Housing and Tax Policy*

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Abstract

In this paper, we investigate the effects of housing-related tax policy measures on macroeconomic aggregates using a dynamic general-equilibrium model. The model features borrowing and lending across heterogeneous households, financial frictions in the form of collateral constraints tied to house prices, and a rental housing market alongside owner-occupied housing. Using our model, we analyze the effects of changes in housing-related tax policy measures on the level of output, tax revenue and household debt, along with other macroeconomic aggregates. The tax policy changes we consider are (i) mortgage interest deduction, (ii) taxation of imputed rental income from owner-occupied housing, (iii) property taxation, and (iv) depreciation allowance for rental income. We find that, once normalized to generate the same tax revenue, all four policies lead to significant output losses, with large long-run tax multipliers of around 2. Among them, reducing the mortgage interest deduction is the most effective in raising tax revenue per unit of output lost, while reducing the depreciation allowance for rental income is the least effective. Our experiments also highlight the differential welfare impact of each tax policy on savers, borrowers and renters in the economy.

Keywords: Housing, tax policy, dynamic general equilibrium.

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1 Introduction

Housing is the single most important asset for the vast majority of U.S. households, and housing services constitute a large fraction of their consumption expenditures. In particular, the value of housing relative to GDP is in the order of 1.3, while shelter services from housing represent approximately 15 percent of personal consumption expenditures, and an even larger fraction of the consumption basket that comprises the consumer price index. The importance of housing is partly due to the favorable treatment it receives in the tax code. In particular, interest payments on home mortgages and property taxes can be deducted when paying personal income tax, and capital gains on primary residences are largely tax-exempt. For rental housing, depreciation allowances are often deductible at faster rates than the physical depreciation incurred by residential property. Arguably though, the most important tax incentive for housing relates to the tax treatment of imputed rental income from owner-occupied housing; even though this imputed income is included in the National Income and Product Accounts (NIPA), it is fully tax-exempt.[1]

The tax savings provided by these policies to households are rather large. In particular, JCT (2013) reports that, in 2012, the government has forgone about 68 billion dollars of revenue due to the mortgage interest deduction and about 24 billion dollars of revenue from the property tax deduction, a total close to 9 percent of the budget deficit. It is thus not surprising that the repeal of these deductions was under serious consideration during the recent austerity debates, and entertained by both major political parties in the United States during the 2012 presidential election. Taxing imputed rental income from owner-occupied housing has not been discussed as prominently, although there are several OECD countries where imputed rents are taxed in some form, despite challenges in accurate measurement.[2] Given the importance of housing in the economy, changes in these housing-related fiscal policy measures could potentially have a large impact on macroeconomic variables, along with their impact on house prices and household debt.

In this paper, we investigate the effects of housing-related fiscal policy measures on the economy using a dynamic general-equilibrium model. The model features borrowing and lending across heterogeneous households, and financial frictions in the form of collateral constraints tied to house prices, similar to Kiyotaki and Moore (1997) and Iacoviello (2005). We exclude nominal rigidities from the latter benchmark model and extend it in several directions. First, we introduce a third type of households called renters who are *hand-to-mouth* consumers, and include a rental housing market alongside owner-occupied housing. Second, we include a rich set of housing-related fiscal tools in the model (i.e., property taxes, mortgage interest deduction, depreciation allowance for rental income, etc.). Finally, we allow housing supply to vary endogenously over time. We calibrate

[1]Both owner-occupied and rental housing enjoy several other incentives in the tax code. For a detailed summary and analysis of these incentives, as well as their possible economic rationales, see the recent report by the Joint Committee on Taxation (JCT) titled "Present Law, Data, and Analysis Relating to Tax Incentives for Residential Real Estate" (2013).

[2]Among OECD countries, Belgium, Greece, Iceland, Luxembourg, the Netherlands, Poland, Slovenia, Switzerland and Turkey tax imputed rental income in some form, although there are cases of underestimation and therefore partial taxation (JCT, 2013).

the parameters of the model so that the initial steady state matches features of post-war U.S. data, including those related to the housing sector (e.g., housing share of borrowers and renters, loan-to-value ratio of outstanding mortgages, equity share of households in total housing). We then use our model to explore the impact of permanent changes in various housing-related fiscal instruments on macroeconomic variables. In particular, we consider the effects of (i) reducing the mortgage interest deduction, (ii) instituting partial taxation of imputed rental income from owner-occupied housing, (iii) increasing property tax rates, and (iv) reducing the depreciation allowance for rental income.[3]

In our experiments, we normalize the size of each policy change to generate the same amount of total tax revenue in present value terms. We find that all four policies lead to significant output losses, with large long-run tax multipliers of around 2.[4] Upon comparing the various policies, we find that reducing mortgage interest deduction is the most efficient policy in terms of raising tax revenue since it results in the smallest output loss in present discounted value. Taxing imputed rents comes second, followed by increasing property taxes, which is a close third. Meanwhile, reducing depreciation allowances for rental housing performs the worst, leading to the largest present value output loss for the same amount of tax revenue generated.

The key behind these results is the type of households being affected directly by each policy. In particular, mortgage interest deductions directly affect only the cost of housing for borrowers, taxing imputed rents targets owner-occupied housing of both borrowers and savers, and property taxes affect all types of housing (owner-occupied and rental). Policies that adversely affect renter households have a relatively large impact on output, since these agents are *hand-to-mouth* consumers, and thus, cannot smooth out the impact of the policy shocks through saving and borrowing. On the other hand, tax reforms that benefit renters also generate lower output losses for the same tax revenue. Reducing mortgage interest deductions and taxing imputed rents end up benefiting renters by inducing substitution from other types of housing, and increasing the relative supply of rental housing. In contrast, reduction in depreciation allowance from rental income leads to a significant reduction in the supply of rental housing and an increase in rental rates, thereby hurting renter households and lowering aggregate output further.

The impact of each policy on the borrowers' incentives to accumulate housing is also important for the results. Tax reforms that impact borrowers adversely are nevertheless more efficient in revenue generation since the decline in these households' housing and borrowing – say, due to an increase in property taxes – also limits their ability to deduct interest on mortgage payments, generating an additional positive effect on tax collection. When we normalize the four policies to generate equal tax revenue, the output impact of policies that reduce impatient households' housing is thus relatively smaller per unit of tax collected. On the other hand, reducing the depreciation allowance

[3]Unlike the other tax provisions we consider, property taxes are collected at the local government level, and thus may be harder to implement in practice on an aggregate level. Note however that, in our set-up, changing property taxes would have equivalent effects with modifying the property tax deduction, which is a policy instituted at the federal level. See the working paper version of the paper for more on this (Alpanda and Zubairy, 2013).

[4]The long-run tax multiplier is computed by $\Delta Y_t/\Delta Tax_t$, where ΔY_t is the present value loss in output under each policy, and ΔTax_t is normalized to be equivalent to 0.125 times initial GDP in present value terms in all our experiments.

on rental housing benefits borrowers through lower house prices and increased credit supply, which leads them to increase their housing levels through borrowing, and therefore allowing them to take more mortgage interest deductions on their taxable income as a result.

Consequently, our experiments also highlight the differential impact of each fiscal policy on the three different types of households in the model economy (savers, borrowers and renters). In particular, reducing the mortgage interest deduction makes borrowers worse off, since they are directly impacted by this policy change. Savers and renters, however, are better off overall, because the reduction in housing demand from borrowers leads to a decline in house prices and rents. Similarly, the reduction of depreciation allowance for rental income has a direct effect on the cost of accumulating rental housing. Thus, it leads to an increase in rents due to lower rental housing supply, leaving renters worse off. Borrowers, however, are better off, due to the decline in house prices and the increase in the supply of credit from savers. In contrast, reduction in property taxes leaves both savers and borrowers worse off, since this change directly affects the effective cost of all types of housing.[5] These disproportionate effects on various segments of the population also highlight a tradeoff between policies that are effective in revenue generation with lower output impact and policies that are more likely to be politically feasible. For instance, the reduction in the mortgage interest deduction is the most effective policy on the aggregate, but it is also the one that causes the largest redistribution of wealth among agents, and as a consequence, could be one of the hardest to implement in practice.

