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Government intervention in the housing market: Who wins, who loses?

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ABSTRACT

Many U.S. government policies aim to encourage homeownership. We use a general equilibrium model with heterogeneous agents to consider the effects of temporary homebuyer tax credits and the asymmetric tax treatment of owner-occupied and rental housing on prices, quantities, allocations, and welfare. The model suggests that homebuyer tax credits temporarily raise house prices and transaction volumes, but have negative effects on welfare. Removing the asymmetric tax treatment of owner-occupied and rental housing can generate welfare gains for a majority of agents across steady states, but welfare impacts are substantially more varied along the transitions between steady states.

1. Introduction

Increasing homeownership has been a U.S. policy goal for decades, and a number of policies, tax rules, and regulatory efforts are directed at raising the affordability and attractiveness of owner-occupied housing. Mortgage interest rates are subsidized through Fannie Mae, Freddie Mac, and Ginnie Mae. The tax code favors owner-occupied over rental housing by exempting imputed rents on owner-occupied housing from income taxation. Capital gains on real estate are not fully taxed. Moreover, property owners can deduct mortgage interest payments from their taxable income. This is true both for owner-occupiers and for landlords. In addition, the U.S. government recently introduced short-term incentives such as the First-Time Homebuyer Tax Credit to boost house prices and encourage homeownership.

This paper studies the effects of such policy interventions in the housing market on prices, quantities, allocations, and welfare using a general equilibrium model with heterogeneous agents. By considering agents who differ along characteristics such as age and productivity, this model is able to address the question of who wins and who loses from these policies. Our analysis first considers the effects of *temporary* homebuyer tax credits in response to a boom-bust cycle in house prices generated by a shock to downpayment requirements. The model suggests that homebuyer tax credits can support house prices when they are in place. Since such tax credits also have the effect of increasing the housing stock, house prices remain below the levels that would have prevailed without the policy intervention for many years after the removal of the tax credits. The tax credits also have a negative welfare impact for the majority of households, whose tax revenue is used to pay for the credit, but who do not benefit from the temporary increase in house prices.

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We also consider the effects of two possible *permanent* changes to current government policies. These changes involve (i) introducing taxes on imputed rents and (ii) removing tax deductions for mortgage interest payments. Such policy changes would end the unequal tax treatment of owner-occupied and rental housing, and are regularly proposed to reform the U.S. housing market and to reduce the fiscal deficit. The effects of these permanent policy changes are first analyzed by comparing stationary equilibria under the alternative policy regimes. Then the analysis is extended to consider changes in welfare during the transition between these stationary equilibria. This allows us to determine which of the current population groups would win, and which would lose, if the U.S. decided to change the policy regime.

When comparing stationary equilibria, removing mortgage interest deductions is welfare-improving for the majority of agents, while taxing imputed rents improves the welfare of slightly less than half of all agents. During the transition to the new steady state, the welfare effects are more varied, and feature fewer winners than in the final steady state. For example, 82% of agents would be better off in a steady state without deductions of mortgage interest payments, due to general equilibrium effects on house prices and an increase in transfers facilitated by higher government revenues. However, only around 66% of agents are better off immediately following the removal of mortgage interest deductibility. This difference is driven by a (negative) overshoot of house prices, which decline by over 3% in the period after the policy change, before recovering to a final level around 1% below the baseline steady state. Similarly, while taxing imputed rents appears to generate aggregate welfare gains when comparing steady states, the significant initial price overshoot suggests that lump-sum taxing all winners and compensating all losers to make all agents indifferent to the policy change would cost significant net resources.

When comparing the two changes to the tax code, these results suggest that a removal of the mortgage interest deduction would be the preferred way of correcting the asymmetry in the tax treatment of the housing market from an aggregate welfare perspective. Fewer agents lose, since house prices fall by less following the policy change, and the aggregate welfare gain is larger. However, the distribution of gains and losses between the two policy changes is also different. While the introduction of a tax on imputed rents primarily hurts the richest agents, who consume the most housing, the removal of mortgage interest deductibility largely harms middle-income agents, who generally have large mortgages.

The implications of government interventions in the housing market have been studied previously (e.g., Gervais, 2002; Chambers et al., 2009; Cho and Francis, 2011; Sommer and Sullivan, 2013). These papers focus on comparing steady states across different policy regimes. We expand on this literature by considering the welfare implications along the transition paths between steady states, which have not previously been analyzed. In comparisons across steady states, the removal of taxes and frictions is generally welfare-improving in most models. However, this is not necessarily the case during the transition to the new steady state. Indeed, our results show that taxing imputed rents appears attractive when comparing steady states, but not when taking into account the transition path, where agents who have optimized their asset holdings at the previous steady state are regularly worse off. For governments optimizing the welfare of agents alive today, these short-run welfare considerations are particularly relevant. Therefore, analyzing the welfare implications along the transition path between steady states can provide important insights into the incentives of governments to adopt changes to tax policies.

Another advantage of analyzing the immediate welfare implications along a transition path is that it allows us to consider the effects of important temporary policy interventions in the housing market, which have not been studied in the prior literature. This would not be possible with a comparison of steady state economies.

The one paper in this literature that considers an explicit transition path between stationary equilibria in a general equilibrium framework is by Kiyotaki et al. (2011). They study the distributional consequences of aggregate shocks through their effect on house prices, but do not model changes to the tax treatment of real estate. Poterba (1984) considers a model of an owner-occupied housing market and analyzes how changes in the expected inflation rate impact equilibrium outcomes. While his model considers dynamics, the absence of heterogeneous agents and a rental market makes it hard to compare the impact on allocations and welfare across different agents.

The remainder of the paper is organized as follows. Section 2 describes the government interventions that are considered in this paper. Sections 3 and 4 discuss the model and the welfare criterion used for the subsequent analyses. Section 5 describes the calibration of the baseline economy. Section 6 discusses the effects of temporary tax credits for first-time and repeat homebuyers. Sections 7.1 and 7.2 analyze (i) the introduction of taxes on imputed rents, and (ii) the removal of mortgage interest deductibility, both across steady states and along the transition paths between steady states. Section 8 concludes.

2. Government interventions in the housing market

Housing is the largest asset on most households' balance sheets, while mortgages make up most of household liabilities. As a result, house price changes have large effects on financial markets and real economic activity (e.g., Ivashina and Scharfstein, 2010; Mian et al., 2013; Stroebel and Vavra, 2014). In addition, there is a wide-spread belief that homeownership has important personal and societal benefits: homeownership is associated with life satisfaction (Rossi and Weber, 1996), and there are perceived positive externalities from homeowners' incentives to take care of their property and neighborhood (Rohe and Stewart, 1996).[1] As a result of these beliefs, government interventions in the housing market are

[1] The National Homeownership Strategy (1995) states that "[h]omeownership is a commitment to strengthening families and good citizenship. Homeownership enables people to have greater control and exercise more responsibility over their living environment."

large and focused on increasing homeownership rates through reducing the relative cost of owner-occupied housing. We next describe some recent temporary government interventions in the housing market, focusing on homebuyer tax credits. We also discuss important permanent government interventions through the tax code, concentrating on the non-taxation of owner-occupied rents and the tax-deductibility of mortgage interest payments.

2.1. Homebuyer tax credits

As part of the American Recovery and Reinvestment Act of 2009, Congress authorized a First-Time Homebuyer Tax Credit of up to $8000 to stimulate the housing market. A first-time homebuyer was defined as anyone who had not owned a "main home" in the three years prior to a home purchase. The tax credit was refundable, meaning that it could be claimed by taxpayers who had little or no federal income tax liability to offset.[2] On November 6, 2009, the tax credit was expanded to include existing homeowners who were purchasing a home to be their principal residence (repeat buyers). They were eligible for a tax credit of up to $6500. Both tax credits expired on April 30, 2010. Section 6 analyzes these policies.[3]

2.2. Current tax policy regime and potential alternatives

Among the most important permanent aspects of the U.S. tax code that affect decisions in the housing market are the income-tax exemption of imputed rents from owner-occupied housing, and the deductibility of mortgage interest payments from taxable income. A landlord pays taxes on the income received from rental units. At the same time, the implicit income from living in owner-occupied housing is exempt from income taxation.[4] This asymmetry between landlords and owners leads to a bias in favor of owner-occupied housing. In addition, agents that itemize deductions in their tax returns can also deduct mortgage interest payments from their tax bill. This policy encourages homeownership and leads both renters and owners to over-consume debt-financed housing services. Glaeser and Shapiro (2003) report that in 1999, a total of $773 billion was deducted by 40 million homeowners, making mortgage interest payments the second largest federal deduction after state taxes.[5]

This paper considers two potential policy changes that are regularly discussed as options to reform the U.S. housing market, and to close the federal fiscal deficit. In practice, there are several ways to remove the asymmetric tax treatment of owner-occupied and rental housing. One way would be to introduce income taxation on imputed rents, as is done in several OECD countries, while allowing owner-occupiers to deduct depreciation expenses on top of the mortgage interest payments they can already deduct under the current policy environment. The effects of such a policy are considered in Section 7.1. A second way to eliminate the asymmetry in tax treatment would be to remove the deductability of mortgage interest payments. Section 7.2 considers such a policy. In both cases, owner-occupied housing and rental housing would be subject to the same taxes and deductions.

3. Model

To analyze the distributional effects of government interventions in the housing market, we build a heterogeneous-agent overlapping-generations general equilibrium model of the housing and rental markets. Agents derive utility from housing services and from a nondurable numeraire consumption good. To obtain housing services, agents either live in owner-occupied housing or in rental housing. Homeowners can purchase additional housing stock and lease those units to other agents. Agents' decisions are affected by government interventions through the tax code. The model allows for a flexible set of non-convex housing transaction costs. Aggregation of agents' individual decisions yields demand for owner-occupied housing and the supply and demand for rental units. House prices, p, and rents, p^r, adjust to clear the housing and the rental markets. The aggregate housing stock responds to changes in prices.

