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Housing and Tax Policy

by Sami Alpanda and Sarah Zubairy

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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 policies we consider are (i) increasing property tax rates, (ii) eliminating the mortgage interest deduction, (iii) eliminating the depreciation allowance for rental income, (iv) instituting taxation of imputed rental income from owner-occupied housing and (v) eliminating the property tax deduction. We find that among these fiscal tools, eliminating the mortgage interest deduction would be the most effective in raising tax revenue, and in reducing household debt, per unit of output lost. On the other hand, eliminating the depreciation allowance for rental income would be the least effective. Our experiments also highlight the differential welfare impact of each tax policy on savers, borrowers and renters.

JEL classification: E62, H24, R38

Bank classification: Economic models; Fiscal policy

Résumé

Dans leur étude, les auteurs analysent les effets sur le plan macroéconomique de diverses mesures fiscales touchant l'habitation à l'aide d'un modèle dynamique d'équilibre général. Leur modèle met en scène un ensemble hétérogène de ménages qui prêtent et empruntent entre eux, des frictions financières constituées par les contraintes de garantie liées au prix des maisons auxquelles ceux-ci sont confrontés, de même qu'un marché locatif côtoyant un marché dans lequel les logements sont habités par leurs propriétaires. Tirant parti de leur modèle, les auteurs étudient les effets sur le niveau de la production, les recettes fiscales, la dette des ménages et d'autres grandeurs macroéconomiques de la modification de la fiscalité du logement par les mesures suivantes : 1) le relèvement des taux d'impôt foncier, 2) la suppression de la déduction fiscale au titre des intérêts d'emprunts hypothécaires, 3) la suppression de la déduction pour amortissement s'appliquant au revenu locatif, 4) l'imposition de loyers fictifs aux propriétaires-occupants et 5) la suppression de la déduction de la taxe foncière. Les auteurs montrent que, de ces instruments de politique fiscale, c'est l'élimination de la déduction au titre des intérêts d'emprunts hypothécaires qui ferait le plus augmenter les recettes fiscales, et abaisser l'endettement des ménages, par unité de production perdue. La mesure la moins efficace serait l'élimination de la déduction pour amortissement s'appliquant au revenu locatif. Nos simulations font également ressortir les écarts d'incidence sur le bien-être des épargnants, des emprunteurs et des locataires résultant des différentes mesures fiscales considérées.

Classification JEL : E62, H24, R38

Classification de la Banque : Modèles économiques; politique budgétaire

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 home ownership relates to the tax treatment of imputed rental income from owner-occupied housing; even though this imputed income is included in the consumption aggregates of 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% 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, home ownership 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 household type, renters, 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, property tax deduction, depreciation allowance for rental income, etc.).

¹Both 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 titled "Present Law, Data, and Analysis Relating to Tax Incentives for Residential Real Estate" (JCT, 2013).

²Among 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).

Finally, we allow housing supply to vary endogenously over time. 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) increasing property tax rates, (ii) eliminating the mortgage interest deduction, (iii) eliminating the depreciation allowance for rental income, (iv) instituting taxation of imputed rental income from owner-occupied housing, and (v) eliminating the property tax deduction.³

We find that, based on their impact on GDP, instituting taxes on imputed rents for owner-occupied housing would have the most detrimental impact, resulting in a present-value output loss of 2.6 times initial GDP. Eliminating the property tax deduction is estimated to cause a present-value output loss of about 0.9 times initial GDP, while increasing property taxes by 0.4 percentage points, eliminating the mortgage interest deduction or eliminating the depreciation allowance on rental income would each lead to about 0.5–0.6 times initial GDP loss in present-value terms. In terms of tax revenue raised per unit of output lost, eliminating the mortgage interest deduction would have the highest impact, raising nearly 2.8 dollars per dollar of output loss in the economy. Taxing imputed rents, increasing property taxes by 0.4 percentage points and eliminating the property tax deduction would each raise about 2 dollars of revenue per dollar of lost output, while the corresponding figure for eliminating depreciation allowances for rental housing is only 1.8 dollars.

In terms of the impact on household debt, instituting taxes on imputed rental income from owner-occupied housing would have the highest impact on household debt (reducing it by about 16% at the terminal steady state relative to its level at the initial steady state), while eliminating the depreciation allowance on rental income would have the least impact (reducing it by only 0.4%). In terms of reducing the level of household debt with the least output cost, eliminating the mortgage interest deduction would again perform the best, reducing the level of household debt by 8% at the terminal steady state while reducing output by 0.7%. 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, eliminating 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 elimination of the 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, the elimination of the property tax deduction leaves most agents in the economy worse off, since this change directly affects the effective cost of all types of housing. Note that we may be slightly overestimating the effects of these policies on each type of household, since we do not allow changes in their housing-tenure status in the model. In reality, the welfare losses may be smaller as some of these policies may induce them to switch type (e.g., some borrowers may choose to rent as a result

³Property taxes are collected at the local government level, whereas the other tax provisions we consider are under the federal government’s jurisdiction.

of the mortgage interest deduction being eliminated).