There are several empirical papers on housing-related fiscal policy that are related to our work. Poterba (1992) considers the effects of the tax reforms instituted in the 1980s, including changes in the subsidies for investing in rental properties due to favorable depreciation-allowance rules. He suggests that the reduction in the marginal tax rates for households, and the reversal of incentives for rental housing investment due to the extension of depreciation lifetime, led to a decline in investment in rental properties and would lead to a longer-run increase in rents. Poterba and Sinai (2008) consider mortgage interest deduction, property tax deduction, capital gains exemptions on owner-occupied housing and the absence of taxation of imputed rent from owner-occupied homes. They use household-level data from the Survey of Consumer Finances to analyze how reforms to these tax treatments would influence the effective cost of housing services as well as the distribution of tax burdens. Their findings suggest that, since mortgage debt is concentrated among younger homeowners, the removal of mortgage interest deduction would lead many homeowners to face only a modest increase in taxes. On the other hand, eliminating property tax deductions and taxing imputed rents would affect all homeowners and thus have similar distributional effects, affecting a larger fraction of the population. These findings are also supported by the results of our paper, where

[5]Note that we do not allow changes in the housing-tenure status of households in the model. Thus, we are capturing the changes in homeownership on the intensive margin, but not on the extensive margin. Therefore, we may be overestimating the effects of some of these policies on each type of household; the welfare losses may be smaller in reality, since some policies may induce households to switch type (e.g., some borrowers may choose to rent as a result of eliminating the mortgage interest deduction). We discuss the importance of our assumption regarding the extensive margin in more detail in Section 4.3.

the reduction in mortgage interest deductibility leaves only the borrowers worse off, whereas reducing property taxes and taxing imputed rents have significant and negative effects on all homeowners (i.e., savers and borrowers).[6]

In the context of the related theoretical literature, most papers have considered the favorable tax treatment of home ownership in the context of life-cycle models. Gervais (2002) considers a general-equilibrium life-cycle economy with heterogeneous individuals, where agents can either own or rent a house. He finds that individuals at all income levels would rather live in a world where imputed rents are taxed, or one where mortgage interest payments are not deductible, and both policies have very small distributional effects in the long run.[7] Chambers et al. (2009) analyze the interactions between the asymmetric tax treatment of owner-occupied and rental housing and the progressivity of income taxation in an overlapping-generations general-equilibrium framework, where rents and interest rates are determined endogenously. Their main finding is that the effects of income tax reforms are amplified in the presence of housing.[8] Sommer and Sullivan (2014) consider a heterogenous agent model with endogenous house prices and rents, and show that a reduction in property taxes and mortgage interest tax deductions would lead to a large decline in house prices, lower rents, and in contrast to previous work, higher home ownership. Our model differs from all of the above in that it utilizes a dynamic general-equilibrium model along the lines of Iacoviello (2005), includes all the major housing-related tax policy details in a single framework, and focuses on the transitional effects of these policies as well as steady-state effects.[9] Our work can also be viewed as complimentary to the aforementioned papers, given our focus on the macroeconomic effects of housing tax reforms (including tax revenue and GDP) rather than housing tenure.

The next section introduces the model. Section 3 describes the calibration of the model. Section 4 presents the results of the various fiscal experiments we conduct, and section 5 concludes.

2 Model

The model is a closed-economy real model with owner-occupied and rental housing. There are three types of infinitely-lived households in the economy: patient households (savers), impatient households (borrowers) and renters. The patient and impatient households own the housing units

[6]The empirical literature on housing-related fiscal policy has also explored how the favorable tax treatment of housing distorts investment decisions toward housing and away from capital (see Rosen, 1979). Also see Nakajima (2010) for optimal capital taxation in an overlapping-generations model with housing.

[7]In that model, individuals strive to accumulate the down payment as quickly as possible to become homeowners. The welfare results are driven by the fact that the elimination of mortgage interest deductibility or taxing imputed rents makes home ownership less attractive, and allows individuals to better smooth consumption.

[8]In more recent work, Chambers et al. (2013) aim to historically quantify the role of different government policies on home-ownership rates in the U.S., and with the help of a theoretical model, conclude that housing policies such as the introduction of mortgage interest deductions could play an important role.

[9]After circulating a first draft of our paper, we became aware of Ortega et al. (2011), who also introduce rental housing into a Iacoviello (2005) type model. However, the focus of that paper is quite different; they investigate the effects of eliminating the subsidy on home ownership in Spain. There are also important differences in terms of modelling choices in the two papers; in particular, they do not include a third household type, but let borrower households also demand rental properties.

they occupy, as in Iacoviello (2005), while patient households also own the rental properties.[10] Borrowing of impatient households is constrained by the collateral value of their housing, as in Kiyotaki and Moore (1997) and Iacoviello (2005). On the production side, non-housing goods producers rent capital and labor services to produce an output good that can be used for non-housing consumption, non-residential and residential investment, and government purchases. The model also features capital and housing producers for convenience, and a full set of fiscal policy tools, including those that relate to the housing market.[11]

2.1 Households

2.1.1 Patient households

The economy is populated by a unit measure of infinitely-lived patient households indexed by i, whose intertemporal preferences over consumption, $c_{P,t}$, housing, $h_{P,t}$, and labor supply, $l_{P,t}$, are described by the following expected utility function:[12]

$$E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \left\{ \log c_{P,\tau} + \xi_h \log h_{P,\tau-1} - \xi_l \frac{l_{P,\tau}^{1+\vartheta}}{1+\vartheta} \right\}, \tag{1}$$

where t indexes time, $\beta_P < 1$ is the time-discount parameter, ξ_h and ξ_l determine the relative importance of housing and labor in the utility function, and ϑ is the inverse of the Frisch-elasticity of labor supply.

The patient households' period budget constraint is given by

$$\begin{aligned}
&(1+\tau_c)\, c_{P,t} + q_{h,t}\left[h_{P,t} - (1-\delta_h)\, h_{P,t-1}\right] + q_{h,t}\left[h_{R,t} - (1-\delta_h)\, h_{R,t-1}\right] + q_{k,t}\left[k_t - (1-\delta_k)\, k_{t-1}\right] + b_t + b_t^g \\
&\quad \leq w_{P,t} l_{P,t} + r_{h,t} h_{R,t-1} + r_{k,t} k_{t-1} + (1+r_{t-1})\left(b_{t-1} + b_{t-1}^g\right) + tr_{P,t} \\
&\qquad - \tau_y \left[w_{P,t} l_{P,t} + \left(r_{h,t} - \widetilde{\delta}_{h,t}\right)\left(h_{R,t-1} + I_{r,t} h_{P,t-1}\right) - \tau_{p,t} q_{h,t}\left(h_{P,t-1} + h_{R,t-1}\right)\right] \\
&\qquad - \tau_k \left(r_{k,t} - \delta_k\right) k_{t-1} - \tau_b r_{t-1}\left(b_{t-1} + b_{t-1}^g\right) - \tau_{p,t} q_{h,t}\left(h_{P,t-1} + h_{R,t-1}\right) - \text{adj. costs},
\end{aligned} \tag{2}$$

where patient households accumulate owner-occupied and rental housing, $h_{P,t}$ and $h_{R,t}$, respectively, as well as capital, $k_{P,t}$. $q_{h,t}$ and $q_{k,t}$ are the relative prices of housing and capital, $r_{h,t}$ and $r_{k,t}$ are the rental income they receive from these assets, and δ_h and δ_k are their corresponding depreciation

[10]Based on the American Housing Survey, about 17% of mortgages are backed by rental housing. We abstract from debt-financed rental housing in our model. Note also that, based on the Property Owners and Managers Survey, households own over 90 percent of rental units, while the remaining are owned by corporations (Chambers et al., 2009). As such, in our set-up the patient households are also playing the role of corporate owners. We are thus abstracting from potential differences in the tax treatment of rental properties owned by corporations versus households.

[11]In the model, we abstract from capital gains taxes on housing. Most households are exempt from this tax given the $250,000 exclusion for singles or married separate tax-filers, and $500,000 exclusion for married joint tax-filers.

[12]Following Iacoviello (2005), we normalize the size of each type of household (patient, impatient and renter) to a unit measure, and determine the economic importance of each type by their respective shares in labor and capital income.

rates. Patient households also lend to impatient households and the government, b_t and b_t^g, for which they receive a predetermined real interest rate of r_t. $\tau_{p,t}$ is the property tax rate on housing, τ_c is the consumption tax rate and τ_b is the tax on interest income.[13] Similarly, labor and rental housing income are taxed at a rate of τ_y, and rental capital income is taxed at a rate of τ_k. Patient households also receive transfers from the government, $tr_{P,t}$, in a lump-sum fashion, and face quadratic costs of adjustment for their owner-occupied and rental housing stocks with a level parameter denoted by κ_h.[14] These adjustment costs ensure that housing cannot be sold quickly across patient and impatient households, and also limits the amount of substitution between owner-occupied and rental housing.

Note that we allow income tax rates to differ across the three types of agents. Note also that property taxes and depreciation allowances for housing and capital, $\widetilde{\delta}_{h,t}$ and δ_k, are deductible from income taxes, and the depreciation allowance for housing may be different from the physical depreciation rate, δ_h. $I_{r,t}$ is a variable that takes values between of 0 and 1, depending on whether imputed rents from owner-occupied housing are subject to income taxation; in our baseline case, we set $I_{r,t} = 0$, indicating tax-exempt status for imputed rents. In addition, property taxes are fully deductible from income taxation.