3.1. Setup of the agent's problem

Preferences: Agents receive utility from consuming housing services $\tilde{h}$ and the nondurable numeraire consumption good c. Preferences over consumption and housing services are non-separable. All else equal, agents prefer owner-occupied housing to rental housing. In terms of the model, agents weight housing services with a factor $\lambda \leq 1$ in their utility function, which takes a value of one for owner-occupied housing and a value less than one for rental housing. Galster (1987) provides

[2] The tax credit phased out for buyers with an adjusted gross income (AGI) above $150000 (increased to $225000 for purchases after November 6, 2009). Partial credits were available for buyers with an AGI above these limits. The tax credit was capped at 10% of the house value.

[3] While our policy analysis focuses on the effects of the federal tax credits, a number of U.S. states also introduced their own homebuyer tax credit programs, such as California on March 25, 2010.

[4] Property taxes and fees might be considered by some as an equivalent form of taxation. However, Fullerton (1987) shows these to be significantly lower than the income tax rate paid by landlords.

[5] The U.S. policy choices are by no means universal. In 1993, imputed rents were taxed in 9 of 24 OECD countries (Gervais, 2002). Similarly, the deductibility of mortgage interest payments for tax purposes is not uniform across countries. Mortgage interest payments are not deductible in Germany, France, the U.K., and Sweden. In Belgium, Italy, and Spain, mortgage interest payments are deductible only up to a limit (Hoek and Radloff, 2007).

evidence for such a preference. The housing share in consumption is θ, the coefficient of relative risk aversion is ρ. The agents' period utility function is:

$$u\left(c,\tilde{h}\right)=\frac{(c^{1-\theta}(\lambda\tilde{h})^{\theta})^{1-\rho}}{1-\rho} \tag{1}$$

Housing services: To receive housing services, agents can either purchase housing ($h>0$) or rent housing units ($h^r>0$). Homeowners have the additional option to supply housing units to the rental market ($h^r<0$). The maximum amount of housing leased to other agents is bounded by the agent's owned housing stock ($h+h^r>0$). The amount of housing services $\tilde{h}$ that an agent consumes is then given by:

$$\tilde{h}=\begin{cases} h^r & \text{if Renter } (h^r>0) \\ h+h^r & \text{if Owner } (h^r\le 0, h+h^r>0) \end{cases} \tag{2}$$

Following Cocco (2005) and Gervais (2002), we set a minimum size for owned housing:

$$h\ge h^{min} \tag{3}$$

This set-up allows us to distinguish the consumption and investment aspects of housing. It imposes that an agent can only live in one place at a time, and will therefore either derive utility from the amount of rented housing or from the amount of owned housing that is not leased to other agents.

Demographics and endowment: Agents work for $J-1$ periods before they retire. In the numerical simulations, a period is equal to five years and J is set to 10. This generates 9 working cohorts aged between 20–25 and 60–65. Once retired, agents face a constant mortality rate of $1-\kappa$.

An agent who dies unexpectedly has her assets liquidated, and, after settling outstanding debts, the remaining value of her assets is distributed as a lump-sum bequest to the working-age population. Agents who die receive utility from bequesting their net assets, φ, according to the utility function (4), where $0\le\omega\le 1$ is a weighting factor:

$$v(\varphi)=\omega\frac{\varphi^{1-\rho}}{1-\rho} \tag{4}$$

In every period, a new cohort of young agents enters the economy to replace the dying retirees such that the overall mass of agents remains constant. Working agents inelastically supply one unit of labor. Agents have age-specific productivity γ_j, and face persistent idiosyncratic shocks to their labor productivity $\eta_{i,t}$, which follow an AR(1) process in log terms with a persistence parameter $|\phi|<1$ and an innovation term $\varepsilon_{i,t}\sim N(0,\sigma_y^2)$. The process for labor income $y_{i,j,t}$ can thus be expressed as:

$$y_{i,j,t}=\gamma_j\eta_{i,t},\quad \log\eta_{i,t}=\phi\log\eta_{i,t-1}+\varepsilon_{i,t} \tag{5}$$

The stationary distribution of agents over age j and the productivity level indexed by i is given as $\mu(i,j)$. Retirees receive Social Security benefits as a fraction g of the working population's average income. Benefits are thus set at:

$$\hat{y}=g\sum_{j=1}^{J-1}\int_i y_{i,j}\mu(i,j)\,di \tag{6}$$

Social security payments are financed by a tax τ^{ss} on labor income. The social security agency breaks even in every period and adjusts the tax rate accordingly.

Depreciation, transaction costs, and moving shocks: An agent's housing stock depreciates at a constant rate δ. The process of buying and selling houses involves significant costs, including the time cost of searching for a suitable home and broker fees. In the model, an agent who buys a house incurs a cost as a fraction ϕ^b of the value of the new house, ph. Similarly, an agent who sells a home incurs a cost as a fraction ϕ^s of the value of the sold house, $ph_{-1}(1-\delta)$. Transaction costs are a deadweight loss for the economy. At the beginning of every period, some fraction of working-age agents receive an exogenous moving shock, $z=1$. This moving shock captures job-related relocations. Agents who receive a moving shock need to sell their current house and pay transaction costs. Retirees never receive a moving shock.

An agent that has not received a moving shock has three options: (i) pay maintenance expenses $p\delta h_{-1}$, and keep the housing stock at last period's level; (ii) let the housing stock depreciate; or (iii) choose a different level of housing stock. In the first two options, the agent remains at her current residence, and hence does not incur any transaction costs. The third option involves the agent buying another property, which requires paying transaction costs.[6] The resulting formulation of transaction costs is:

$$AC(h_{-1},h,z)=\begin{cases} 0 & \text{if } z=0\wedge h=\{(1-\delta)h_{-1},h_{-1}\} \\ p\left(\phi^b h+\phi^s h_{-1}(1-\delta)\right) & \text{otherwise} \end{cases} \tag{7}$$

The cost of moving between rental units is smaller. Most agents that rent do not engage in expensive remodeling work and brokerage fees are – if applicable at all – much lower. We thus normalize the moving costs for renters to zero. This allows a

[6] By assumption, agents are not allowed to engage in partial transaction-cost-free maintenance. This is to facilitate the computational solution of this problem on a δ-spaced grid (see Appendix C).

substantial numerical simplification, which is discussed in Appendix B.1. On the other hand, being a landlord involves non-trivial costs. Owners of rental units need to search for and screen potential renters, and carry the risk of unfilled inventory. In the model, this is represented as a fixed per-period participation cost ξ.

Borrowing and saving: Agents have access to a risk-free bond s' that pays interest r. The choice of s' can be positive, in which case the agent saves, or negative, in which case the agent borrows. Markets are incomplete, and agents can only borrow against the value of their house subject to a downpayment requirement, d:

$$s' > -(1-d)\, hp. \tag{8}$$

The interest rate, r, is treated as exogenous in the model. This is motivated in part by the large and persistent U.S. current account deficit. As a result of high savings rates overseas, the U.S. has been able to borrow on international capital markets, lowering the interest rate from the level that would clear the domestic savings market.[7]

When borrowing, agents pay a higher interest rate $r+m$. The mortgage premium m captures the probability of mortgage default in reduced form. Therefore, the pre-tax return on asset position s is given by $(1+r+mI_{\{s<0\}})$. For an arbitrary policy regime, the budget constraint of a working agent can be expressed as:

$$c+s'+ph+AC+\max\{0,T-D\} = p^r(h-\tilde{h})+(1+r+mI_{\{s<0\}})s+(1-\tau^{ss})y+p(1-\delta)h_{-1}+F \tag{9}$$

where T denotes the tax burden, and comprises taxes on labor income, capital income, and rental income. The sum of applicable tax deductions is denoted by D and is capped at the level of the total tax owed. F represents a lump-sum transfer from the government to working-aged agents – this transfer adjusts to ensure that the government breaks even each period. The government intervenes through the specification of T and D, as discussed in Section 3.3.

3.1.1. *Recursive formulation of the agents' problem:*

The problem of the retiree can be expressed in recursive form as:

$$\begin{aligned}
&V^J(h_{-1},s,z;p^r,p,p_{-1}) = \max_{s',h,\tilde{h}}\left\{\kappa\left[u(c,\tilde{h})+\beta\mathbb{E}V^J(h,s',z';p^{r'},p',p)\right]+(1-\kappa)v(\varphi)\right\}\\
&\quad\text{subject to :}\\
&\quad c+s'+ph+AC+\max\{0,T-D\} = p^r(h-\tilde{h})+(1+r+mI_{\{s<0\}})s+\hat{y}+p(1-\delta)h_{-1}\\
&\quad \varphi = s(1+r+mI_{\{s<0\}})+(1-\phi^s)(1-\delta)ph_{-1}\\
&\quad p^{r'} = \Gamma_1(\Omega_t,\ldots),\quad p' = \Gamma_2(\Omega_t,\ldots)\ (1)\text{–}(4),(6)\text{–}(8)
\end{aligned} \tag{10}$$

In this formulation, β is the discount rate, and φ captures the net resources that the agent bequeaths if she dies. Bequests are equal to the sum of the resources obtained from selling a house and the agent's financial assets. For the remaining cohorts, 1 to $J-1$, the problem can be solved recursively. The problem of working cohort j can be expressed as:

$$\begin{aligned}
&V^j(h_{-1},s,y,z;p^r,p,p_{-1},F) = \max_{s',h,\tilde{h}}\left\{u(c,\tilde{h})+\beta\mathbb{E}V^{j+1}(h,s',y',z';p^{r'},p',p,F')\right\}\\
&\quad\text{subject to :}\\
&\quad c+s'+ph+AC+\max\{0,T-D\} = p^r(h-\tilde{h})+(1+r+mI_{\{s<0\}})s+(1-\tau^{ss})\,y+p(1-\delta)\,h_{-1}+F\\
&\quad p^{r'} = \Gamma_1(\Omega_t,\ldots),\quad p' = \Gamma_2(\Omega_t,\ldots),\quad F' = \Gamma_3(\Omega_t,\ldots)\\
&\quad (1)\text{–}(3),(5),(7),(8)
\end{aligned} \tag{11}$$

where F is the lump-sum transfers from the government to the working-aged agents.