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 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 homes and the absence of taxation on 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 to many homeowners facing 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 the elimination of the mortgage interest deduction leaves only the borrowers worse off, whereas eliminating property tax deductions and taxing imputed rents have a significant and negative effect on all homeowners (i.e., savers and borrowers).⁴

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. In that model, individuals strive to accumulate the down payment as quickly as possible to become homeowners. The welfare results in that model 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. 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 importance of income tax reforms is amplified in the presence of housing. Sommer and Sullivan (2012) also consider a life-cycle model with endogenous house prices and rents, and show that a reduction in property tax and mortgage interest tax deductions would lead to a large decline in house prices, lower rents and higher home ownership. Our model differs from the above in that it utilizes a dynamic general-equilibrium model along the lines of Iacoviello (2005),

⁴The 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 (cf. Rosen, 1979). Also see Nakajima (2010) for optimal capital taxation in an overlapping-generations model with housing.

and includes all the major housing-related tax policy details in a single framework.⁵

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 they occupy, as in Iacoviello (2005), while patient households also own the rental properties.⁶ 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.⁷

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:

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

where t indexes time, $\beta_P < 1$ is the time-discount parameter, ζ is the external habit parameter for consumption, 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.

⁵After circulating a first draft of our paper, we became aware of Ortega et al. (2011), who also introduce rental housing into a Iacoviello-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.

⁶In the data, about 17% of mortgages are backed by rental housing. We abstract from debt-financed rental housing in our model. In addition, about 85% of rental properties with 1–4 units are owned by households, while larger multi-unit rental properties are owned mainly by corporations. 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.

⁷In 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.

The patient households' period budget constraint is given by

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

where patient households accumulate owner-occupied and rental housing, $h_{P,t}$ and $h_{R,t}$, as well as capital, $k_{P,t}$; $q_{h,t}$ and $q_{k,t}$ are the relative prices of housing and capital, respectively; $r_{h,t}$ and $r_{k,t}$ are the rental income they receive from these assets; and δ_h and δ_k are their corresponding depreciation 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, and τ_b is the tax on interest income.⁸ Similarly, labor and rental housing income are taxed at a rate of τ_{yP} , 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 housing and capital stocks, whose level parameters are denoted by κ_h and κ_k , respectively.

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, $\tilde{\delta}_{h,t}$ 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 an indicator function that takes the value of 0 or 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. Similarly, $I_{p,t}$ indicates whether property taxes are deductible from income taxation, which in our baseline case is set equal to 1, indicating that property deductions are allowed.

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 $\lambda_{P,t}$. 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):

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

⁸We 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.

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):

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

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

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:

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

2.1.2 Impatient households

The economy is also populated by a unit measure of infinitely-lived impatient households.⁹ 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

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

where τ_{yI} is the income tax rate for impatient households and $t r_{I,t}$ denotes lump-sum transfers received from the government. $I_{m,t}$ is an indicator function determining whether interest payments on borrowing are deductible when paying income taxes; in our baseline calibration, we set $I_{m,t}$ to 1 indicating mortgage interest deductibility. 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

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

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 (2012).¹⁰

⁹We normalize the size of each type of household to measure one. The economic importance of each type of agent is determined by their respective shares in labor and capital income, similar to Iacoviello (2005).

¹⁰See 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, in our model, the loan-to-value (LTV) ratio, ϕ , stays constant with changes in fiscal policy. 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. We do not currently capture

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

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

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

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

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.¹¹ The renter households' period budget constraint is given by

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

where τ_{yR} 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:

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

this margin in our framework, and leave it for future research.

¹¹Note, 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.

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:

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

where 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 $\psi_P + \psi_I + \psi_R = 1$. 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

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

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 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:

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

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:

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

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 undepreciated 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:

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

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

After capital production, the end-of-period installed capital stock is sold back to patient house-

holds at the installed capital price of $q_{k,t}$. The capital producers' objective is thus to maximize

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

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

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

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

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

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

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

2.4 Fiscal policy

The total tax revenue of the government is given by

$$\begin{aligned} tax_t &= \tau_c c_t + \tau_y P w_{P,t} l_{P,t} + \tau_y I w_{I,t} l_{I,t} + \tau_y R w_{R,t} l_{R,t} \\ &+ \tau_y P \left(r_{h,t} - \tilde{\delta}_{h,t} \right) (h_{R,t-1} + I_{r,t} h_{P,t-1}) + I_{r,t} \tau_y I \left(r_{h,t} - \tilde{\delta}_{h,t} \right) h_{I,t-1} \\ &+ \tau_k \left(r_{k,t} - \tilde{\delta}_k \right) k_{t-1} + \tau_b r_{t-1} (b_{t-1} + b_{t-1}^g) - I_{m,t} \tau_y I r_{t-1} b_{t-1} \\ &+ \tau_{p,t} q_{h,t} [(1 - I_{p,t} \tau_y P) (h_{P,t-1} + h_{R,t-1}) + (1 - I_{p,t} \tau_y I) h_{I,t-1}], \end{aligned} \quad (22)$$