The patient households' objective is to maximize utility subject to their budget constraint and the appropriate No-Ponzi conditions. The first-order condition with respect to consumption equates the marginal utility gain from consumption to the marginal cost of spending a dollar out of the budget; i.e., the Lagrange multiplier $\lambda_{P,t}$.[15] Similarly, the optimality condition for labor equates the marginal rate of substitution between labor and consumption to the after-tax wage rate. The optimality condition for owner-occupied housing equates the marginal cost of acquiring a unit of housing to the marginal utility gain from housing services and the discounted value of expected capital gains net of taxes, which can be written as (ignoring adjustment costs):

$$q_{h,t} = \beta_P E_t \left\{ \frac{\xi_h}{\lambda_{P,t} h_{P,t}} + \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \left[\left[1 - \delta_h - \tau_{p,t+1}(1-\tau_y)\right] q_{h,t+1} - I_{r,t+1} \tau_y \left(r_{h,t+1} - \widetilde{\delta}_{h,t+1} \right) \right] \right\}. \quad (3)$$

Similarly, the optimality conditions for rental housing and capital equate their respective marginal cost to the expected marginal gain in net-of-tax rental income and capital gains, which can be written as (ignoring adjustment costs):

$$q_{h,t} = \beta_P E_t \left\{ \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \left[\left[1 - \delta_h - \tau_{p,t+1}(1-\tau_y)\right] q_{h,t+1} + (1-\tau_y) r_{h,t+1} + \tau_y \widetilde{\delta}_{h,t+1} \right] \right\}, \quad (4)$$

$$q_{k,t} = \beta_P E_t \left\{ \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \left[(1-\delta_k) q_{k,t+1} + (1-\tau_k) r_{k,t+1} + \tau_k \delta_k \right] \right\}. \quad (5)$$

[13] We abstract from fixed factor land and property taxes on capital holdings (including non-residential structures). See Alpanda (2012) for a general-equilibrium treatment of these issues in the context of Japan.

[14] These costs are specified as $\frac{\kappa_h}{2}\left[\frac{h_{P,t}(i)}{h_{P,t-1}(i)} - 1\right]^2 q_{h,t} h_{P,t}$ and $\frac{\kappa_h}{2}\left[\frac{h_{R,t}(i)}{h_{R,t-1}(i)} - 1\right]^2 q_{h,t} h_{R,t}$, respectively.

[15] See the online appendix of the paper, where we list the full set of equations that characterize the equilibrium in our model.

Finally, the first-order condition for debt equates the marginal utility cost of forgone consumption from saving to the expected discounted utility gain from the resulting interest income net of taxes:

$$1 = \beta_P E_t \left\{ \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \left[1 + (1 - \tau_b) r_t\right] \right\}. \tag{6}$$

2.1.2 Impatient households

The economy is also populated by a unit measure of infinitely-lived impatient households. Their utility function is identical to that of patient households, except that their time-discount factor is assumed to be less than that of patient households, to facilitate borrowing and lending across these agents; hence, $\beta_I < \beta_P$. The impatient households' period budget constraint is given by

$$\begin{aligned} &(1 + \tau_c) c_{I,t} + q_{h,t} \left[h_{I,t} - (1 - \delta_h) h_{I,t-1}\right] + (1 + r_{t-1}) b_{t-1} \\ &\quad \leq w_{I,t} l_{I,t} + b_t - \tau_y \left[w_{I,t} l_{I,t} - \tau_{p,t} q_{h,t} h_{I,t-1} - I_{m,t} r_{t-1} b_{t-1} + I_{r,t} \left(r_{h,t} - \widetilde{\delta}_{h,t}\right) h_{I,t-1}\right] \\ &\qquad - \tau_{p,t} q_{h,t} h_{I,t-1} + tr_{I,t} - \text{adj. costs}, \end{aligned} \tag{7}$$

where $tr_{I,t}$ denotes lump-sum transfers received by impatient households from the government. $I_{m,t}$ is a variable determining whether interest payments on borrowing are deductible when paying income taxes, and takes values between 0 and 1; in our baseline calibration, we set $I_{m,t}$ to 1 indicating full deductibility of mortgage interest. Impatient households also face quadratic adjustment costs in their housing stock, similar to patient households.

Impatient households face a borrowing constraint in the form of

$$b_t \leq \rho_b b_{t-1} + (1 - \rho_b) \phi q_{h,t} h_{I,t}, \tag{8}$$

where ϕ is the fraction of assets that can be collateralized for borrowing, and ρ_b determines the persistence in the borrowing constraint, as in Iacoviello (2015).[16]

The first-order conditions of the impatient households with respect to consumption and labor are similar to those of patient households. For housing, the optimality condition equates the marginal cost of acquiring a unit of housing with the marginal utility and expected net-of-tax capital gains, but the marginal cost is dampened by the shadow gain from the relaxation of the borrowing constraint

[16] See also Justiniano et al. (2013) for a similar borrowing constraint specification, where the persistence term takes effect only with a decline in house prices. Note also that Gervais and Pandey (2008) argue that the elimination of the mortgage interest deduction would lead to a reshuffling of household balance sheets, and a lowering of LTV. In our model, the loan-to-value (LTV) ratio, stays constant with changes in fiscal policy in the long run, but not in the short run due to the persistence term. This margin can alternatively be captured by replacing the borrowing constraint with an endogenous spread as in Aoki et al. (2004), or modeling a fixed rate mortgage contract as in Kydland et al. (2012). Note however that this margin may not be that important; for example, Kiyotaki et al. (2011) find that changes in LTV ratio have limited effects on house prices.

with the increase in the level of housing, which can be written as (ignoring adjustment costs)

$$\begin{aligned}&[1-\mu_t(1-\rho_b)\phi]\,q_{h,t}\\&\quad=\beta_I E_t\left\{\frac{\xi_h}{\lambda_{I,t}h_{I,t}}+\frac{\lambda_{I,t+1}}{\lambda_{I,t}}\left[[1-\delta_h-\tau_{p,t+1}(1-\tau_y)]\,q_{h,t+1}-I_{r,t+1}\tau_y\left(r_{h,t+1}-\widetilde{\delta}_{h,t+1}\right)\right]\right\},\end{aligned}\tag{9}$$

where μ_t is the Lagrange multiplier on the borrowing constraint. Similarly, the optimality condition for borrowing is given by

$$1-\mu_t=\beta_I E_t\left\{\frac{\lambda_{I,t+1}}{\lambda_{I,t}}\left[1+(1-I_{m,t+1}\tau_y)\,r_t-\mu_{t+1}\rho_b\right]\right\},\tag{10}$$

which equates the marginal gain from borrowing (excluding the shadow cost of tightening the borrowing constraint) with the expected discounted interest cost net of tax benefits from mortgage interest deduction.

2.1.3 Renter households

The economy is also populated by a unit measure of infinitely-lived renter households, whose utility function is identical to that of impatient households.[17] The renter households' period budget constraint is given by

$$(1+\tau_c)\,c_{R,t}+r_{h,t}h_{R,t-1}\leq(1-\tau_R)\,w_{R,t}l_{R,t}+tr_{R,t},\tag{11}$$

where τ_R is the income tax rate for renter households and $tr_{R,t}$ denotes lump-sum transfers received from the government.

The first-order conditions of the renter households with respect to consumption and labor are also similar to those of patient households. For housing, the optimality condition equates the marginal cost (i.e., relative price of rental housing) with the marginal utility gain:

$$r_{h,t}=\frac{\xi_h}{\lambda_{R,t}h_{R,t-1}}.\tag{12}$$

2.2 Production of non-housing goods and services

There is a representative non-housing goods producer whose technology is described by the following production function:

$$y_{n,t}=z_t\,(u_t k_{t-1})^{\alpha}\left(l_{P,t}^{\psi_P}l_{I,t}^{\psi_I}l_{R,t}^{\psi_R}\right)^{1-\alpha},\tag{13}$$

where $y_{n,t}$ denotes non-housing output, α is the share of capital in overall production, and ψ_P, ψ_I and ψ_R denote the labor shares of each type of household in production with $\psi_P+\psi_I+\psi_R=1$.

[17]Note, however, that renter households' problem is not intertemporal; they will play the role of *hand-to-mouth* consumers in our model, who consume their disposable income every period.

u_t denotes the utilization rate of capital, and z_t is the aggregate level of productivity, which is exogenously determined.