Expectation formation: In these recursive specifications, Γ_1, Γ_2, and Γ_3 refer to the laws of motion for prices and transfers that agents assume for the key aggregate state variables p^r, p, and F. Agents form expectations about future prices which, in addition to being a function of current prices and aggregate variables like the size of the housing stock, will depend on the full distribution of agents over the state space, Ω_t, a complex object. In the model, agents are assumed to form expectations rationally. Given the absence of aggregate uncertainty, this means that agents have perfect foresight about the future path of prices, except in periods with unexpected policy changes.

In a stationary equilibrium, prices and transfers are constant. Agents' price forecasts are thus very simple: $p^{r\prime} = \Gamma_1(p^r) = p^r$, $p' = \Gamma_2(p) = p$, and $F' = \Gamma_3(F) = F$. Along the transition path between steady states, prices and transfers are no longer constant. In the absence of aggregate uncertainty, rational expectations imply that following an unexpected change in policy (such as the introduction of a temporary homebuyer tax credit), the agents have perfect foresight about the paths of prices and transfers on the transition to the eventual steady state. The calculation of the transition paths follows the approach used by Auerbach and Kotlikoff (1987) and assumes that the economy converges to its new steady state within a finite number of periods. Agents have perfect foresight and know the sequence of prices along the transition path. Given price expectations, market clearing is checked to ensure that actual prices given the expectations are consistent with the expectations. Appendix C describes the solution algorithm in more detail.

[7] An exogenous interest rate also reduces the number of endogenous variables that must be solved for in equilibrium, making the numerical computation of the model less demanding.

3.2. Housing supply

There is a construction sector that transforms land available for development L into new housing stock H^{new}. This sector purchases land at a constant price that is normalized to 1, and immediately sells the housing stock in the market at price p. Following Davis and Heathcote (2005), every period some amount of land of fixed quality is made available for development. Not all of this land was formerly unoccupied, since the depreciation process frees up previously occupied land for development. Every period, as more of the available land is developed, developing additional units becomes more expensive. Alternatively, every period the available land is developed in decreasing order of quality. This generates decreasing returns in the production of new housing stock: $H^{\text{new}} = \psi_1 L^{\psi_2}$, where $\psi_2 < 1$. The construction sector thus solves the following static problem: $\max_L \{p\psi_1 L^{\psi_2} - L\}$. The resulting law of motion for the aggregate housing stock is:

$$H = H_{-1}(1-\delta) + H^{\text{new}} = H_{-1}(1-\delta) + \psi_1 \left(\frac{1}{p\psi_1\psi_2}\right)^{\left(\frac{\psi_2}{\psi_2 - 1}\right)} \tag{12}$$

It is assumed that the construction sector is owned from abroad. As a result, it is not necessary to keep track of the distribution of its ownership in the population.

3.3. Government intervention in the model

The model environment allows the government to tax labor income, capital income, and rental income. Taxes can be levied on both actual rental income and imputed rental income from owner-occupied housing. In the benchmark calibration, taxes on imputed rents are deducted to reflect the current U.S. tax policy.

A policy regime is determined by the specification of each agent's tax bill, $\max\{0, T-D\}$, which is a function of total tax owed T and potential deductions D. The total tax burden can be broken down as follows:

$$T = \sum \begin{pmatrix} \tau^y y & \text{Labor income taxes} \\ \tau^s r s I_{\{s>0\}} & \text{Capital income tax} \\ \tau^r (p^r - \delta p) h & \text{Tax on rental income (real and imputed) less depreciation} \end{pmatrix} \tag{13}$$

The tax-base for income on rents (real and imputed) gets adjusted by the value of the depreciation of that property, reflecting current U.S. policy. The deductions that are considered in this paper are summarized below, where the indicators Ψ_1 to Ψ_4 are used as a convenient way to combine policy alternatives in a single equation:

$$D = \sum \begin{pmatrix} \Psi_1 \tau^r \tilde{h}(p^r - \delta p) I_{\{h>0\}} & \text{No tax on owner-consumed housing} \\ \Psi_2 \tau^y (-1)(r+m) s I_{\{s<0\}} & \text{Deductibility of all mortgage interest} \\ \Psi_3 TC^{FTHB} I_{\{h>0 \wedge h_{-1}=0\}} & \text{First-Time Homebuyer Tax Credit} \\ \Psi_4 TC^{RHB} I_{\{h>0 \wedge h \neq (1-\delta)h_{-1} \wedge h \neq h_{-1}\}} & \text{Repeat Homebuyer Tax Credit} \end{pmatrix} \tag{14}$$

In the baseline policy regime, which corresponds to the current U.S. tax policy, $\Psi_1 = 1$, $\Psi_2 = 1$, $\Psi_3 = 0$, and $\Psi_4 = 0$. Section 6.1 analyzes prices, quantities and welfare for the First-Time Homebuyer Tax Credit by setting $\Psi_3 = 1$ for one period. Section 6.2 simulates the Repeat Homebuyer Tax Credit by setting $\Psi_4 = 1$ for one period. Section 7.1 analyzes the effects of a permanent introduction of taxes on imputed rents by setting $\Psi_1 = 0$. Section 7.2 considers the effects of a permanent elimination of mortgage interest deductibility by setting $\Psi_2 = 0$.

Aside from the collection and redistribution of taxes, the government in the model is also used to facilitate the distribution of the bequests from the retirees who die to the working-age population. Each period, the government sells the houses of those who have died at the market price, pays off any outstanding debts held by each retiree who died, and transfers the remaining resources equally to all working-age individuals as a lump-sum transfer. Q denotes the total (net) bequest income the government collects.

In the welfare comparisons, it will be important to consider the tax revenue implications of potential policy alternatives. By assumption, the government is required to run a balanced budget in every period, that is:

$$\int_i \int_j \int_h \int_s \max\{0, T(i,j,h,s) - D(i,j,h,s)\} \mu(i,j,h,s)\, ds\, dh\, dj\, di + Q = \chi F \tag{15}$$

The parameter χ gives the population share of the working-age population. This balanced budget constraint makes the agent's tax bill and the lump-sum government transfers important redistributive channels. For example, a reform that increases tax revenues by abolishing deductions can benefit low-income agents through higher government transfers.

3.4. Market clearing and equilibrium definition

Purchase and rental prices for housing are determined every period by a market-clearing condition in both markets. Rental units are endogenously supplied by agents who decide to become landlords. The market clearing conditions are

formally expressed as follows:

$$\int_i \int_j \int_h \int_s h(i,j,h,s)\mu(i,j,h,s)\, ds\, dh\, dj\, di = H \tag{16}$$

$$\int_i \int_j \int_h \int_s h^r(i,j,h,s)\mu(i,j,h,s)\, ds\, dh\, dj\, di = 0 \tag{17}$$

It is now possible to define a stationary recursive competitive equilibrium for the economy.

Definition 1. Given a taxation regime T and D that includes a set of government policies τ_y, τ_s, and τ_r and an interest rate r, a *stationary recursive competitive equilibrium* is defined by prices p and p^r, value and policy functions for agents V, c, h, h^r, s', a policy for the construction sector H^{new}, lump-sum government transfers F, and a distribution of agents μ (over i, j, h, s) such that:

1. Given prices and transfers, agents optimize.
2. Given prices, the construction sector optimizes.
3. The housing and rental markets clear.
4. The government budget breaks even in every period.
5. The distribution μ is invariant with respect to the exogenous Markov process for labor productivity and the policy functions h and s'.

4. Welfare criterion for policy analysis

The main interest of this paper is to analyze the price and quantity effects of government interventions, and to consider their aggregate and distributional welfare effects. We next describe how the instantaneous welfare effects are analyzed. This criterion is used to measure the effects of temporary policies such as homebuyer tax credits, as well as to determine the immediate welfare effects following a permanent change in policy. We also describe the criterion used to compare welfare across steady states.

Instantaneous welfare effects: The immediate change in expected discounted life-time utility following a reform is equivalent to the change in the value functions V^j in (10) and (11). To aid the interpretation, the values of these welfare effects are presented in consumption equivalent units. Consider two economies in a given state in period $t-1$. The first economy unexpectedly introduces a policy reform in period t, while the second economy does not. Let $\widehat{V}_t^j$ represent the value function in period t in the first economy (the one introducing the change), while V_t^j represents the value function in the second economy. Also let c^* and $\tilde{h}^*$ be the solution to (10) or (11) in the original steady state: $V_t^j = u(c_t^*, \tilde{h}_t^*) + \beta\mathbb{E}[V_{t+1}^{j+1}]$. For a given set of state variables (h_{-1}, s, y, j), the consumption equivalent change Δc measures the one-time change to period t consumption (reported as a percentage of current consumption) of agents in the second economy (the one without a policy change) required to ensure they are as well off as agents of the same type in the first economy:[8]

$$\widehat{V}_t^j = u\left(c_t^* + \Delta c, \tilde{h}_t^*\right) + \beta\mathbb{E}[V_{t+1}^{j+1}]. \tag{18}$$

A positive value for Δc suggests that agents are better off immediately following the introduction of the policy change.

Steady state comparison: For permanent policy changes, welfare is also compared between the alternative steady states. Each agent's welfare is assessed in the baseline case, V^j, and in the new stationary equilibrium following the policy change, $\widehat{V}^j$. Again, the values of the welfare differences are expressed in terms of the change in one-period contemporaneous consumption Δc that would make a specific agent in the baseline steady state as well off as an agent with the same state variables in the alternative steady state. As before, this can be determined by inverting (18). To interpret this consumption-equivalent variation, consider two countries with economies in steady state, one with the baseline U.S. policy regime and the other with the experiment calibration. If the welfare of a certain type of agent is higher in the post-experiment steady state than in the baseline steady state (where type is defined by h_{-1}, s, y and j), Δc represents the one-time increase in consumption that this type of agent in the baseline steady state would need to be offered to make her indifferent to switching places with a similar agent in the post-experiment steady state. Equivalently, if the reform has a negative welfare impact, the consumption equivalent is the one-time reduction in consumption ($\Delta c < 0$) that agents would be happy to accept to stay in the baseline steady state, rather than having to switch with a similar agent in the post-experiment, lower-welfare steady state.[9]

[8] The consumption transfer is made after the agents have optimized (without suspecting either a change in policy, or the potential for a consumption transfer). That is, agents are not allowed to re-optimize their behavior in period t.