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

$$b_t^g = (1 + r_{t-1}) b_{t-1}^g + g_t + tr_{P,t} + tr_{I,t} + tr_{R,t} - tax_t, \quad (23)$$

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

$$tr_{i,t} = \chi_i y_n \left(\frac{y_t}{y} \right)^{-\varrho_y} \tilde{\varepsilon}_{tr,t} - \varrho_b b_{t-1}^g, \text{ for } i = P, I, R,$$

where χ_P , χ_I and χ_R are level parameters; ϱ_y is the automatic stabilizer component of transfers; and ϱ_b determines the response of transfers to government debt.¹² Note that, with our specification, an increase in tax revenue would be used to retire government debt and slowly increase transfers to each type of household.

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

$$c_t^{NIPA} = (1 + \tau_c) c_t + r_h h_{t-1},$$

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. Similarly, 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.

¹²Either taxes, government expenditure or transfers need to adjust with the level of government debt, so that the government cannot run a Ponzi scheme. We choose to make the adjustment through transfers based on the results of Leeper et al. (2010).

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. 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 habit parameter for consumption, ζ , is set to 0, following Iacoviello (2005). 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.

The inverse of the elasticity of the utilization rate to the rental rate of capital, ϖ , is set to 5, 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 costs, κ_{ik} and κ_{ih} , are set to 8 and 30, respectively, implying that the elasticity of investment demand to Tobin's q is around 0.063 for capital and 0.017 for housing.¹³

In the 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 2 on an annualized basis. Based on these, we calibrate the quarterly depreciation rates for housing and capital stocks, δ_h and δ_k , to 0.96% and 1.5%, respectively. The depreciation allowance for rental housing, $\tilde{\delta}_h$, is set equal to δ_h at the steady state. The share of capital in domestic production, α , is calibrated to 0.27 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. 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. We calibrate the wage share of impatient households, ψ_I , to 0.54, to hit this target. Similarly, the value share of rental housing in total housing is close to 21%, according to the RFS and AHS surveys.¹⁴ Thus we calibrate the wage share of renter households, ψ_R , to 0.27, to hit this target, and the wage share of patient households is obtained as a residual.¹⁵

The level parameters for transfers for households are calibrated so that the ratio of total transfers to GDP is about 7.7%, and the shares of transfers across the different types of households reflect their respective income shares. In the benchmark calibration, we shut off the automatic stabilizer aspect of transfers by setting ϱ_y to 0, and we set ϱ_b to 0.005 to preserve determinacy of the model

¹³We set the adjustment costs for the housing and capital stocks, κ_h and κ_k , to 0.1 and 0, respectively, to ensure determinacy of the model while ensuring that they do not affect the results in a substantial way.

¹⁴Rental units comprise about 1/3 of all housing units, but rental units are, on average, worth about 2/3 of owner-occupied housing units.

¹⁵While about a fifth of labor income accrues to patient households, all capital income accrues to them.

while ensuring that government debt does not play a major role in determining the dynamics of the model.

Government expenditure is calibrated to ensure that its share in output in the initial steady state, g/y , is 18%. The labor income tax rates for patient, impatient and renter households, τ_{yP} , τ_{yI} and τ_{yR} , are set to 0.3, 0.3, and 0.2, respectively, to reflect the progressivity of the tax code and an average labor income tax rate of around 27%. The capital income tax rate, τ_k , is set to 0.4, following Zubairy (forthcoming), and the consumption tax rate, τ_c , is set to 5%, as in McGrattan and Prescott (2005). 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.

4 Fiscal Experiments

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) increasing the property tax rate, (ii) eliminating the mortgage interest deduction, (iii) eliminating the depreciation allowance for rental income, (iv) instituting taxation of imputed rental income from owner-occupied housing and (v) eliminating the property tax deduction.

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.¹⁶

We quantify the present value of output loss from each experiment using the following expression:

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

where future changes in output are discounted using the time-discount factor of patient households. We also report the constant annualized percent change in output, λ_y , that would generate an equiv-

¹⁶We 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.

alent present-value loss to the above. This is calculated as

$$\sum_{t=0}^{\infty} \beta_P^t (1 + \lambda_y) y_0 = \sum_{t=0}^{\infty} \beta_P^t y_t. \quad (27)$$

We compute similar measures for tax revenue, and report the tax revenue generated by each policy per unit of output loss as a measure of efficiency. To assess the impact of the fiscal experiments on the three types of households in the economy (i.e., patient, impatient and renter households), we also compute the lifetime consumption-equivalent loss of each type of household as a result of the change in fiscal policy. We thus report λ_i that satisfies

$$\sum_{t=0}^{\infty} \beta_i^t U((1 + \lambda_i)c_{i,0}, h_{i,0}, l_{i,0}) = \sum_{t=0}^{\infty} \beta_i^t U(c_{i,t}, h_{i,t}, l_{i,t}), \quad (28)$$

for $i = P, I, R$.