The representative firm's profit at period t is given by

$$\Pi_{n,t} = y_{n,t} - w_{P,t}l_{P,t} - w_{I,t}l_{I,t} - w_{R,t}l_{R,t} - r_{k,t}k_{t-1} - \frac{\kappa_u}{1+\varpi}\left(u_t^{1+\varpi} - 1\right)k_{t-1}, \tag{14}$$

where κ_u and ϖ are the level and elasticity parameters in the utilization cost specification. The firm's objective is to choose the quantity of inputs, capital utilization rate, and output each period to maximize profits. At the optimum, the marginal product of each input is equated to its respective marginal cost. For capital, the marginal costs include the rental rate paid to patient households, as well as utilization costs:

$$\alpha\frac{y_{n,t}}{k_{t-1}} = r_{k,t} + \frac{\kappa_u}{1+\varpi}\left(u_t^{1+\varpi} - 1\right). \tag{15}$$

Finally, the optimality condition for capital utilization equates the marginal cost of increasing utilization at the margin with the revenue gain that arises from increased production:

$$\alpha\frac{y_{n,t}}{u_t} = \kappa_u u_t^{\varpi} k_{t-1}. \tag{16}$$

2.3 Capital and housing producers

To make the model tractable, and to ensure a single price for housing across agents, we assume that the accumulation of capital and housing are undertaken by perfectly competitive capital and housing producers, similar to Bernanke et al. (1999) and Basant Roi and Mendes (2007). Capital producers purchase the un-depreciated part of the installed capital from patient households at a relative price of $q_{k,t}$, plus the new capital investment goods from final-goods firms at a relative price of 1, and produce the capital stock to be carried over to the next period. This production is subject to adjustment costs in the change in investment similar to Christiano et al. (2005) and Smets and Wouters (2007), and is described by the following law of motion of capital:

$$k_t = (1-\delta_k)\,k_{t-1} + \left[1 - \frac{\kappa_{ik}}{2}\left(\frac{i_{k,t}}{i_{k,t-1}} - 1\right)^2\right] i_{k,t}, \tag{17}$$

where κ_{ik} is the investment adjustment cost parameter.

After capital production, the end-of-period installed capital stock is sold back to patient households at the installed capital price of $q_{k,t}$. The capital producers' objective is thus to maximize

$$E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t}\frac{\lambda_{P,\tau}}{\lambda_{P,t}}\left[q_{k,\tau}k_\tau - q_{k,\tau}\left(1-\delta_k\right)k_{\tau-1} - i_{k,\tau}\right], \tag{18}$$

subject to the law of motion of capital, where future profits are again discounted using the patient households' stochastic discount factor. The first-order condition of capital producers yields an investment demand equation of non-residential investment demand, which in log-linearized form can be written as[18]

$$\widehat{i}_{k,t} = \frac{\beta_P}{1+\beta_P} E_t \widehat{i}_{k,t+1} + \frac{1}{1+\beta_P} \widehat{i}_{k,t-1} + \frac{1}{(1+\beta_P)\,\kappa_{ik}} \widehat{q}_{k,t}. \tag{19}$$

Housing producers are modelled analogous to capital producers. The law of motion of total housing, $h_t = h_{P,t} + h_{I,t} + h_{R,t}$, is given by

$$h_t = (1-\delta_h)\, h_{t-1} + \left[1 - \frac{\kappa_{ih}}{2}\left(\frac{i_{h,t}}{i_{h,t-1}} - 1\right)^2\right] i_{h,t}, \tag{20}$$

where κ_{ih} is the adjustment cost parameter.[19] The first-order condition of housing producers yields a similar demand equation for residential investment, which in log-linearized form can be written as

$$\widehat{i}_{h,t} = \frac{\beta_P}{1+\beta_P} E_t \widehat{i}_{h,t+1} + \frac{1}{1+\beta_P} \widehat{i}_{h,t-1} + \frac{1}{(1+\beta_P)\,\kappa_{ih}} \widehat{q}_{h,t}. \tag{21}$$

2.4 Fiscal policy

The total tax revenue of the government is given by

$$\begin{aligned} tax_t &= \tau_c c_t + \tau_y \left(w_{P,t} l_{P,t} + w_{I,t} l_{I,t}\right) + \tau_R w_{R,t} l_{R,t} \\ &+ \tau_y \left(r_{h,t} - \widetilde{\delta}_{h,t}\right) \left(h_{R,t-1} + I_{r,t} h_{P,t-1}\right) + I_{r,t} \tau_y \left(r_{h,t} - \widetilde{\delta}_{h,t}\right) h_{I,t-1} \\ &+ \tau_k \left(r_{k,t} - \delta_k\right) k_{t-1} + \tau_b r_{t-1} \left(b_{t-1} + b^g_{t-1}\right) - I_{m,t} \tau_y r_{t-1} b_{t-1} + (1-\tau_y)\, \tau_{p,t} q_{h,t} h_{t-1}, \end{aligned} \tag{22}$$

where the time variation in the housing-related fiscal tools are exogenously determined. Government debt accumulates according to the following law of motion:

$$b^g_t = (1 + r_{t-1})\, b^g_{t-1} + g_t + tr_{P,t} + tr_{I,t} + tr_{R,t} - tax_t, \tag{23}$$

where government expenditure, g_t, is exogenously determined, and transfer payments to each type of household are given by

$$tr_{i,t} = \chi_i y_n - \varrho_b b^g_{t-1}, \text{ for } i = P, I, R,$$

where χ_P, χ_I and χ_R are level parameters specific to the type of household; and ϱ_b determines the response of transfers to government debt. With our specification, an increase in tax revenue is used mainly to retire government debt, but it is also used to slowly increase transfer payments to each type of household. Note that either taxes, government spending or transfers would need to adjust with the level of government debt, so that the government cannot run a Ponzi scheme. We choose

[18] Note that we use the non-linear version of this condition when simulating the model (see the online appendix).

[19] We implicitly assume that owner-occupied housing and rental housing are perfect substitutes in production, abstracting from possible imperfect substitutability along this margin in the real world.

to make the adjustment through transfers based on the results of Leeper et. al (2010).

2.5 Market clearing conditions

The non-housing goods market clearing condition is given by

$$c_t + i_t + g_t = y_{n,t}, \tag{24}$$

where total non-housing consumption is $c_t = c_{P,t} + c_{I,t} + c_{R,t}$, and total investment is $i_t = i_{k,t} + i_{h,t}$.

NIPA-consistent consumption is given by $(1 + \tau_c)\, c_t + r_h h_{t-1}$, where the relative price of non-housing consumption includes sales taxes, and housing provides consumption services, which for owner-occupied housing are imputed using rental prices. Thus, NIPA-consistent GDP in the model, y_t, is defined as

$$y_t = (1 + \tau_c)\, c_t + r_h h_{t-1} + i_t + g_t. \tag{25}$$

The model's equilibrium is defined as prices and allocations such that households maximize the discounted present value of utility, firms maximize profits subject to their constraints, and all markets clear.

3 Calibration

We calibrate the parameters using steady-state relationships in the model (Cooley and Prescott, 1995), and data from the National Income and Product Accounts (NIPA; Bureau of Economic Analysis), the Flow of Funds Accounts (FOF; Federal Reserve Board) averaged over 1960–2012, the 2001 Residential Finance Survey (RFS; Census Bureau), and the 2011 American Housing Survey (AHS; Census Bureau). Table 1 summarizes the list of parameters, and Table 2 presents the main ratios at the steady state of the model versus their counterparts in the data. The calibration procedure that is used is as follows.

The time-discount factors of patient and impatient households, β_P and β_I, are set to 0.9916 and 0.9852, respectively, to match an annualized 4% real risk-free interest rate, and a Lagrange multiplier on household loans that is equivalent to a 200 basis point spread on the risk-free rate.[20] The inverse of the Frisch elasticity of labor supply, ϑ, is set to 1, as a compromise between estimates in the Real Business Cycle and New Keynesian literatures (Smets and Wouters, 2007). The level parameter for housing in the utility function, ξ_h, is calibrated to ensure that the total housing value is around 1.3 times annual GDP and the ratio of quarterly consumption to housing is around 0.1, consistent with NIPA and FOF data. The level parameter for labor supply, ξ_l, is calibrated to ensure that the labor supply of patient households is equal to 1 at the steady state without loss of generality.

[20] The spread between 30-year conventional mortgages and 10-year Treasury bonds is on average 170 bps over a sample period of 1971-2014. Given the existence of other types of mortgages with higher spreads and additional costs related to mortgages (such as origination costs, insurance etc.), we decided to target a spread of 200 bps. The results are not qualitatively different if we use a slightly different target for this spread.

Based on NIPA and FOF data, residential and non-residential investment are about 5% and 12% of output, respectively, while the housing-to-GDP and capital-to-GDP ratios are about 1.3 and 1.5, respectively on an annualized basis.[21] Based on these, we calibrate the quarterly depreciation rates for housing and capital stocks, δ_h and δ_k, to 0.96% and 2.0%, respectively. The depreciation allowance for rental housing, $\widetilde{\delta}_h$, is set equal to δ_h at the steady state. The share of capital in domestic production, α, is calibrated to 0.24 using the capital-output ratio and the model-implied after-tax rental rate of capital.