[9] One limitation of our welfare analysis is its inability to account for the positive externalities of homeownership. The utility function captures the welfare benefits of homeownership that accrue to the owner through the parameter λ. However, the utility function does not capture any externalities of homeownership that other agents in the economy receive. For example, homeowners may be more involved in caring for their local neighborhoods. Additionally, by assuming that the government runs a balanced budget each period, the government in the model is not able to use budgetary deficits and surpluses to smooth welfare gains and losses across generations. This will also impact the welfare results along the transition path. The size and direction of how our welfare results will be affected depend upon how the government weights future welfare gains and losses to those in the short-run.

Table 1
Pre-defined parameter values.

Parameter	Description	Model value	Annual value
r	Risk-free interest rate	0.127	0.024
m	Mortgage premium	0.042	0.008
θ	Share of housing in consumption	0.141	–
ρ	Coefficient of relative risk aversion	2.0	–
κ	Conditional survival probability of retirees	0.73	0.939
g	Replacement ratio	0.386	–
τ^y	Tax rate on labor income	0.275	–
τ^r	Tax rate on rental income	0.275	–
τ^s	Tax rate on capital income	0.292	–
ϕ^b	Transaction costs for buyer (fraction of house value)	0.025	–
ϕ^s	Transaction costs for seller (fraction of house value)	0.06	–
δ	Housing stock depreciation rate	0.096	0.02
ϕ	Persistence of income process	0.85	–
σ_y^2	Variance of income innovations	0.30	–
d	Downpayment requirement	0.20	–
ϵ	Price elasticity of housing construction	2.5	–

Note: The parameters in this table are calibrated to be in the approximate center of the range of values in the literature. The third column lists the parameter value used in the model simulations (where one model period corresponds to five years). The fourth column shows the corresponding annual value if appropriate.

5. Calibration

The parameters of the baseline economy are selected using a mixture of two different approaches. Some parameters, such as preference and income process parameters, are taken from the literature where they have been previously estimated. Other parameters are calibrated so that the baseline steady state approximates important moments of the U.S. economy.

5.1. Selection of pre-defined parameter values

Table 1 summarizes the parameters that are taken as given. The values for these parameters are selected to be approximately in the center of the range of values used in the literature. Recall that a period in the model refers to a 5-year time span. To ease comparison with the literature, the calibration is discussed in terms of annual values. A detailed discussion of how the parameter values were chosen is provided in Appendix A.

The annual real interest rate is set at 2.42%, and the annual mortgage premium m at 0.8%. The coefficient of relative risk aversion $\rho = 2$, and the share of housing in consumption $\theta = 0.141$, are both taken from the previous literature. The annual survival rate of retirees is set at 93.9%, based on data from the U.S. Decennial Life Tables for 1989–1991. The replacement rate for retiree's income is set to 38.6% of economy-wide average earnings. Tax rates are set based on estimates from the NBER TAXSIM model by Díaz and Luengo-Prado (2008). In keeping with existing estimates of the transaction costs of buying and selling houses, the cost for sellers is assumed to be 6% of the house's value and the cost for buyers is assumed to be 2.5%. The housing stock depreciates at an annual rate of 2%. The parameters related to the workers' income process are chosen to match both the hump-shaped profile of earnings over the life-cycle as well as the dispersion of incomes in PSID data. The downpayment requirement is set equal to 20% of the house value. In the baseline estimates, the housing production function is parameterized to fit a price elasticity of housing starts of $\epsilon = 2.5$ based on estimates from the literature.[10]

5.2. Calibration using method of moments approach

The remaining model parameters are calibrated by jointly matching important moments of the U.S. economy, as summarized by Table 2. Below, we discuss each of the parameters in relation to the data moment it most strongly influences. Absolute housing quantities in this model are not easily related to real-world counterparts, since either h^{min} or H can be normalized in the baseline steady state. We choose to set the value of the steady-state housing stock in the economy, H, equal to 1.

Relative size of rental housing: To calibrate h^{min}, the level of the smallest housing unit available for purchase, the relative size of owner-occupied and rental housing is targeted. The 1999 American Housing Survey shows that the average size of owner-occupied housing is 1860 sqft, while the average size of renter-occupied housing is 668 sqft. When h^{min} is set to 1.07, the ratio of the average size of owner-occupied to rental housing in the model is 2.25, compared to 2.78 in the data.

Percentage of landlords: The fixed cost of becoming a landlord, ξ, is calibrated to target the proportion of U.S. households that are landlords. Chambers et al. (2009) use the American Housing Survey to determine that about 15% of American households are

[10] The sensitivity of the results to the price elasticity of housing starts was tested by also considering price elasticity values of $\epsilon = 6$ and $\epsilon = 0$. These results are reported in Appendix D.

Table 2
Calibrated parameters and target moments.

Parameter	Description	Value	Target moment	Data	Model
$h^{\min}$	Minimum owned house size	1.070	Avg. size of owned/rented house	2.78	2.25
ξ	Fixed cost of being landlord	0.012	Share of landlords in economy	15.0%	18.6%
λ	Utility discount for rentals	0.950	Average homeownership rate	67.4%	72.3%
ω	Bequest discount factor	0.139	Homeownership rate (age 65+)	80.4%	78.2%
β	Time discount factor	0.969	Loan-to-value ratio in economy	35.8%	29.5%
$P(z=1)$	Probability of moving shock	0.151	Fraction of moving owners	24.4%	24.9%

Note: The model parameters in this table are calibrated using a method of moments approach. The parameter values in the third column were jointly chosen with the aim of matching the data moments in column five. The corresponding moments produced by the model are presented in column six. The discount factor, β, is expressed in annual terms. The parameters are ordered in the table to line up with the target moment they influence most strongly.

landlords. A value of 0.012 for ξ, corresponding to about 3.55% of mean annual income, results in a landlord rate of 18.6%. In 2004, mean U.S. household income was around $60500. Thus ξ represents an annual cost of being a landlord of around $2150.

Homeownership rate: The aggregate homeownership rate in 2000 was about 67.4% (U.S. Census Bureau's Statistical Abstract of the United States, Table 957). This rate is targeted by setting the value of the utility discount for rental units, λ, equal to 0.95, which produced an average homeownership rate of 72.3% in the model. This value implies that agents are indifferent between renting 1000 square feet of housing and owner-occupying 950 square feet. Not only does the model approximate the average U.S. homeownership rate, but it also generates a life-cycle profile of homeownership that is similar to that in the data (see Appendix A for more details).

Homeownership rate of retirees: The average homeownership rate in 2000 of those aged over 65 was about 80.4%. The bequest discount factor ω is used to target the homeownership rate of retirees in the model. Setting $\omega = 0.139$ produces a homeownership rate of retirees of 78.2% in the model.

Loan-to-value ratio: The time discount rate β is calibrated to match the aggregate loan-to-value (LTV) ratio in the economy. The average of the 1998 and 2004 Survey of Consumer Finances economy-wide LTV ratios was 35.8%. When the annual β equals 0.969, the LTV ratio in the baseline steady state is 29.5%. The model also captures the decline in the LTV ratio over the life-cycle that is seen in the data.

Moving owners: The probability of receiving a moving shock is calibrated to match the share of homeowners that move. Cocco (2005) finds in PSID data that 24.4% of owners move per 5-year period. When the exogenous probability of a moving shock is 15.1%, the model implies 24.9% of homeowners move per period.

6. Tax credits for homebuyers

We first analyze the aggregate and distributional effects of the unexpected introduction of homebuyer tax credits during the financial crisis. These policies were introduced in response to a significant decline in house prices following a previous boom in house prices. Such a house price cycle is generated in the model using an unexpected one-period reduction of the downpayment requirement from 20% to 10%, corresponding to events over the period 2001–2006.[11] After the one-time drop, the downpayment requirement returns to its steady-state level of 20%, with agents having perfect foresight over the corresponding price paths. The dashed lines in Fig. 1 show that this sequence of events generates a 9% increase in house prices when the downpayment requirement is reduced and more agents can afford to buy larger houses. Rents fall by around 7% as agents move out of the rental market and into the owner-occupied market. The housing stock increases by 2.3% in response to the higher demand and higher prices. After the downpayment requirement is raised back to its old level, house prices decline by more than 10 percentage points and stay below their steady-state level for 40 years. Rents and the housing stock gradually adjust back to their steady-state levels.

The first column of Table 3 summarizes the welfare effects immediately following the reduction in the downpayment requirement. Around 86% of agents are worse off due to the shock, with the negative effects concentrated among initial homeowners and landlords. Young, rich agents benefit from the downpayment reduction: they were previously renting but are now able to take advantage of the relaxed downpayment requirement to purchase their first house. In addition, agents that continue to rent also receive some benefit from the lower rents.

In the following scenarios, it is assumed that the government introduces the tax credits in the period when the downpayment requirement returns to 20% (model-period two), in an attempt to moderate the decline in house prices and the associated welfare effects. Tax credits last for one model-period (five years) and are unanticipated by agents during the initial decline in the required downpayment.

[11] The size of the downpayment shock is meant to capture the fact that during the housing boom it was relatively easy to get a second mortgage in addition to the standard 20% downpayment mortgage, while this was very hard to do during the housing bust period.

