2013. "The Equilibrium Effect of Fundamentals on House Prices and Rents." *Journal of Monetary Economics*, 60(7): 854–870.
- Survey of Consumer Finances.** 1998, 2007, 2010. Data retrieved from Federal Reserve Board, <https://www.federalreserve.gov/econres/scf-previous-surveys.htm>.
- Topel, Robert, and Sherwin Rosen.** 1988. "Housing Investment in the United States." *Journal of Political Economy*, 96(4): 718–740.