According to the AHS data, the ratio of outstanding mortgage loan to house value is, on average, 0.66, and 0.71 for the median borrower. Based on this, we calibrate the loan-to-value ratio, ϕ, to 0.7.[22] We also set the persistence parameter in the borrowing constraint, ρ_b, to 0.85 given that household debt data is highly persistent. Based on FOF data averaged over the postwar period, the ratio of mortgage debt owed by households relative to their real estate holdings is around 0.3. Given an LTV ratio of 0.7, this implies that borrower households own about 43% of the total housing stock (i.e. $h_I/h = 0.43$). We calibrate the wage share of impatient households, ψ_I, to 0.51, to hit this target. Similarly, the value share of rental housing in total housing is close to 20%, according to the RFS and AHS surveys (i.e. $h_R/h = 0.2$).[23] Thus, we calibrate the wage share of renter households, ψ_R, to 0.26, to hit this target. The wage share of patient households is obtained as a residual, with an implied housing share of 37% (i.e. $h_P/h = 0.37$).[24]

The inverse of the elasticity of the utilization rate to the rental rate of capital, ϖ, is set to 5 following Murchison and Rennison (2006), implying an elasticity of utilization to the rental rate of capital equal to 0.2. The level parameter in the utilization cost specification, κ_u, is calibrated to ensure that the utilization rate is equal to 1 at the steady state without loss of generality. The investment adjustment cost for capital, κ_{ik}, is set to 8, largely consistent with Smets and Wouters (2007), while the adjustment cost for housing, κ_{ih}, is set to 30, in between the values considered in Basant Roi and Mendes (2007) and Justiniano et al. (2013). We conduct sensitivity analysis on these, and a few other parameters, in the results section.[25]

The level parameters for transfers to households are calibrated so that the ratio of total transfers to GDP is about 7.4%, largely consistent with NIPA data, and the shares of transfers across the different types of households reflect their respective shares in total labor and capital income. In the benchmark calibration, we set the elasticity of transfers to government debt, ϱ_b to 0.005 to preserve determinacy of the model while ensuring that government debt does not play a major role in determining the dynamics of the model.

[21] Our target housing-to-GDP ratio includes the value of all residential housing including rentals, and also includes the value of residential land. In order to be consistent, the value of capital is computed by taking the difference of total physical assets and residential real estate holdings, including land values.

[22] In Section 4.2, we discuss results of robustness check with a higher value for ϕ as well.

[23] Rental units comprise about a third of all housing units, but rental units are, on average, worth about two-thirds of owner-occupied housing units.

[24] Note that, while only a fifth of the total labor income accrues to patient households, all capital and rental income accrues to them.

[25] We also set the adjustment cost for the housing stock, κ_h to 0.1, and conduct sensitivity analysis in Section 4.2.

Government expenditure is calibrated to ensure that its share in output in the initial steady state, g/y, is 18% consistent with NIPA data. The labor income tax rates, τ_y and τ_R, are set to 0.3 and 0.2, respectively, to reflect the progressivity of the tax code and an average labor income tax rate of around 27%, while the average capital income tax rate, τ_k, is set to 0.4, both following Zubairy (2014). The consumption tax rate, τ_c, is set to 5%. The property tax rate at the initial steady state, τ_p, is set to 0.0035 (corresponding to an annual rate of 1.4%) based on the *50-State Property Tax Comparison Study* conducted by the Minnesota Taxpayers Association (2011). Finally, the tax rate on interest income, τ_b, is set to 0.15 in the benchmark simulation, reflecting its favorable treatment in the tax code relative to labor income.[26]

4 Results

In this section, we explore the impact of permanent changes in various housing-related fiscal instruments on macroeconomic variables. In particular, we consider the effects of (i) reducing the mortgage interest deduction, (ii) instituting partial taxation of imputed rental income from owner-occupied housing, (iii) increasing property tax rates, and (iv) reducing the depreciation allowance for rental income.

For each experiment, we assume that the economy is at its initial steady state at period 0, prior to any changes in fiscal policy. Each fiscal change takes full effect in period 1, is completely unanticipated by agents in the economy prior to the change, and is expected to last indefinitely once the change occurs. There are no future shocks in the economy after period 1; thus, the economy is deterministic and agents have perfect foresight thereafter while the economy converges to its terminal steady state asymptotically.[27]

We quantify the present value of output (i.e., GDP) loss from each experiment using the following expression:

$$PV_y = \frac{1}{y_0} \sum_{t=0}^{\infty} \beta_P^t \left(y_t - y_0 \right), \tag{26}$$

where future changes in output are discounted using the time-discount factor of patient households, and are scaled relative to the initial steady-state level of output.[28] We also compute the present value of non-housing output, PV_{yn}, and the present value of tax revenue generated from each fiscal

[26]The lower tax rate for interest income reflects the favorable treatment of individual savings in fixed income securities held in non-taxed or tax-deferred accounts such as pension funds and individual retirement accounts.

[27]We keep the levels of productivity and government expenditure constant at their initial values in our simulations. To compute the transition path from the initial to the terminal steady state, we use the Matlab routines available in Dynare. The model converges to the terminal steady state after 1,000 periods, corresponding to 250 years. The transition path is computed by imposing the initial and terminal values, and simultaneously solving a system of non-linear equations that characterize equilibrium in all periods using a Newton method.

[28]We compute present values using the discount factor of the patient households in all experiments. However, since they are only a subset of the population, we also considered using the discount factor of impatient households, β_I, or a weighted average of discount factors of agents in the economy, $\frac{c_P}{c}\beta_P + \frac{c_I}{c}\beta_I + \frac{c_R}{c}\beta_R$ in our calculations. Our results regarding the ranking of policies based on output loss and efficiency are robust to the choice of this discount factor.

policy, PV_{tax}, in an analogous fashion.[29]

The effects of the policy changes are rather disparate across the different types of households due to the primary distortions created by each tax policy and which types of households they affect directly. In particular, changing property taxes affect the effective cost of all types of housing, while taxing imputed rents from owner-occupied housing directly affects only the owner-occupied housing of borrowers and savers, but does not directly impact rental housing and therefore renter households. Similarly, changes in mortgage interest deduction rules have a direct impact on borrowers only, while changes in the depreciation allowance for rental income would directly impact the effective cost of only rental housing. In order to assess the impact of each tax policy on the three different types of households in the economy (i.e., patient, impatient and renter households), we compute the change in their respective lifetime welfare in terms of annual consumption-equivalents. We thus calculate λ_i that satisfies

$$\sum_{t=0}^{\infty} \beta_i^t U\left((1+\lambda_i)c_{i,0}, h_{i,0}, l_{i,0}\right) = \sum_{t=0}^{\infty} \beta_i^t U\left(c_{i,t}, h_{i,t}, l_{i,t}\right), \tag{27}$$

for each $i = P, I, R$.

4.1 Housing-related tax policy experiments

To facilitate easier comparison among the four tax policies we consider, we normalize the size of each policy change to generate the same amount of total tax revenue in present value terms.[30] In particular, we target the present value of tax revenue, PV_{tax}, to equal 0.5 (in units of the initial steady-state tax revenue, tax_0) in each experiment. Given a steady-state tax-to-GDP ratio of 0.25, this tax target is also equal to 12.5% of initial steady-state GDP, y_0, in present value terms.[31]

In Figure 5, we show the transition path of key model variables in the first 25 years after each policy change (in percent-deviations from the initial steady state). Tables 3 and 4 summarize the impact of each policy on the present value of output, and the welfare implications for each type of agent in the economy, respectively. The computations shown in these tables are based on the complete transition path of 1,000 periods. For completeness, we also summarize the steady-state impact of each policy on macroeconomic variables of interest in Table 5. We now consider each of the four policies one by one, ordered from the lowest to the highest output loss in present value terms, PV_y.

[29]Note that, since we are scaling the present value of output and taxes by their respective initial steady-state values, the long-run tax multiplier of each policy can be calculated as $\frac{PV_y}{PV_{tax}} \frac{y_0}{tax_0}$.

[30]In the working paper version, we also conducted experiments where we completely eliminated each of the housing subsidies. The ranking of the four policies was preserved in terms of tax revenue generated per unit of output loss. Furthermore, these efficiency figures were very close to the baseline, indicating that the effects of the tax policy measures that we consider here are more or less linear; in other words, the results reported in Tables 3-5 can be scaled up or down based on the magnitude of the tax changes considered.

[31]Note that increasing the present value of taxes by 0.125 initial GDPs is equivalent to increasing the annual tax burden by 0.11% of steady-state level of GDP, y_0.

4.1.1 Reducing the mortgage interest deduction

In the initial steady-state, impatient households can fully deduct their mortgage interest payments from their taxable income (i.e., $I_{m,0} = 1$; see equation 7). In this subsection, we consider the consequences of permanently reducing this deduction. In the model, generating an increase in the total tax revenue that is equivalent to 0.125 initial GDPs in present-value terms, would require permanently reducing the mortgage interest deduction by about 30 percent and allowing only about 70 percent of the mortgage interest to be deductible (i.e., $I_{m,t} = 0.696$ for all $t \geq 1$).

Since interest payments are no longer fully deductible, the effective cost of borrowing increases for impatient households, which prompts them to substantially reduce their borrowing levels. They reduce their consumption and housing demand as a result. The decline in housing demand leads to an overall fall in house prices, but only in the short run. In our model, there is no permanent change in house prices from the initial to the terminal steady-state since the price of housing relative to the non-housing output good deviates from 1 only due to the quadratic adjustment costs in the law of motion of housing (see equation 20). In the long-run, house price reverts back to its initial steady-state level as the effect of investment adjustment costs dissipates and the supply of housing adjusts.[32]

While the impatient households are negatively impacted by the reversal in mortgage deduction, the effects are significantly different for patient households and renters. Given the fall in house prices, patient households increase their demand for both owner-occupied and rental housing. They also increase their consumption in the short run along with the reduction in their capital holdings. The increase in the supply of rental housing leads to lower rental rates in the short run, which causes renters to increase their consumption due to positive income effects. The disparate effects across the three agents are reported in Table 4: the impatient households are significantly worse off, experiencing a 0.59% of lifetime consumption-equivalent loss, whereas patient households and renters are better off, experiencing welfare gains of 0.22% and 0.33% in lifetime consumption, respectively.