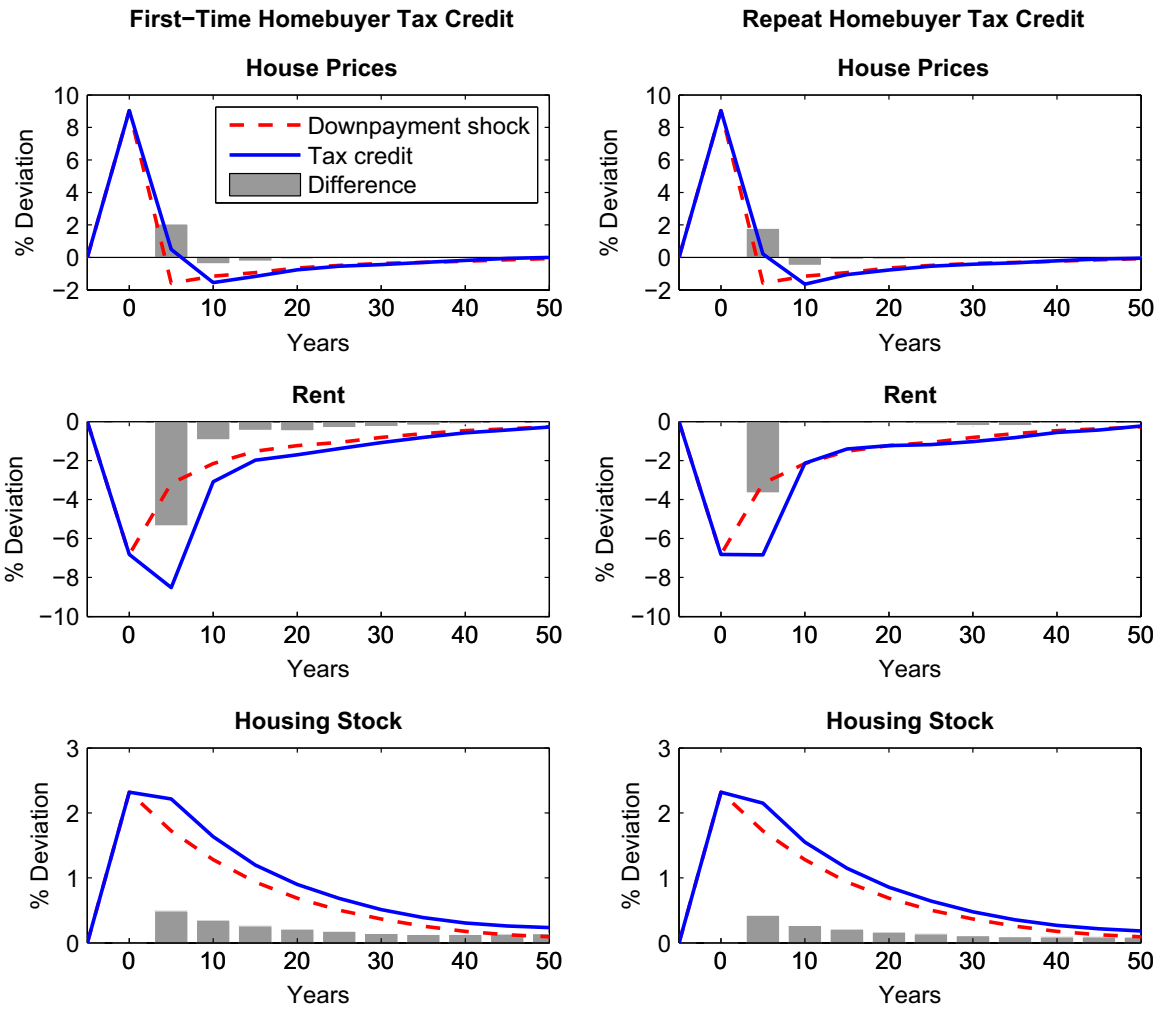

Fig. 1. Transition dynamics for the First-Time and Repeat Homebuyer Tax Credits. *Note*: The first column shows the transition paths of house prices, rents, and the housing stock for the First-Time Homebuyer Tax Credit. The second column shows these transition paths for the Repeat Homebuyer Tax Credit. All values are expressed as percentage deviations from steady state. The dashed line denotes the transition paths when housing downpayment requirements are unexpectedly relaxed from 20% to 10% for one model period (five years) beginning in period zero. The solid line denotes the transition paths when the government responds to the shock by introducing a one-off tax credit in the following period. The bars indicate the effect the tax credit has in percentage points.

Table 3
Welfare effects immediately following tax credit.

Characteristic	Downpayment shock	Tax Credit	
		FTHB	RHB
Agents losing in new steady state (in %)	86.3	71.6	67.5
Initial owners losing (in %)	93.8	78.3	68.6
Initial renters losing (in %)	66.7	52.1	63.4
Initial landlords losing (in %)	97.8	95.9	89.8
Consumption needed to compensate losers (% of $\overline{y}$)	1.40	0.72	0.47
Net gain after compensating all households (% of $\overline{y}$)	−1.31	−0.48	−0.32

Note: The second column shows the aggregate welfare implications immediately following an unexpected relaxation of the downpayment requirement from 20% to 10% for one model period (5 years). The welfare implications are expressed relative to the situation where the economy remained in steady state. The last two columns show the aggregate welfare implications immediately after the government introduces a First-Time Homebuyer (FTHB) or Repeat Homebuyer (RHB) Tax Credit in response to the downpayment shock which occurred in the previous period. The welfare implications of the tax credits are computed relative to the situation where the government did not responded to the downpayment shock. $\overline{y}$ denotes total labor income in the economy.

Table 4
Immediate welfare effects of the First-Time Homebuyer Tax Credit.

Income octant	Age groups									
	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65+
1st	−0.73	−0.69	−0.66	−0.66	−0.77	−0.85	−1.11	−1.89	−1.17	0.31
2nd	−0.59	−0.64	−0.57	−0.64	−0.86	−1.00	−1.34	−1.32	−1.12	
3rd	−0.13	−0.35	0.04	0.52	−0.25	−0.69	−1.32	−1.29	−1.03	
4th	0.49	−0.09	−0.31	−0.12	−0.78	−0.71	−1.16	−1.23	−0.64	
5th	0.99	−0.43	−0.87	−0.66	−0.79	−0.72	−0.98	−1.03	−0.83	
6th	1.94	−0.76	−1.20	−0.61	−0.81	−0.87	−0.92	−0.91	−0.81	
7th	2.17	−0.99	−0.88	−0.83	−0.81	−0.80	−0.80	−0.78	−0.62	
8th	0.88	−0.91	−0.91	−1.02	−1.10	−0.90	−0.80	−0.79	−0.76	
Average	0.63	−0.61	−0.67	−0.50	−0.77	−0.82	−1.05	−1.16	−0.87	0.31

Note: The table shows welfare changes in consumption equivalence units for different combinations of age and income immediately following the introduction of the First-Time Homebuyer Tax Credit in response to the downpayment shock. For example, the first number in the top-left corner suggests that the average poor 20–24 year old in the baseline steady state would be prepared to reduce one-period consumption by about 0.73% of their current consumption level to avoid the introduction of the tax credit. Each cell aggregates over agents with the same immutable characteristics, but different holdings of housing and savings, and thus potentially confounds positive and negative welfare effects. The weights used to average welfare effects over different choices of housing and savings correspond to the relevant population densities.

6.1. First-time homebuyer tax credit

The first temporary homebuyer tax credit considered is a one-period tax credit for first-time homebuyers. The size of the tax credit considered is $8000, corresponding to the size of the actual U.S. credit for first-time homebuyers discussed in Section 2.1. The value of TC^{FTHB} in the model is set such that the tax credit represents the appropriate share of the average income in the economy.

The solid lines in the first column of graphs in Fig. 1 show prices and quantities in a scenario where the First-Time Homebuyer Tax Credit is introduced in response to the downpayment shock. The bars show the difference to the scenario without the tax credit (and only the downpayment shock). Immediately following the introduction of the First-Time Homebuyer Tax Credit, house prices are about 2 percentage points higher than in the absence of the tax credit, as first-time homebuyers take advantage of the tax credit to buy houses. Rents fall further as the demand for rental housing declines. The construction sector responds to the higher house prices, increasing the housing stock by nearly 0.5 percentage points relative to the scenario with no tax credit response.

When the tax credit is removed, house prices fall slightly below the levels that would have prevailed if the government had not intervened. Rents rise as agents return to the rental market. Over time, prices and rents adjust back to steady state, but both stay below their respective paths in the absence of the tax credit, while the housing stock stays slightly above its path in the absence of the tax credit.

The welfare effects of the First-Time Homebuyer Tax Credit are overwhelmingly negative. The second column of numbers in Table 3 summarizes the welfare implications of the tax credit immediately after its introduction in response to the downpayment shock. The welfare effects are computed against the baseline scenario in which the government does not respond to the downpayment shock. Following the First-Time Homebuyer Tax Credit, about 72% of agents in the economy are worse off than they would have been if the government had not intervened. Table 4 splits out the welfare effects for different agents based on age and income. Because the government runs a balanced budget, paying out a tax credit lowers transfers. Therefore most agents who do not purchase a house suffer a welfare loss. In the case of renters, this loss is generally larger than the welfare gains from lower rents, leaving low-income agents worse off. Even some first-time homebuyers are worse off, since the tax credit results in higher house prices, and therefore does not allow them to purchase significantly more housing. Among initial owners, the only ones that gain from the intervention are the few agents that use the temporary price increase to adjust their housing stock downwards (closer towards their optimal level).[12] The main age-income cells that benefit from the introduction of the tax credit are young, rich agents. These agents enter the economy as renters, and are able to exploit the tax credit to buy a house they might otherwise not have been able to afford. They choose to consume significantly more housing in the first periods of their life. This outweighs the cost of having to inject new equity in the house after the (relative) price collapse in the period following the removal of the tax credit. Making all agents indifferent to the introduction of the tax credit by giving lump-sum transfers to losers and lump-sum taxing winners would involve a one-period cost of 0.48% of total labor income.

6.2. Repeat homebuyer tax credit

We next consider the effects of a one-period tax credit for all homebuyers. The size of the tax credit is set to $6500, the size of the actual U.S. credit that was offered to all agents in late 2009 (see Section 2.1). Price and quantity effects following the introduction of a tax credit for repeat homebuyers are qualitatively similar to the effects following the introduction of

[12] Table 4 aggregates agents up into age-income groups and on net, the gains by agents that are better off are generally not enough to offset the losses by others.