In what follows, we assess the impact of each housing-related fiscal policy change in detail. In Figures 1–5, 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 tax revenue, and welfare implications for each type of agent in the economy. For completeness, we also summarize the steady-state impact of each policy on macroeconomic variables of interest in Table 5.

4.1 Increasing the property tax rate

We first conduct an experiment where we increase the property tax rate permanently from 1.4% to 1.8%, a 0.4 percentage point increase.¹⁷ Note that the tax base for the property tax is rather large, since both owner-occupied and rental housing are subject to the property 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 cost of housing, resulting in a fall in housing demand and output (Figure 1).¹⁸ The fall in housing demand also results in a decline in the relative price of housing in the short run, which reverts back to its initial steady-state level as the effect of investment adjustment costs dissipates and the supply of housing adjusts.¹⁹ Overall tax revenues rise, and government debt is reduced as a result. The present-value output loss as a result of this

¹⁷We have a quarterly model, so we raise the property tax rate – which is equal to $0.014/4=0.0035$ in the initial steady state – by 0.001 when conducting this experiment.

¹⁸In Figures 1–5, we are showing 100 periods (i.e., a 25-year horizon), where most of the variables are close to converging to their terminal steady state. The computations shown in Tables 3–6, on the other hand, are based on the complete transition path of 1,000 periods.

¹⁹There is no permanent change in house prices from the initial to the terminal steady state. This is because the price of housing relative to the non-housing output good deviates from 1 only because of the quadratic adjustment costs in the law of motion of housing (17). 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).

policy is estimated to be 0.61 times the initial level of GDP (i.e., equivalent to a constant annual loss of 0.51% of output), while tax revenue increases by 1.21 times initial GDP in present-value terms (Table 3). Therefore, tax revenue generated per unit of output lost as a result of this policy is 1.99. At the terminal steady state, output and household debt are 0.66% and 2.7% lower, respectively, while the rental rate of housing is about 5% higher, relative to their levels at the initial steady state (see Table 5).

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 and lead to a reduction in their consumption. The patient households, on the other hand, increase their consumption in the short run and reduce capital investment.²⁰ The decline in their saving results in the real interest rate rising on impact. While property taxes directly affect homeowners (owner-occupied or rental), they also have negative consequences for renters. The reduction in rental housing supply causes rents to rise, which in turn leads renters to decrease their consumption in the short run. Comparing the welfare impact across the three agents, both the patient and impatient homeowners are worse off, incurring an annual loss of 0.29% and 0.53% of lifetime consumption-equivalent, respectively, whereas the renters' welfare is nearly unchanged.

4.2 Eliminating the mortgage interest deduction

The impatient households (i.e., borrowers) can deduct their mortgage interest payments from their taxable income. We next consider the consequence of eliminating this deduction; i.e., $I_{m,t} = 0$ for $t \geq 1$. Overall, this shock is also contractionary, leading to a decline in output. While the effects of the elimination of the mortgage deduction differ significantly in terms of impact on different types of agents in the economy, the effects on output are very close in magnitude to the effects of a 0.4% rise in property taxes, as shown in Tables 3 and 5. In particular, output falls by about 0.7% at the terminal steady state, while the present value of output loss during the whole transition path is in the order of 0.56 initial GDPs. Note, however, that this policy raises significantly higher tax revenue per unit of output loss (estimated to be around 2.8) than all the other policies we consider (which range from 1.8 to 2). This is primarily due to the fact that this policy benefits the savers who end up paying more taxes, particularly from property taxes, since they increase their holdings of both owner-occupied and rental housing.

This policy also leads to a significant decline in household debt. Since interest payments are no longer deductible, borrowers demand less housing, which leads to an overall fall in house prices. The negative wealth effect and the tightening of the borrowing constraint lead impatient households to also lower their consumption in the short run (Figure 2). While the impatient households are negatively impacted by this reversal in mortgage deduction, the effects are significantly different

²⁰Non-residential investment declines along with residential investment in the short run, although, in the very long run, the value of non-residential investment is higher at the terminal steady state relative to the initial steady state.

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 as they reduce their capital holdings. The increase in the supply of rental housing leads to lower rents in the short run, which causes renters to increase their consumption due to positive wealth effects. The disparate effects across the three agents are reported in Table 4: the impatient households are significantly worse off, experiencing a 1.86% of lifetime consumption-equivalent loss, whereas patient households and renters are, overall, better off, experiencing welfare gains of 0.66% and 1.09% in lifetime consumption, respectively.