Overall, this shock is contractionary, leading to a decline in output. Note, however, that this policy leads to the least output loss (estimated to be around 0.19 in present value) relative to all the other policies we consider (which range from 0.25 to 0.28). This is primarily due to the fact that the policy specifically targets the borrowers in the economy, and ultimately benefits savers and renters. While all the policies we consider reduce housing and residential investment overall, the effects of reducing the mortgage deduction on output are partially offset by the savers and renters, who increase their demand for housing and consumption goods. In contrast, the other policies either impact savers negatively along with borrowers, leading to a larger impact in overall demand and output, or hurt renters while benefiting borrowers, thus offering a poor trade-off between tax revenue generation and output loss.

[32]Since capital and housing capital face different adjustment costs, the prices of the two assets may potentially differ along the transition paths in response to a policy change. A permanent change in the relative price of housing can be obtained by introducing a separate production sector for residential investment (Iacoviello and Neri, 2010), or aggregate residential structures with a fixed factor such as land to produce housing (Davis and Heathcote, 2005; Garriga et al., 2012).

4.1.2 Taxing imputed rental income from owner-occupied housing

Owner-occupied housing receives preferential treatment in the tax code, since housing services provided by owner-occupied housing are not subject to taxation (i.e., $I_{r,0} = 0$), while rental income generated by rental housing is. This creates an incentive for households to own rather than rent. We conduct an experiment in which we assume a shift to a policy of partially taxing imputed rental income - net of depreciation allowance - from owner-occupied housing (see Figure 5). Targeting a tax revenue of 0.125 initial GDPs in present-value terms requires instituting a tax on imputed rental income from owner-occupied housing at a rate of 7.7% (i.e., $I_{r,t} = 0.077$ for $t \geq 1$).

Note that both patient and impatient households in the economy would be subject to this tax, and the effective cost of purchasing owner-occupied housing for both agents goes up. As with the mortgage interest deduction case, impatient households demand less housing, which leads to a decline in house prices in the short run. This in turn results in a tightening of their borrowing constraint, and leads to a reduction in household borrowing. In addition, impatient households substitute away from housing to consumption. While patient households face the same negative wealth effects associated with higher taxes on housing, and lower their demand in the long run; in the short run they demand more housing due to a fall in relative house prices and a decline in savings. Also, patient households substitute away from owner-occupied to rental housing as the tax advantage of owner-occupied housing is taken away. This impacts renters positively, since the increase in rental housing lowers rents in the short-run and allows them to increase their consumption. This policy change has a significant negative impact on the welfare of patient and impatient households, who experience welfare losses of 0.17% and 0.3%, respectively, in terms of lifetime consumption-equivalents. Renters, on the other hand, experience a welfare gain of 0.33% (see Table 4).

In terms of output loss, this policy ranks second best among the various policies considered (see Table 3). Similar to the mortgage deduction case, the output impact of this policy is somewhat cushioned by the substitution of saver households towards rental housing, and the beneficial impact of this on renters' demand. On the other hand, the policy adversely affects patient households overall, leading to a larger drop in capital and housing investment. Moreover, the borrowing of impatient households now falls significantly less, which results in a smaller drop in mortgage interest deductions taken by borrowers, thus offering a relatively worse trade-off between tax revenue generation and output loss.

4.1.3 Increasing the property tax rate

We next consider an experiment where we increase the property tax rate.[33] In order to target a revenue amounting to 0.125 initial GDPs in present-value terms, we increase the annual property tax rate by 0.16 percentage points (i.e., τ_p increases from 0.014/4 to 0.0156/4 given that the model is quarterly). Note that the tax base for the property tax is rather large since both owner-occupied

[33] As noted earlier, changing property taxes in our set-up is equivalent to modifying the property tax deduction. See the working paper version of the paper for more on this (Alpanda and Zubairy, 2013).

and rental housing are subject to this tax, and the value of total housing in the economy is in the order of 1.3 annual GDPs. Therefore, small changes in this tax can have a large impact on the economy.

The increase in the property tax rate increases the effective cost of housing of all types, resulting in a fall in housing demand and output (Figure 5). The fall in housing demand also results in a decline in the relative price of housing in the short run. At the disaggregated level, the three types of households are affected through distinct channels. For the impatient households, the increase in the cost of holding housing leads to a decline in their housing demand, while the fall in house prices and the decline in the supply of credit from savers tighten their collateral constraint, leading to a reduction in their consumption as well. The patient households, on the other hand, increase their consumption in the short run and reduce capital investment. The decline in their saving results in the real interest rate to rise on impact. While property taxes directly affect homeowners (patient and impatient households), they also have negative consequences for renters in the short-run. The reduction in rental housing supply causes rents to rise, which in turn leads renters to decrease their purchases of consumption and housing services. Over time though, consumption of renters increase due to the increase in transfer payments. Comparing the welfare impact across the three agents, both the patient and impatient homeowners are worse off, incurring an annual loss of 0.11% and 0.22% in lifetime consumption-equivalents, respectively, while the renters' welfare is nearly unchanged.

In terms of output loss, this policy fares slightly worse than taxing imputed rents (see Table 3). First, the increase in property taxes reduces the supply of rental housing, and therefore, does not generate the same beneficial impact on renters' demand. As a result, residential investment falls more severely in this case, driven down not just by changes in owner-occupied housing of patient and impatient households, but also by rental housing. Furthermore, impatient households' borrowing declines less in this case, resulting in a relatively smaller drop in deductions on mortgage payments and generating an offsetting negative effect on tax revenue.

4.1.4 Reducing the depreciation allowance for rental income

In the initial steady-state, patient households are allowed to deduct depreciation of their rental property when paying taxes on their rental income (i.e., $\widetilde{\delta}_{h,0} = 0.0096$). We next conduct an experiment where we reduce this depreciation allowance by about a half in order to generate the target tax revenue (i.e., $\widetilde{\delta}_{h,t} = 0.005$ for all $t \geq 1$), and explore the impact of this change on macroeconomic variables (Figure 5).

The reduction of the depreciation allowance results in an overall decline in output and housing. Since the effective cost of rental housing goes up, the demand of rental housing from the patient households falls, leading to a decline in house prices. The patient households substitute away from rental housing to owner-occupied housing, so their owner-occupied housing goes up. The fall in house prices leads to a tightening in the collateral constraint of the impatient households, and a decline in their consumption in the short run. Nevertheless, they increase their level of housing given the decline in house prices and the increase in the supply of credit. Overall, both patient and impatient households experience small welfare gains, of 0.13% and 0.08% of lifetime consumption-equivalents, respectively. On the other hand, renters are worse off as a consequence of this fiscal change. With a decline in the rental housing supply, the rental rate of housing rises by about 7.5%, and thus renters reduce their consumption. They experience a large lifetime consumption-equivalent welfare loss of 1.16%.

This policy change results in the largest output loss. This policy has a large impact on output since it adversely affects renters who are *hand-to-mouth* consumers in our set-up, and thus, cannot smooth out the impact of the shocks through saving and borrowing. Furthermore, it benefits impatient households, who increase their housing and debt levels, resulting in higher mortgage interest deductions, thus offering a significantly worse trade-off between tax revenue generation and output loss relative to the other fiscal tools considered above.

4.2 Sensitivity analysis

In this subsection, we investigate the robustness of our key results by conducting sensitivity analysis on some of the parameters (see Table 6). Note that, with the exception of the LTV parameter, ϕ, the parameters we consider affect only the transitional dynamics, but have no affect on the terminal steady state. Nevertheless, our main results on the effects of each policy on tax revenue and output (Table 3) take into account the transition path from the initial to the terminal steady state; hence, parameters that only affect dynamics can still affect these results. As we discuss below however, our results are, certainly qualitatively, but to a large extent also quantitatively, robust to different parameter choices.

First, we consider a smaller labor supply elasticity by setting ϑ, the *inverse* of the labor supply elasticity, equal to 3 (as opposed to 1 in the baseline calibration). In the model, for each policy change, the agent affected by the policy faces a negative wealth effect and an incentive to increase labor supply. However, at the same time, since output and demand of goods falls, labor demand falls. This results in a decline in wages, which creates downward pressure on labor supply as the substitution effect kicks in. Overall, the substitution effect more than offsets the wealth effect so that aggregate labor declines. In the case of a smaller labor supply elasticity, the output loss is smaller for all policies as agents do not reduce labor supply as much as the baseline case with the fall in wages. Note that the ranking of policies in terms of output loss is the same as in the benchmark case. In particular, eliminating the mortgage interest deduction again comes out first, followed by taxing imputed rents and increasing property taxes, and the last is reducing the depreciation allowance for rental housing.