Table 5
Immediate welfare effects of the repeat homebuyer tax credit.

Income octant	Age groups									
	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65+
1st	−1.76	−1.62	−1.55	−1.51	−1.46	−1.46	−1.60	−2.50	−1.88	0.23
2nd	−1.54	−1.29	−1.18	−1.16	−1.13	−1.23	−1.53	−1.56	−1.46	
3rd	−1.33	−0.68	−0.31	0.01	−0.39	−0.68	−1.27	−1.37	−1.20	
4th	−0.70	−0.25	−0.38	−0.34	−0.72	−0.80	−1.01	−1.05	−0.68	
5th	−0.15	−0.34	−0.72	−0.67	−0.69	−0.63	−0.80	−0.83	−0.69	
6th	0.70	−0.56	−0.95	−0.58	−0.64	−0.69	−0.72	−0.73	−0.62	
7th	1.17	−0.74	−0.65	−0.69	−0.62	−0.61	−0.61	−0.60	−0.44	
8th	0.35	−0.69	−0.07	−0.31	−0.37	−0.34	−0.30	−0.27	−0.49	
Average	−0.41	−0.77	−0.73	−0.66	−0.75	−0.81	−0.98	−1.11	−0.93	0.23

Note: The table shows welfare changes in consumption equivalence units for different combinations of age and income immediately following the introduction of the Repeat Homebuyer Tax Credit in response to the downpayment shock. For example, the first number in the top-left corner suggests that the average poor 20–24 year old in the baseline steady state would be prepared to reduce one-period consumption by about 1.76% of their current consumption level to avoid the introduction of the tax credit. Each cell aggregates over agents with the same immutable characteristics, but different holdings of housing and savings, and thus potentially confounds positive and negative welfare effects. The weights used to average welfare effects over different choices of housing and savings correspond to the relevant population densities.

tax credits for first-time homebuyers. As shown in the second column of Fig. 1, house prices increase by nearly 2 percentage points, while rents are 3.6 percentage points lower than without the government intervention, due to agents leaving the rental market. The housing stock increases slightly, before slowly reverting back to the old steady state.

Table 3 shows the welfare implications of the Repeat Homebuyer Tax Credit. Compared to the First-Time Homebuyer Tax Credit, the Repeat Homebuyer Tax Credit appears marginally preferable with slightly fewer agents losing as a result of the tax credit. For the First-Time Homebuyer Tax Credit, a higher fraction of the losers are existing homeowners, and fewer are renters. Homeowners on average are richer than renters, and require a larger absolute change in consumption to compensate them for a given fall in utility. The overall amount required to compensate all losers is therefore slightly higher for the First-Time Homebuyer Tax Credit. Table 5 also shows that it is again the young, rich agents (most of whom would have purchased anyway) that benefit from the tax credit. A comparison of Tables 4 and 5 reveals that the average loss for richer homeowners is smaller for the Repeat Homebuyer Tax Credit than for the First-Time Homebuyer Tax Credit, since some of these agents take advantage of the tax credit, allowing them to adjust their property holdings.

6.3. *Tax credit – discussion*

The previous analysis suggests that temporary tax credits in response to a house price decline following a housing boom reduce aggregate welfare. Tax credits drive up prices and trading volumes, without allowing agents to consume significantly more housing. Higher trading volumes increase the deadweight loss in the economy generated by transaction costs. The reduction in transfers required to fund the tax credits leaves the large part of the population that does not purchase a house in that period worse off. Overall, the findings suggest that while tax credits are able to support housing markets by raising prices and volumes in the short-run, the distortions created by agents shifting forward the timing of their housing purchases to take advantage of the tax credit reduces housing demand in subsequent periods. This leads to a fall of house prices below the level without the tax credits.

While the preceding analysis provides important insights into the effects of the Obama Administration's tax credits, there are some limitations. One of the explicit motivations for the tax credits was to support housing markets, which likely had additional benefits that the model does not capture, such as supporting the banking sector. In addition, our model does not allow for a role of uncertainty about the price of housing. If agents had postponed planned home purchases due to uncertainty about future price developments during the crisis, the tax credit could be seen as a corrective tax that moves agents back to their optimal level of homeownership.

7. Permanent changes to the tax policy

This section analyzes possible permanent changes to current U.S. tax policy. The results focus on prices, quantities, and welfare, both across steady states and along the transition path between steady states. Section 7.1 analyzes the introduction of a tax on imputed rents. Section 7.2 considers a policy change that would remove the income tax deductibility of mortgage interest payments. Both of these experiments would end the unequal tax treatment of owner-occupied and rental housing.

Table 6
Quantity and price effects in steady state.

Moment of interest	Baseline	Tax imputed rents	No MID
House price (normalized)	1.00	0.96	0.99
Rental price (normalized)	1.00	1.00	1.02
Price–rent ratio	21.66	20.68	21.02
Housing stock (normalized)	1.00	0.90	0.98
Rental market (normalized)	1.00	2.60	1.76
Homeownership rate (in %)	72.27	39.88	57.51
Share of Landlords (in %)	18.59	21.54	19.93
Average LTV (in %)	29.53	7.56	15.26
Transfers (% of $\bar{y}$)	38.57	41.45	39.83
Tax loss: mortgage interest deduction	0.48	0.13	0.00
Tax loss: non-taxed imputed rents	1.77	0.00	1.57

Note: The table shows moments of interest in the stationary equilibrium of the baseline model, as well as in the steady states under the two alternative policies considered, Taxing imputed rents and the removal of mortgage interest deductions (No MID). $\bar{y}$ denotes total labor income in the economy.

Table 7
Welfare comparison – permanent policy changes.

Characteristic	Tax imputed rents		No MID	
	S.S.	Trans.	S.S.	Trans.
Agents losing in new steady state (in %)	52.4	53.4	17.8	33.6
Initial owners losing (in %)	63.7	73.1	15.8	37.4
Initial renters losing (in %)	23.0	1.9	23.0	23.9
Initial landlords losing (in %)	74.7	80.6	25.0	77.6
Consumption needed to compensate losers (% of $\bar{y}$)	2.68	3.29	0.10	0.36
Net gain after compensating all households (% of $\bar{y}$)	0.83	−0.37	2.20	1.21

Note: The first two columns show the aggregate welfare implications if the government was to introduce a tax on imputed rents. The first column shows the welfare implications when comparing the steady state with a tax on imputed rents (S.S.) to the baseline steady state. The second column shows the welfare implications immediately after the change in tax policy on the transition path (Trans.). The third and fourth columns show the aggregate welfare implications if the government was to remove mortgage interest deductability (No MID) for all agents in the new steady state (S.S.) and immediately after the change in tax policy (Trans). $\bar{y}$ denotes total labor income in the economy.

7.1. Taxes on imputed rents

In the first permanent policy experiment, the model is solved for the stationary equilibrium with taxes on the imputed rents that a property generates for owner-occupiers.

Prices and quantities: Table 6 summarizes the steady-state effects of this experiment on prices and quantities relative to the baseline economy. A tax on imputed rents reduces the incentives of being a homeowner. The homeownership rate nearly halves, falling from 72.3% to 39.9%. Correspondingly, house prices fall by 4% as more agents choose to rent rather than to buy. This drop in house prices comes about despite a 10% decline in the housing stock. Although there is no significant change in rents, the absolute size of the rental market more than doubles. Homeowners are now more willing to lease out some of their housing stock, since they no longer give up the tax benefit of owner-occupying. Young agents now purchase housing later in life and consume more rental housing during their early years.

The share of landlords in the economy increases from 18.6% to 21.5%: in the new steady state, more than half the homeowners are also landlords. It is primarily the richest agents aged 35 and older that own a larger housing stock in the alternative steady state, and rent out a significant fraction of that housing stock. These results suggest that in the baseline steady state, the tax wedge induced homeowners to overconsume housing services out of their owned housing stock.

The average LTV ratio in the economy falls significantly. This happens because the average homeowner in the new steady state is wealthier, and has sufficient resources to cash-purchase her housing.[13] The low- to middle-income agents that have high LTV ratios in the baseline steady state are renters in the alternative steady state.

Welfare comparisons: The following section compares the welfare of agents in the baseline steady state with agents of identical characteristics in the alternative steady state. As described in Section 4, welfare comparisons are made using expected discounted utility, measured in one-time consumption equivalent units, as our welfare criterion.

[13] Poterba and Sinai (2008) show that in the data LTV ratios are also declining in income, peaking for the agents with an annual income of $75,000 to $125,000, at 47.4%. Agents with annual income of over $250,000 have average LTV ratios of 29.4%.

Table 8
Stationary welfare effects – model with tax on imputed rents.

Income octant	Age groups									
	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65+
1st	35.01	34.14	33.19	31.26	28.76	26.07	22.17	17.72	4.52	−6.91
2nd	29.95	29.34	27.72	24.43	21.65	18.97	14.93	6.09	0.39	
3rd	26.05	25.20	22.15	17.95	15.05	12.32	7.51	2.67	−0.93	
4th	22.69	21.27	15.64	11.74	9.30	5.62	1.93	−0.79	−3.50	
5th	19.53	15.66	10.96	8.01	3.40	0.58	−1.66	−3.60	−5.48	
6th	16.33	11.05	7.68	2.54	0.46	−1.50	−3.70	−5.74	−7.19	
7th	11.83	7.19	2.60	0.06	−2.23	−4.00	−5.63	−6.98	−8.26	
8th	6.27	1.30	−1.26	−3.03	−5.13	−6.37	−7.28	−8.29	−9.01	
Average	20.96	18.14	14.83	11.62	8.91	6.46	3.53	0.13	−3.68	−6.91

Note: The table shows welfare changes in consumption equivalence units for different combinations of age and income found when comparing the steady state when imputed rents are taxed to the baseline steady state. For example, the first number in the top-left corner suggests that the average poor 20–24 year old in the baseline steady state would be prepared to reduce one-period consumption by about 35.01% of their current consumption level to switch to a steady state with a tax on imputed rents. Each cell aggregates over agents with the same immutable characteristics, but different holdings of housing and savings, and thus potentially confounds positive and negative welfare effects. The weights used to average welfare effects over different choices of housing and savings correspond to the relevant population densities.