4.3 Eliminating the depreciation allowance for rental income

Owners of rental housing are allowed to deduct depreciation of their rental property from their rental income (i.e., $\tilde{\delta}_{h,t} > 0$), thus reducing their taxable income, where the depreciation allowance for housing can be different from its physical depreciation rate. We next conduct an experiment where we eliminate this depreciation allowance, $\tilde{\delta}_{h,t} = 0$, and explore its impact on macroeconomic variables (Figure 3).

The elimination of the depreciation allowance results in an overall decline in output and housing. Since the effective cost of rental housing goes up, the demand for rental housing 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 of 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 0.24% and 0.18% of lifetime consumption-equivalent gains, 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 16%, and thus renters reduce their consumption. They experience a lifetime consumption-equivalent welfare loss of 2.36%.

Note that the magnitude of the negative impact on output of the elimination of the depreciation allowance for tax on rental income is very similar to the impact of a 0.4 percentage point increase in the property tax rate or the elimination of the mortgage interest deduction (Table 3). However, this policy raises significantly lower tax revenue per unit of output loss, estimated to be around 1.79. This is because, unlike the mortgage interest deduction, elimination of the depreciation allowance hits savers, who reduce their holdings of rental housing, and benefits borrowers, who increase their holding of housing and claim more in mortgage interest deductions in the short run.

4.4 Taxing imputed rental income from owner-occupied housing

Owner-occupied housing receives preferential treatment, since housing services provided by owner-occupied housing are not subject to taxation, unlike rental housing. 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 taxing owner-occupied housing services; i.e., taxing imputed rents under the same assumptions as rental housing, including depreciation allowances. This translates into $I_{r,t} = 1$ for $t \geq 1$ (see Figure 4).

Note that both patient and impatient households in the economy would be subject to this tax, and instituting this taxation is significantly contractionary for the economy. Of the five fiscal policies we consider, this has the largest negative impact on GDP. It results in a steady-state decline of 2.8% with a present-value output loss of 2.6 times initial GDP during the transition path (or, alternatively, an annual loss of 2.2% of output). This policy is estimated to generate about a 2.01-dollars increase in tax revenue per dollar of lost output, a trade-off that is similar to the property tax increase and the elimination of the property tax deduction (Table 3). This policy is also estimated to reduce household debt by about 16.2% at the terminal steady state, substantially more than all the other policies considered in this paper (Table 5).

Since the effective cost of housing goes up, 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 in the short run, since the increase in rental housing lowers rents and allows them to increase their consumption. This policy change has a very large negative impact on the welfare of patient and impatient households, who experience a welfare loss of 2.1% and 3.4%, respectively, in terms of lifetime consumption-equivalents. Renters, on the other hand, experience a welfare gain of 3.4% (Table 4).

4.5 Eliminating the property tax deduction

Both patient and impatient households in the model are subject to property taxes on housing; however, they can deduct their property tax burden from their taxable income. We next consider the effects of repealing this deduction, which is implemented by setting $I_{p,t} = 0$ instead of 1 in the initial steady state (Figure 5). The reversal of property tax deductions propagates through the economy similar to a rise in property taxes, and results in a decline in total housing and output. However, eliminating the property tax deduction leads to significantly larger contractionary effects on the economy, more than a third larger than the effects of eliminating the mortgage interest deduction. In particular, eliminating the property tax deduction leads to a present-value output loss of 0.9 units of GDP (or an annual loss of 0.76% of output).²¹ It also reduces household debt

²¹Note, however, that we might be overstating the impact of eliminating the property tax deduction, since not all homeowners claim this deduction (which requires itemizing deductions), unlike the assumption in the model. One possibility is to assume that only impatient households in the economy can claim this deduction, since they are far

by about 4% at the terminal steady state, about half of the estimated impact of eliminating the mortgage interest deduction.

The effects of this policy propagate very similarly to the effects of an increase in the property tax rate. This policy change leads to a rise in the effective cost of housing, leading to an overall fall in housing demand and a fall in house prices. For impatient households, this results in a tightening of their collateral constraint, so they reduce their borrowing, and, at least in the short run, reduce their consumption. In the long run, they substitute away from housing to consumption, leading to a rise in consumption overall. While patient households also face the same negative wealth effects associated with property taxes no longer being deductible, and lower their demand in the long run, in the short run they demand more consumption and owner-occupied housing due to the fall in the relative price of housing and the decline in desired capital holdings. Patient households reduce their demand for rental housing as well, since rentals are also subject to property taxes. This results in an increase in the rental rate of housing, and leads to a decline in renters' consumption. This policy change, overall, leaves all homeowners in the economy worse off, with patient and impatient households experiencing lifetime consumption-equivalent losses of 0.4% and 0.8%, respectively. The renters are hit negatively by the rise in rents, but over their lifetime are not left worse off, and, overall, experience a very small lifetime welfare gain.

4.6 Tax-neutral experiment

We next conduct a tax-neutral experiment, where we change the five tax policy tools described above in varying degrees to generate an equal amount of tax revenue from each; in particular, we target a revenue amounting to 0.5 initial GDPs in present-value terms (Table 6). This requires increasing the property tax rate by 0.16 percentage points, allowing only 69% of the mortgage interest payments to be deductible, reducing the depreciation allowance by about half, instituting taxation of 8% of imputed rental income from owner-occupied housing or allowing only 73% of the property tax burden to be deductible from income tax.