Next we consider the parameterization of the various adjustment costs in the model. We consider a smaller capital utilization cost by setting ϖ to 1 (instead of 5 in the benchmark case), which implies that existing capital can be utilized more intensely at a lower cost. Consequently, in this case too, the output loss is slightly less than the baseline, for each of the policy changes. But the overall ranking, as well as the qualitative results, remain intact. On the other hand, when we we consider a lower adjustment cost for investing in capital (by setting κ_{ik} to 4 as opposed to 8 in the benchmark case), it results in a larger present value of output loss. In almost all the policy changes considered, the patient households have a portfolio choice between capital and residential investment, and when the adjustment cost of capital investment is lower, the timing of adjustment is affected where capital investment falls faster in the short-run, while residential investment falls more gradually. As a result of the short-run drop in capital investment, output falls more in the short-run as well, resulting in a larger present discounted value of output loss. The opposite happens when we consider a lower adjustment cost for investing in housing (by setting κ_{ih} to 8 instead of 30), where the output loss is smaller in all cases. Under this calibration, output falls less in the short-run since capital investment falls less, while the lower adjustment cost of residential investment results in a larger fall in housing investment in the short-run. We also consider a higher adjustment cost in the stock of housing (by setting κ_h to 0.5 as opposed to 0.1), which has a very small but slightly negative impact on the output loss. While the size of these parameters affect the dynamics of the macroeconomic variables and the resulting present value of output loss, they affect incentives in a similar direction across all the experiments so that the ranking of the policies in terms of efficiency is robust to their parameterizations.

Lastly, we consider the case a of higher LTV ratio (by setting ϕ to 0.9 as opposed to 0.7).[34] As shown in the bottom last column in Table 6, the output losses are larger than the baseline case as the effects of policy shocks are amplified with higher levels of LTV. Nevertheless, the ranking of policies in terms of output loss is preserved in this case as well.[35]

4.3 Additional considerations

In our analysis, we do not account for the fact that households might switch type as a result of a change in tax policy; thus our model captures how the fiscal policies considered would affect housing at the intensive margin, but not the extensive margin. In this section, we assess the quantitative importance of our assumption of keeping the shares of the three groups in the population constant in response to policy changes.

The most significant impact on tenure status would likely be as a result of policies that affect only a particular subset of households, and not all of them uniformly, so as to induce some agents to change type. Thus, policy changes where housing tenure decisions are more likely to be important include mortgage interest deduction, taxation of imputed rents on owner-occupied housing, and the depreciation allowance on rental housing. These changes have the potential to change the incentives of households to rent versus own; thus, their impact should show up in the aggregate home ownership

[34] Many papers including Iacoviello and Neri (2010) and Justiniano et. al (2013) consider an LTV ratio as high as 0.85.

[35] For this last experiment, we recalibrate the labor share parameters to ensure that the ratio of mortgage debt owed by households relative to their real estate holdings (b/h_I) remain 0.3, consistent with our data target. In particular, ψ_I is reduced to 0.38, and the share of patient households is adjusted accordingly. Note however that the results without this adjustment are also very similar to the benchmark case.

rates.[36]

Empirical literature analyzing the effects of mortgage deduction rules on home ownership rates by and large find a muted impact. Glaesar and Shapiro (2003) conclude that the mortgage interest deduction policy is not significant for the home ownership rate, since the deductibility of the mortgage interest and property tax payments encourages home ownership by the wealthy, who are already homeowners. Hilber and Turner (2014) exploit the variation in the subsidy arising from changes in the mortgage interest deduction within and across states, to test whether the deduction promotes home ownership, and find that the mortgage interest deduction has no discernible impact on the level of aggregate home ownership in the U.S. Hanson (2012) also uses differences in state level policy to estimate the effect of mortgage interest deductibility on home ownership and the size of homes purchased. He concludes that the deduction causes increased consumption of housing on the intensive (larger home) margin, but finds no effects on the extensive (more homeowners) margin. These findings are very much in line with our model, which does not incorporate housing tenure change, but allows for changes on the intensive margin due to mortgage interest policies.

The empirical evidence on the effects of taxing imputed rents from owner-occupied housing is much less sharp. International evidence, though, shows that home ownership rates can be comparable across countries with and without imputed rental taxation, and are sometimes higher in countries that tax imputed rental income.[37] If we assume that taxation of imputed rents affect home ownership, then the margin along which the changes would take place is most likely borrowers switching to become renters, since the effective cost of owner-occupied housing would rise. This would mean that, overall, there would be fewer borrowers in the economy being adversely affected. As a result, the size of the output loss would be relatively smaller than shown in our baseline results in Table 3.

Lastly, we consider the reduction in the depreciation allowance on rental housing. Reduction in the depreciation allowance may perhaps lead some renters to switch to become borrowers if the resulting increase in rents is significant, but would more likely induce purchases of larger owner-occupied homes by savers and borrowers. Poterba (1994) considers various changes to the depreciation allowance laws, and proposes that, since the depreciation tax benefits are a key consideration in rental investment, the reversal of depreciation allowance could cause rents to rise.[38] However, he also notes that the net incentive to invest in rental property depends on various other taxes that affect other investment opportunities. More importantly, the effect on home ownership rates might be ambiguous based on who the *marginal* investor in the rental property is (i.e., corporations vs.

[36]Life cycle models provide competing theories for the effects of policy changes such as lowering mortgage interest deductions. For instance, Gervais (2002) finds that elimination of mortgage interest deductibility makes homeownership much less attractive, in a general equilibrium life-cycle model. However, Sommer and Sullivan (2013) find that eliminating mortgage interest deductions can promote homeownership through lowering of house prices.

[37]For example, Netherlands and Sweden tax imputed rents and have homeownership rates of 67.1% and 69.7%, respectively, while France and UK do not tax imputed rents and have homeownership rates of 63.1% and 67.9% (JCT, 2013).

[38]Poterba (1994) documents that the 1981 Economic Recovery Tax Act (ERTA) that shortened the tax lifetime for residential rental property from 32 to 15 years. The 1986 Tax Reform Act reversed this policy, extending the lifetime to 27.5 years, and requiring straight line depreciation rather than more accelerated 175 percent declining balance.

individual investors). In particular, changes in depreciation allowances would have limited impact if corporations are marginal suppliers of rental housing since they face smaller reductions in marginal tax rates, relative to individual investors. In our model, the savers also play the role of corporations, and the substitution between rental housing and other investment opportunities like capital investment and owner-occupied housing at the intensive margin are endogenously generated in response to changes in the depreciation allowance.

Overall, the literature suggests significant impact of these policies on the intensive margin, which our model successfully captures. Our model abstracts from the extensive margin (i.e. the home ownership rate); however, the empirical literature also does not provide strong evidence of significant changes along this margin for many of the policies considered here. The only exception is the case of taxing imputed rents where we are likely over-estimating the output loss to some degree. Given the large difference between the output loss under reduction of mortgage deductions and taxing imputed rents in our baseline results, we suspect that the rankings would still be preserved so that eliminating mortgage interest deductions would remain the most efficient policy at play.

5 Conclusion

In this paper, we analyze the effects of various housing-related fiscal policy instruments on the economy using a dynamic general-equilibrium model. The model features borrowing and lending across heterogeneous households, financial frictions in the form of collateral constraints tied to house prices, and a rental housing market alongside owner-occupied housing. We find that, once normalized to generate the same tax revenue, all housing-related policies we consider lead to significant output losses, with large long-run tax multipliers of around 2. Among them, reducing the mortgage interest deduction is the most effective in raising tax revenue per unit of output lost, while reducing the depreciation allowance for rental income is the least effective. We also find that different policy instruments have different impacts on savers, borrowers and renters, and our results highlight a tradeoff between policies that are effective in revenue generation with lower output impact and policies that are more likely to be politically feasible. For instance, the reduction in the mortgage interest deduction is the most effective policy on the aggregate, but it is also the one that causes the largest redistribution of wealth among agents, and as a consequence, could be one of the hardest to implement in practice.

In future research, we plan to extend our model to include nominal rigidities and monetary policy, as well as macroprudential regulations on LTV ratios, in order to assess the impact of housing-related fiscal policies relative to other policies. In particular, our extended model would allow us to analyze the relative merits of using fiscal policy as opposed to monetary policy or macroprudential regulations in order to balance risks related to achieving macroeconomic and financial stability. Note that housing-related fiscal policy is a targeted tool similar to LTV regulations, but could be broader in its implementation, since it can affect all existing homeowners, as opposed to only new homebuyers.