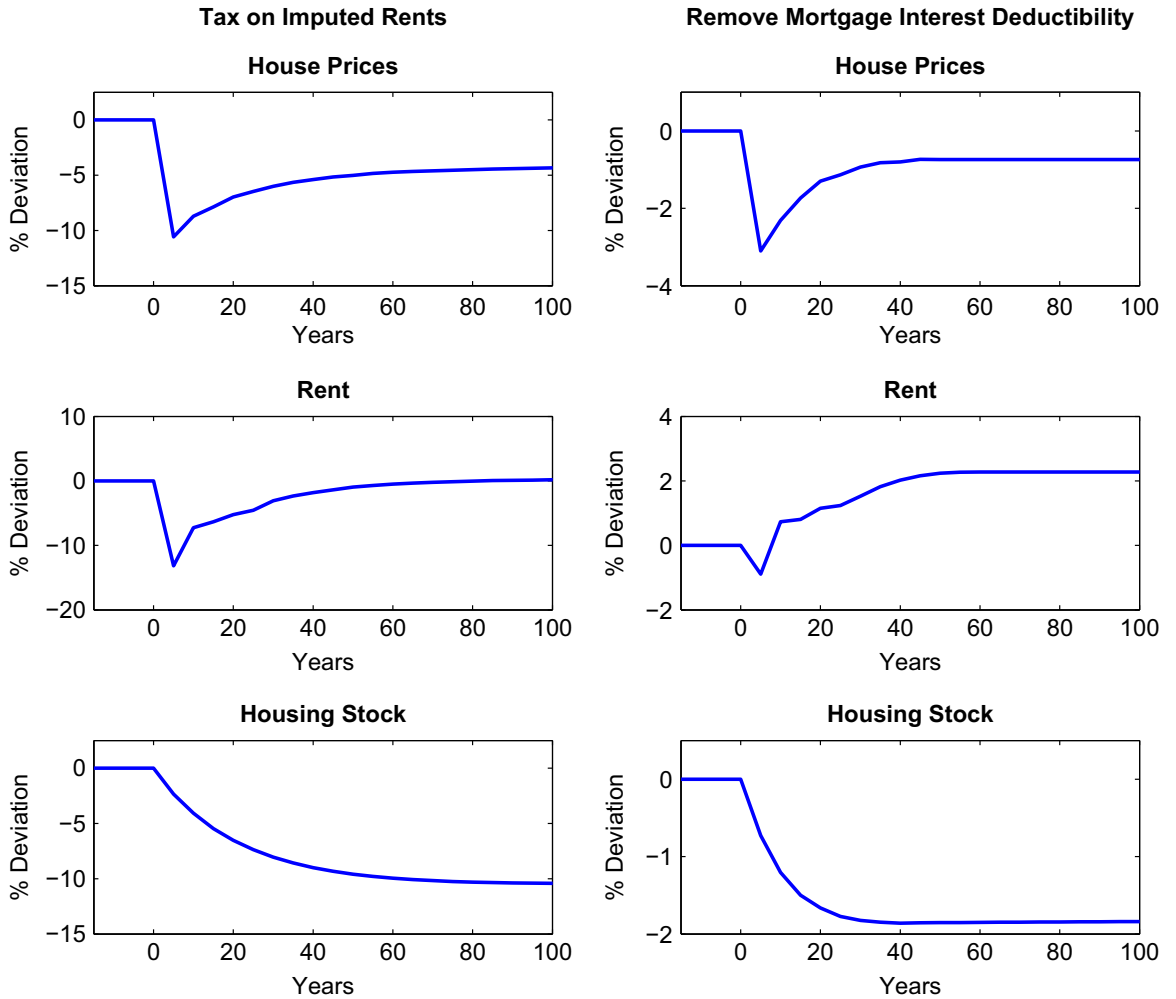

Fig. 2. Transition dynamics for permanent policy changes. *Note*: The first column shows the transition paths of house prices, rents, and the housing stock when the government begins (unexpectedly) taxing imputed rents in year zero. The second column shows the transition paths when the government removes mortgage interest deductibility in year zero. All variables are expressed as a percentage deviation from the baseline steady states.

Table 9
Immediate welfare effects – tax on imputed rents.

Income octant	Age groups									
	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65+
1st	30.37	30.03	29.15	26.33	22.47	18.65	14.29	11.33	−1.57	−8.64
2nd	26.41	26.57	24.30	19.04	15.20	12.34	8.76	1.56	−2.78	
3rd	23.32	23.29	18.65	12.46	9.25	7.07	3.90	−1.28	−4.29	
4th	20.68	19.89	12.16	7.00	4.87	2.59	−1.16	−4.14	−6.06	
5th	18.23	14.58	7.80	4.38	0.99	−2.54	−4.42	−5.71	−7.21	
6th	15.79	10.07	5.30	−0.22	−2.26	−3.58	−5.34	−7.25	−8.16	
7th	12.24	6.50	0.49	−1.13	−3.74	−5.16	−6.52	−7.82	−8.83	
8th	8.55	1.25	−1.17	−2.14	−4.48	−5.77	−6.51	−7.33	−8.35	
Average	19.45	16.52	12.08	8.22	5.29	2.95	0.38	−2.58	−5.91	−8.64

Note: The table shows welfare changes in consumption equivalence units for different combinations of age and income immediately after the tax on imputed rents is introduced. For example, the first number in the top-left corner suggests that the average poor 20–24 year old in the baseline steady state would be prepared to reduce one-period consumption by about 30.37% of their current consumption level to have a tax on imputed rents introduced. Each cell aggregates over agents with the same immutable characteristics, but different holdings of housing and savings, and thus potentially confounds positive and negative welfare effects. The weights used to average welfare effects over different choices of housing and savings correspond to the relevant population densities.

Table 7 shows that 47.6% of agents are better off in the alternative steady state than agents with the same characteristics in the baseline steady state. Compensating the agents that are worse off in an economy with taxes on imputed rents, such that they would be willing to switch position with an agent of the same characteristics in the alternative steady state, would involve a one-period cost of 2.7% of total labor income. When lump-sum taxing winners and compensating losers to make such a switch welfare-neutral, the government would have a one-time net gain of 0.8% of the total labor income earned in one period.

Table 8 shows the average consumption-equivalent welfare compensation for a switch to the steady state with taxes on imputed rents for different age groups and levels of income. In the alternative steady state, renters generally consume both more housing services and more consumption goods than before. Their income increases through higher transfers financed by taxes raised from owner-occupied housing, which more than offsets the small increase in rents. Almost all renters are better off in the alternative steady state.

Rich homeowners generally prefer the status quo. These agents desire to owner-occupy the largest amount of housing, and benefit least from the increase in transfer payments resulting from increased tax revenues. It is primarily the housing consumption of the rich agents that falls to accommodate the decline in the aggregate housing stock, which drops by 10%. Despite the rental revenue they now receive as landlords, tax payments on their remaining owner-occupied units mean that these agents are only able to marginally increase non-housing consumption.

Transition periods: The first column of Fig. 2 illustrates the paths of prices and quantities during the perfect-foresight transition to the steady state in which imputed rents are taxed. Following the reform, agents with large houses attempt to sell or rent out part of their housing stock, since the new tax reduces the incentive to owner-occupy. House prices fall by 11% in the first period after the introduction of the tax on owner-occupied housing. The housing stock declines, but does not immediately adjust to its new steady-state level. Over time, as the housing stock approaches its new steady-state level, house prices recover and reach their new equilibrium level – about 4% below the initial price level – after about 50 years. The overshooting of the house price is intuitive: After the removal of the preferential treatment of owner-occupied housing, the aggregate demand for housing falls. Since the supply of housing units is relatively inelastic in the short-run, house prices fall below their new long-run equilibrium level in the periods following the introduction of the tax on imputed rents. Over time, depreciation naturally leads to a decline of the housing stock to its new steady-state level, and prices recover. Fig. 2 also shows that rents fall initially, before increasing to their new steady-state level that is very similar to the level in the baseline steady state.

Table 7 also summarizes the welfare effects immediately following the introduction of the tax on imputed rents. Around 53.4% of agents, the vast majority of them homeowners, are worse off following the introduction of the tax. Relative to the steady-state comparison, more renters are better off, since rents fall in the short-run, and more owners are worse off, because house prices overshoot negatively. It would take a one-time expense of 3.29% of total labor income to compensate all losers for the introduction of taxes on imputed rents. This is almost 23% higher than the figure obtained by comparing steady states. In addition, if it were possible to also lump-sum tax all agents who benefit from the policy shift and compensate all agents who lose, a welfare-neutral shift would lead to a one-time net loss of 0.37% of the total labor income earned in one period.

Table 9 shows the average one-time consumption change required to compensate agents of different immutable characteristics for the introduction of the policy change. Along the transition path, richer agents generally lose as a result of the introduction of the new tax, since they suddenly find themselves holding a sub-optimally large housing stock. The amount of owner-occupied housing they planned to consume under the old policy regime now comes with an additional tax burden. Therefore, these agents will look to sell or rent out part of their housing stock. Since the aggregate housing stock does not adjust downward immediately, this generates a substantial supply overhang in the rental market. At the same time, falling rents make it more difficult for agents to reduce their tax-exposure by increasing the amount of housing leased to other agents. Consequently, the richest agents reduce both

Table 10
Stationary welfare effects – no mortgage interest deductions.