The ranking of the five tax policies is preserved in terms of output loss relative to what is reported in Table 3. In particular, we find that reducing the mortgage interest deduction would lead to the smallest output loss, while reducing depreciation allowances on rental housing would be the most costly. If we calculate the tax revenue generated for each unit of output loss in Table 6, we get results very close to those reported in the last column of Table 3. This indicates that the effects of the tax policy measures that we consider here are more or less linear in terms of their effects; 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.

In addition, the last column of Table 6 reports the impact of each policy on non-housing output, y_n , in order to judge whether the tax policies have different sectoral implications. For most of the

more likely to itemize deductions in the real world due to the mortgage interest deduction. We conjecture that this would still lead to a larger decline in output than eliminating the mortgage interest deduction or depreciation allowance on rental income.

experiments, about half the present value of GDP loss is due to the policy’s impact on the non-housing sector. At the terminal steady state, the impact on the non-housing sector is slightly less than half of the total GDP impact (Table 5).

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. We find that housing-related fiscal policies, especially those that are more broad-based, such as taxing imputed rents from owner-occupied housing or eliminating property tax deductions, would potentially lead to a large decline in output. The elimination of mortgage interest deductions, which affects only a certain segment of the population, would have a significant yet smaller negative impact on GDP. If the objective is to raise revenues to reduce the government deficit, then our results suggest that repealing mortgage interest deductions would generate the most revenue per unit of output loss. In terms of their impact on household debt, taxing imputed rental income from owner-occupied housing and eliminating mortgage interest deductions would be the most effective.

We also find that different policy instruments have different impacts on savers, borrowers and renters, and these distributional consequences should also be taken into account when instituting changes in housing-related fiscal policies. For example, for the case of eliminating mortgage interest deductions, the decline in welfare would be limited to a particular segment of the population who are mostly young homeowners (borrowers), since many older homeowners in the economy have paid off their mortgage debt (savers).

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 in relation 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 affects all existing homeowners, as opposed to only new homebuyers.

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Table 1. Parameters

	Symbol	Value
Discount factor	β_P, β_I	0.9916, 0.9852
Inverse labor supply elasticity	ϑ	1
Habit in consumption	ζ	0
Level for housing and labor in utility	ξ_h, ξ_l	0.21, 0.45
Loan-to-value ratio	ϕ	0.7
Persistence in borrowing constraint	ρ_b	0.85
Capital share in production	α	0.27
Labor share in production	ψ_P, ψ_I, ψ_R	0.19, 0.54, 0.27
Depreciation rate	δ_h, δ_k	0.0096, 0.015
Investment adj. cost	κ_{ih}, κ_{ik}	30, 8
Stock adj. cost	κ_h, κ_k	0.1, 0
Utilization cost – elasticity	ϖ	5
Transfer share	Ξ_P, Ξ_I, Ξ_R	0.041, 0.035, 0.015
Response of transfers to y and b	ϱ_y, ϱ_b	0, 0.005
Tax rates – consumption	τ_c	0.05
– interest income	τ_b	0.15
– labor income	$\tau_{yP}, \tau_{yI}, \tau_{yR}$	0.3, 0.3, 0.2
– capital income	τ_k	0.4
– property	τ_p	0.014/4

Table 2. Model steady-state ratios versus data targets

	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	0.11
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	0.08	0.08
Wage share in non-housing income	$1 - \alpha$	0.73	0.73
share of patient households	ψ_P	0.19	
share of impatient households	ψ_I	0.54	
share of renter households	ψ_R	0.27	
Capital stock / GDP (qtr)	k/y	7.83	8.00
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

Table 3. Effects of fiscal policies on output and tax revenue (present value and constant annual equivalent)

	Present value		Annual (in percent)		Tax revenue per unit of output lost
	output	tax revenue	output	tax revenue	
Property tax increase by 0.4 p.p.	-0.61	1.21	-0.51	1.02	1.99
Elimination of mortgage interest deduction	-0.56	1.55	-0.48	1.31	2.75
Elimination of depreciation allowance	-0.54	0.96	-0.45	0.81	1.79
Instituting taxation of imputed rents	-2.55	5.10	-2.15	4.30	2.01
Elimination of property tax deduction	-0.90	1.80	-0.76	1.52	1.99

Table 4. Welfare effect of policies on households in lifetime consumption-equivalents

	Savers	Borrowers	Renters
Property tax increase by 0.4 p.p.	-0.29 %	-0.53 %	0.05 %
Elimination of mortgage interest deduction	0.66 %	-1.86 %	1.09 %
Elimination of depreciation allowance	0.24 %	0.18 %	-2.36 %
Instituting taxation of imputed rents	-2.05 %	-3.37 %	3.37 %
Elimination of property tax deduction	-0.44 %	-0.79 %	0.07 %