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Table 1: Model parameters

	Symbol	Value
Discount factor	β_P, β_I	0.9916, 0.9852
Inverse labor supply elasticity	ϑ	1
Level for housing and labor in utility	ξ_h, ξ_l	0.21, 0.56
Loan-to-value ratio	ϕ	0.7
Persistence in borrowing constraint	ρ_b	0.85
Capital share in production	α	0.24
Labor share in production	ψ_P, ψ_I,ψ_R	0.23, 0.51, 0.26
Depreciation rate	δ_h, δ_k	0.0096, 0.02
Investment adj. cost	κ_{ih}, κ_{ik}	30, 8
Housing stock adj. cost	κ_h	0.1
Utilization cost – elasticity	ϖ	5
Transfer share	Ξ_P, Ξ_I, Ξ_R	0.038, 0.035, 0.015
Response of transfers to gov. debt	ϱ_b	0.005
Tax rates – consumption	τ_c	0.05
– interest income	τ_b	0.15
– labor income	τ_y,τ_R	0.3, 0.2
– capital income	τ_k	0.4
– property	τ_p	0.014/4

Table 2: Model steady-state ratios versus data

	Symbol	Model	Data target
Total consumption / GDP	$(1+\tau_c)\,c/y + r_h h/y$	0.66	0.65
Non-housing goods and services / GDP	$(1+\tau_c)\,c/y$	0.53	0.54
share of patient households	c_P/c	0.35	
share of impatient households	c_I/c	0.43	
share of renter households	c_R/c	0.23	
Housing services / GDP	$r_h h/y$	0.13	0.13
Total investment / GDP	i/y	0.17	0.17
residential investment / GDP	i_h/y	0.05	0.05
non-residential investment / GDP	i_k/y	0.12	0.12
Government expenditure / GDP	g/y	0.18	0.18
Tax revenue / GDP	tax/y	0.25	0.26
Transfers / GDP	tr/y	0.07	0.08
Wage share in non-housing income	$1-\alpha$	0.76	0.76
share of patient households	ψ_P	0.23	
share of impatient households	ψ_I	0.51	
share of renter households	ψ_R	0.26	
Capital stock / GDP (qtr)	k/y	5.87	6.00
Housing stock / GDP (qtr)	h/y	5.09	5.20
share of savers' owner-occ.	h_P/h	0.37	0.37
share of borrowers' owner-occ.	h_I/h	0.43	0.43
share of rentals	h_R/h	0.20	0.20
Mortgage debt / total housing value	b/h	0.30	0.30
loan-to-value ratio for borrowers	b/h_I	0.70	0.70

Table 3: Effects of housing-related fiscal policy experiments

	Tax policy		Present value	
	initial	new	output (y)	non-housing output (y_n)
Reduction of mortgage interest deduction	$I_m = 1$	$I_m = 0.70$	-0.191	-0.103
Instituting partial taxation of imputed rents	$I_r = 0$	$I_r = 0.08$	-0.245	-0.139
Property tax increase	$\tau_p = 0.014$	$\tau_p = 0.0156$	-0.252	-0.144
Reduction of depreciation allowance	$\widetilde{\delta}_h = 0.0096$	$\widetilde{\delta}_h = 0.0050$	-0.277	-0.160

Table 4: Welfare effects of housing-related fiscal policy experiments on households in lifetime consumption-equivalents

	Savers	Borrowers	Renters
Reduction of mortgage interest deduction	0.22 %	-0.59 %	0.33 %
Instituting partial taxation of imputed rents	-0.17 %	-0.30 %	0.33 %
Property tax increase	-0.11 %	-0.22 %	0.01 %
Reduction of depreciation allowance	0.13%	0.08 %	-1.16 %

Table 5: Changes in key model variables from the initial to the terminal steady state

(in percent)	y	y_n	c	i_k	i_h	b	r_h
Reduction of mortgage interest deduction	-0.216	-0.080	-0.004	-0.080	-1.160	-2.539	0.000
Instituting partial taxation of imputed rents	-0.258	-0.095	-0.004	-0.095	-1.383	-1.462	0.000
Property tax increase	-0.261	-0.097	-0.005	-0.097	-1.400	-1.082	1.578
Reduction of depreciation allowance	-0.280	-0.105	-0.007	-0.105	-1.497	0.238	7.482

Table 6: Sensitivity analysis for the effects of fiscal policies on the present value of output loss

	Inverse labor supply elasticity $\vartheta = 3$	Utilization cost param. $\varpi = 1$	Capital inv. adj. cost $\kappa_{ik} = 4$
Reduction of mortgage interest deduction	-0.155	-0.172	-0.198
Instituting partial taxation of imputed rents	-0.197	-0.223	-0.254
Property tax increase	-0.202	-0.229	-0.261
Reduction of depreciation allowance	-0.220	-0.252	-0.285
	Housing inv. adj. cost $\kappa_{ih} = 8$	Housing stock cost param. $\kappa_h = 0.5$	LTV ratio $\phi = 0.9$
Reduction of mortgage interest deduction	-0.145	-0.190	-0.224
Instituting partial taxation of imputed rents	-0.189	-0.245	-0.283
Property tax increase	-0.194	-0.252	-0.287
Reduction of depreciation allowance	-0.214	-0.276	-0.306

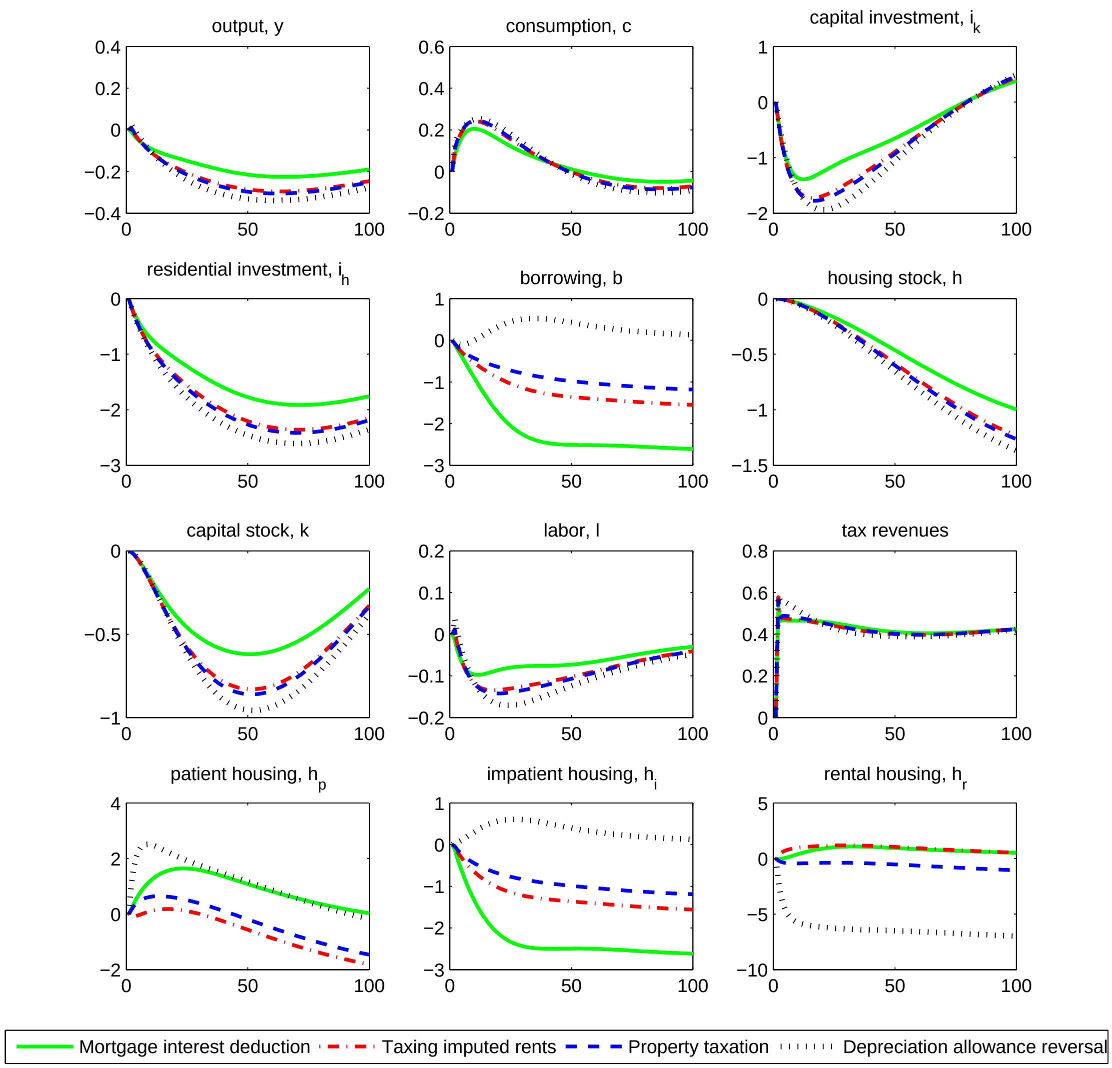

Figure 1: The figure plots the responses of key model variables under the four fiscal policy changes described in the text. Each policy is scaled to generate an equivalent increase in the present value of total tax revenue, equal to 12.5% of initial steady-state GDP. The y-axis measures percent deviation of the variable from the steady state, and the x-axis denotes the number of quarters from the policy shock.