Income octant	Age groups									
	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65+
1st	12.03	11.77	11.35	10.06	8.29	6.80	5.67	5.40	2.29	0.15
2nd	10.45	10.25	9.11	6.70	5.26	4.55	4.02	2.85	1.96	
3rd	9.18	8.80	6.51	3.86	3.33	3.44	3.60	3.01	2.15	
4th	8.05	7.30	3.35	1.63	2.20	3.65	3.63	3.30	2.04	
5th	7.00	4.55	1.45	1.28	3.22	4.00	3.83	3.40	1.97	
6th	6.01	2.55	2.39	3.29	4.35	4.59	4.08	3.08	1.89	
7th	4.41	1.83	3.74	4.96	4.95	4.49	3.63	2.60	1.61	
8th	3.63	5.29	5.57	5.58	4.84	4.06	3.22	2.40	1.48	
Average	7.59	6.54	5.43	4.67	4.55	4.45	3.96	3.26	1.92	0.15

Note: The table shows welfare changes in consumption equivalence units for different combinations of age and income found when comparing the steady state where mortgage interest deductability is not allowed to the baseline steady state. For example, the first number in the top-left corner suggests that the average poor 20–24 year old in the baseline steady state would be prepared to reduce one-period consumption by about 12.03% of their current consumption level to switch to a steady state without mortgage interest deductions. Each cell aggregates over agents with the same immutable characteristics, but different holdings of housing and savings, and thus potentially confounds positive and negative welfare effects. The weights used to average welfare effects over different choices of housing and savings correspond to the relevant population densities.

housing and non-housing consumption in the period following the introduction of the tax on imputed rents. This welfare loss is somewhat offset for rich homeowners as the initial fall in rents reduces the value of imputed rents, and hence their tax bill.[14] The initial decline in rents also explains why tax revenues and transfers only adjust slowly to their new steady-state value.

Renters from the initial steady state continue to gain from the reform. The (negative) rent overshoot allows those agents to significantly increase their housing consumption, mainly as renters of larger homes. They also benefit from the increase in lump-sum transfer payments following the introduction of the tax on owner-occupied housing, even though the lower value of imputed rents reduces those payments relative to the steady-state comparison.

Our results suggest that, on aggregate, taxing imputed rents is welfare-improving in the long run for the economy. However, the immediate aggregate effects of the policy change are, on net, negative for the current cohort of agents in the economy. In addition, the distribution of agents that win and lose immediately following the policy change is different from the distribution of winners and losers in the steady-state comparison. Therefore, the decision to introduce a tax on imputed rents involves a tradeoff between the welfare implications imposed on agents today versus agents in the future, and also between different groups of agents alive today.

7.2. *No mortgage interest deductions*

The second policy experiment removes the asymmetry in the tax treatment of owner-occupied and rental housing. In this experiment, property owners are no longer allowed to deduct mortgage interest payments from their tax bill.

Prices and quantities: Table 6 shows that in the new steady state, house prices are marginally lower than in the baseline steady state, and rents are around 2% higher. The removal of mortgage interest deductions makes homeownership less attractive, especially for the young and credit-constrained agents that require a large mortgage. The size of the rental market increases by 76% as owner-occupiers become renters. The share of landlords increases slightly as richer agents, who are less reliant on mortgage financing, increase their supply of rental housing to meet the growing demand in the economy. As a result, the average LTV ratio in the economy declines from 29.5% to 15.3%. Total transfers increase by 3.3% due to the government's revenue gain from removing the mortgage interest deductions.

Welfare comparisons: Table 7 shows that 17.8% of agents lose in the new steady state. The one-time consumption increase required to compensate them for their welfare loss is relatively low, about 0.10% of total labor income. Table 10 shows that the welfare effects are relatively small across the distribution of agents. Those agents that have recently bought and mortgage-financed a house (those with a medium income and also the high-income young) benefit a lot less than those agents who rent.[15]

[14] Another important welfare effect for homeowners comes through the decline in prices. (8) ensures that an agent's equity in her home is bounded from below by the downpayment requirement. When prices fall, agents who hold high LTV mortgages will face a margin call, which requires them to inject new equity into the home. The model does not allow for mortgage default. In reality, no mortgages explicitly include such a margin call, and following the 2007 crisis in the U.S. housing market, many homeowners were under water. In recourse states, where homeowners cannot just walk away from their mortgage, being under water has large negative welfare effects, similar to those generated in our model. In non-recourse states, the direct effects on agents through the "margin-call channel" may not be as sizable as the model suggests.

[15] In Table 10, these agents fail to consistently show up with a negative sign since the overall welfare effects on their age/productivity cell are dominated by the welfare increases of renters with the same immutable characteristics. In the model, agents with the same income and age characteristics make different choices due the fact that they have different income histories, and thus a different portfolio of savings and housing.

Table 11
Immediate welfare effects – no mortgage interest deductions.

Income octant	Age groups									
	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65+
1st	7.78	7.65	7.28	5.93	4.01	2.35	1.19	1.03	−0.41	−0.14
2nd	6.75	6.67	5.46	2.85	1.29	0.67	0.49	0.17	0.70	
3rd	5.89	5.64	3.13	0.25	−0.23	0.18	0.95	0.66	0.88	
4th	5.13	4.48	0.23	−1.61	−0.86	0.67	1.13	1.34	0.90	
5th	4.42	2.07	−1.42	−1.55	0.31	1.51	1.75	1.99	1.33	
6th	3.81	0.31	−0.94	0.65	2.00	2.68	2.50	1.78	1.18	
7th	2.69	−0.13	1.59	2.96	3.14	3.09	2.49	1.68	1.08	
8th	2.99	3.88	4.56	5.24	4.50	3.91	3.26	2.58	1.66	
Average	4.93	3.82	2.49	1.84	1.77	1.88	1.72	1.40	0.92	−0.14

Note: The table shows welfare changes in consumption equivalence units for different combinations of age and income immediately after the removal of mortgage interest deductability. For example, the first number in the top-left corner suggests that the average poor 20–24 year old in the baseline steady state would be prepared to reduce one-period consumption by about 7.78% of their current consumption level to have mortgage interest deductions eliminated. Each cell aggregates over agents with the same immutable characteristics, but different holdings of housing and savings, and thus potentially confounds positive and negative welfare effects. The weights used to average welfare effects over different choices of housing and savings correspond to the relevant population densities.

Older and richer agents are less reliant on mortgage financing, and thus suffer less than middle-income agents from the removal of mortgage interest deductibility. At the same time, they have the resources to own rental property, and thus benefit from the increased demand for rentals. The higher government transfers benefit poorer agents relatively more than richer agents.

Transition periods: Fig. 2 shows transition paths for house prices, rents, and the housing stock after the removal of mortgage interest deductions. House prices initially drop by about 3% before recovering to their new steady-state level, nearly 1% below the baseline steady state, after about 30 years. As in the previous experiment, this (negative) overshooting of house prices is explained by the fact that the housing stock does not adjust to its new steady-state level immediately. Rents also initially decline before recovering to their new steady-state level.

Table 7 shows that about 33.6% of agents would be worse off in the period directly following the removal of deductions for mortgage interest payments. This is greater than the share of agents who lose in the final steady state (17.8%). The compensation needed to make no agent worse off is significantly higher than in the final steady state (0.36% of total labor income compared to 0.10%). Making the policy change welfare-neutral for all agents by taxing winners and subsidizing losers amounts to a net gain of 1.21% of total labor income following the policy change, significantly less than in the final steady state.

Table 11 shows that younger, poorer agents who rent receive the largest immediate benefit from the policy change. As was the case with the steady-state comparison, the agents that lose from the removal of deductions for mortgage interest payments are middle-income homeowners who recently purchased a home with a large mortgage. These agents now lose the ability to deduct their mortgage interest payments from their taxes, while facing significant margin calls. Richer and older agents fare better, since they have the financial resources available to purchase housing to lease to other agents. This is an attractive proposition for the agents as housing assets are known to appreciate along the perfect foresight transition path.

Relative to taxing imputed rents, removing mortgage interest deductions leaves fewer agents worse off, and requires less compensation for those agents that do lose after the policy change, both in the final steady state and along the transition path. However, the two policies have very different distributions of burden. The welfare cost of removing mortgage interest deductions is concentrated among middle-income agents (who rely on mortgages more than other agents), while the welfare cost of taxing imputed rents falls mainly on rich agents.

8. Conclusion

Many U.S. policies are aimed at raising the homeownership rate. This paper develops a heterogeneous-agent, overlapping-generations general equilibrium framework to analyze the effects of some of these government interventions in the housing market on prices, quantities, allocations, and welfare.

The first interventions considered are a First-Time Homebuyer Tax Credit and a Repeat Homebuyer Tax Credit in response to a temporary shock to the downpayment requirement which generates a boom-bust cycle in house prices. The results show that these tax credits are successful at temporarily raising house prices and transaction volumes. However, in the periods following the expiration of the tax credit, house prices remain below the counterfactual price level without the tax credit. The welfare effects of homebuyer tax credits are negative for most agents. When comparing the two tax credits, the results reveal that the Repeat Homebuyer Tax Credit is marginally preferable from an aggregate welfare perspective.

In addition to analyzing the homebuyer tax credits, two permanent changes to the tax framework are also considered. The first is the introduction of taxes on imputed rents, and the second is the removal of mortgage interest deductibility. These permanent changes to the tax framework would remove the asymmetric tax treatment of owner-occupied and rental

housing. The findings suggest that both policies lead to aggregate welfare gains in the long run. In terms of the share of agents that benefit from the policy change in the long run, just under half would benefit from taxing imputed rents, and around 82% would benefit from the removal of mortgage interest deductions.

However, in the short run, taxing imputed rents leads to an aggregate welfare loss, and the immediate welfare gain from removing mortgage interest deductions is significantly smaller than the long-run gains. From an aggregate welfare perspective, the removal of mortgage interest deductions appears superior. However, the distribution of gains and losses for the two policy changes is different in important ways. While the introduction of a tax on imputed rents harms primarily the richest agents, the removal of mortgage interest deductions harms middle-income agents. Therefore, the preferred tool for removing the asymmetry in the tax treatment depends on a trade-off between aggregate and distributional objectives, as well as on the feasibility of implementing a lump-sum compensation scheme.

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Appendix. Supplementary data

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.jmoneco.2016.04.005.

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