Table 5. Percent change in key model variables from initial to terminal steady state

(in percent)	y	y_n	c	i_k	i_h	b	r_h	tax
Property tax increase by 0.4 p.p.	-0.66	-0.26	-0.05	-0.26	-3.43	-2.69	3.96	0.81
Elimination of mortgage interest deduction	-0.70	-0.28	-0.05	-0.28	-3.63	-7.86	0.00	1.04
Elimination of depreciation allowance	-0.57	-0.23	-0.05	-0.23	-2.93	-0.42	16.31	0.65
Instituting taxation of imputed rents	-2.82	-1.10	-0.16	-1.10	-14.64	-16.21	0.00	3.58
Elimination of property tax deduction	-0.98	-0.39	-0.07	-0.39	-5.05	-3.98	5.94	1.20

Table 6. Tax-neutral experiment to generate tax revenue of 0.5 initial GDPs in present value

	Tax policy		Present value	
	initial	new	output (y)	non-housing output (y_n)
Property tax increase	$\tau_p = 0.014$	$\tau_p = 0.0156$	-0.25	-0.14
Reduction of mortgage interest deduction	$I_m = 1$	$I_m = 0.69$	-0.19	-0.10
Reduction of depreciation allowance	$\tilde{\delta}_h = 0.0096$	$\tilde{\delta}_h = 0.0047$	-0.28	-0.16
Instituting partial taxation of imputed rents	$I_r = 0$	$I_r = 0.08$	-0.25	-0.14
Reduction of property tax deduction	$I_p = 1$	$I_p = 0.73$	-0.25	-0.14

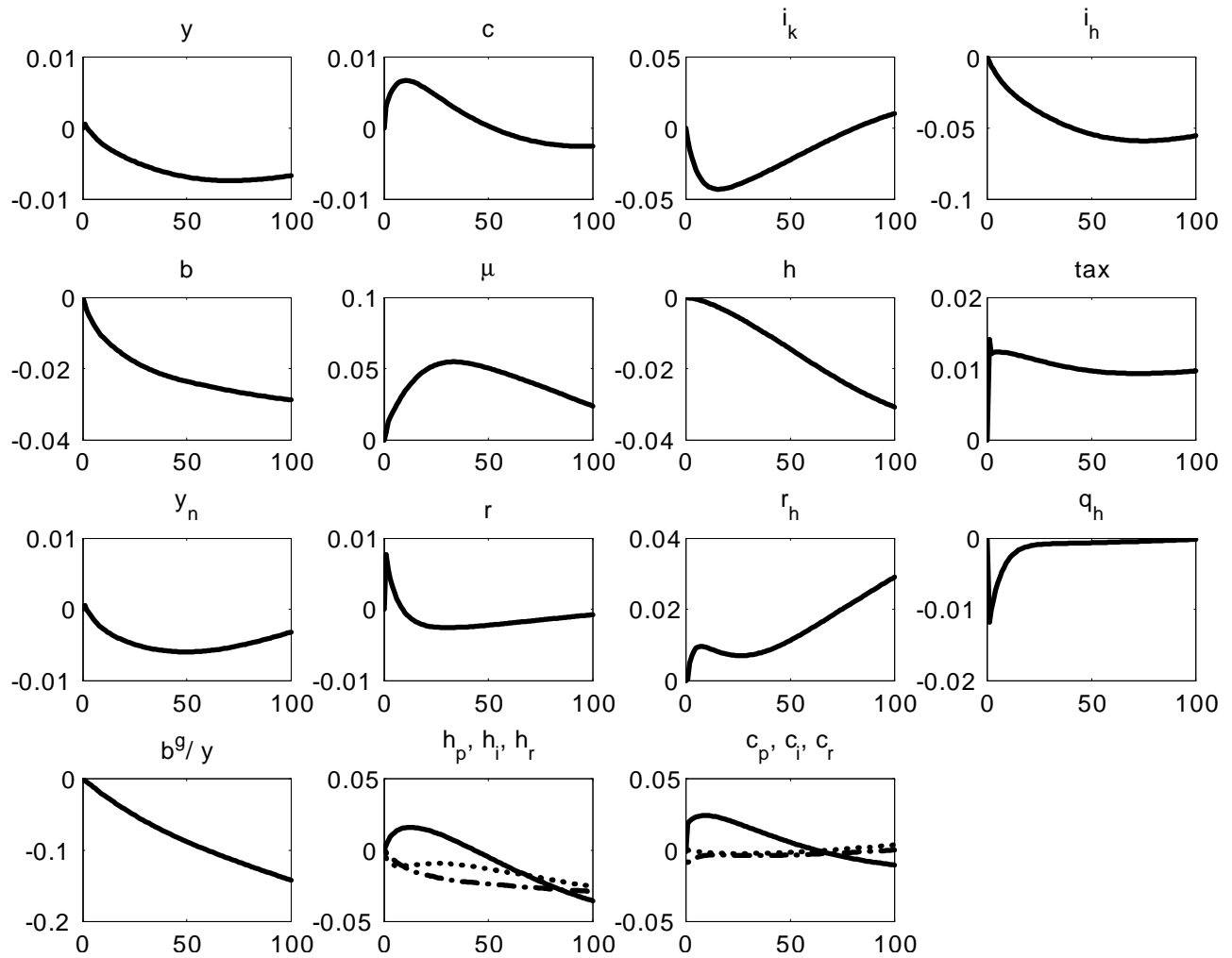


Figure 1: Permanent increase in property tax rate. *Note:* The y-axis measures percent deviation from steady state and the x-axis measures quarters from the shock. The last two panels give the patient household (solid), impatient household (dash) and renter (dot) responses.

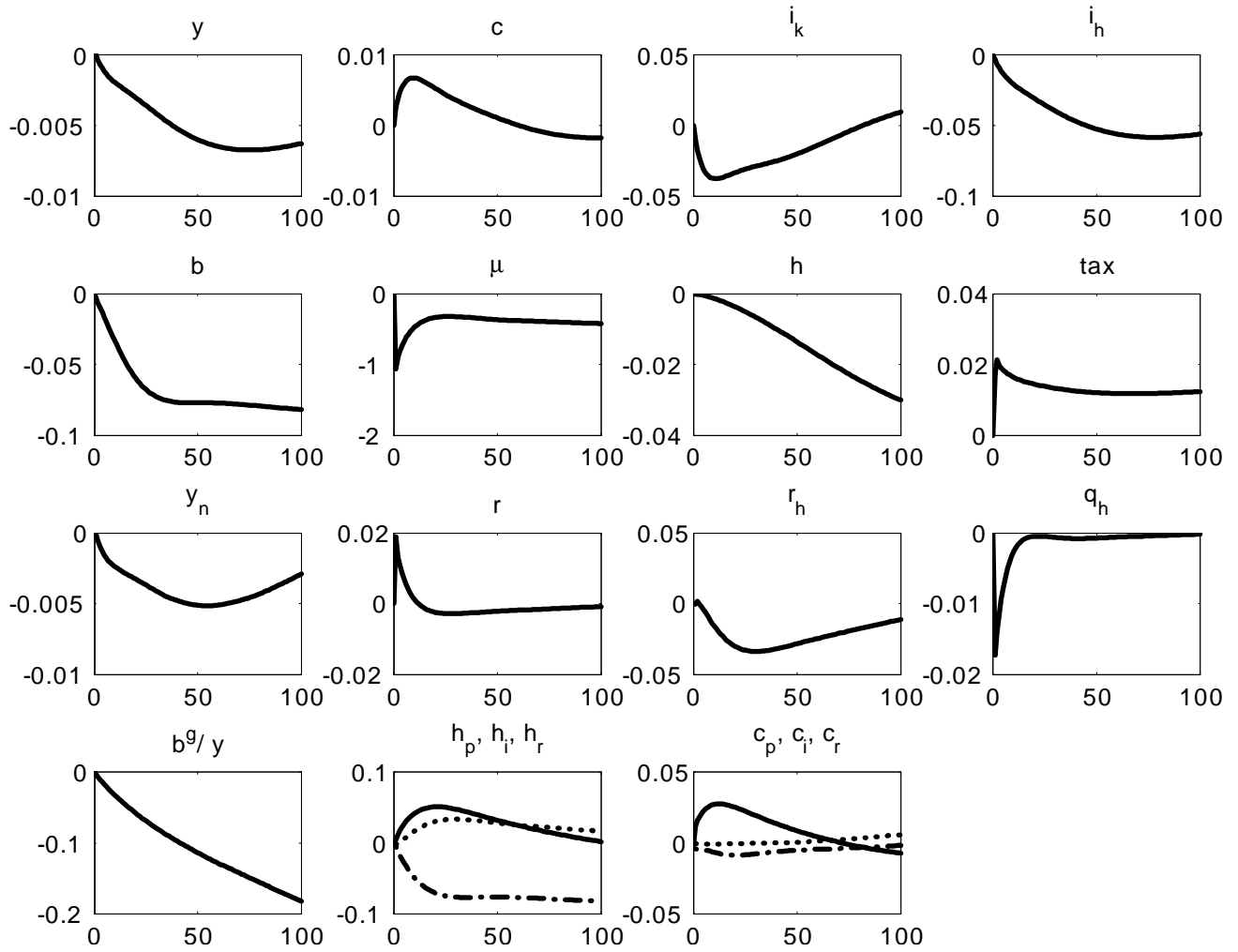


Figure 2: Elimination of mortgage interest deduction. *Note:* The y-axis measures percent deviation from steady state and the x-axis measures quarters from the shock. The last two panels give the patient household (solid), impatient household (dash) and renter (dot) responses.

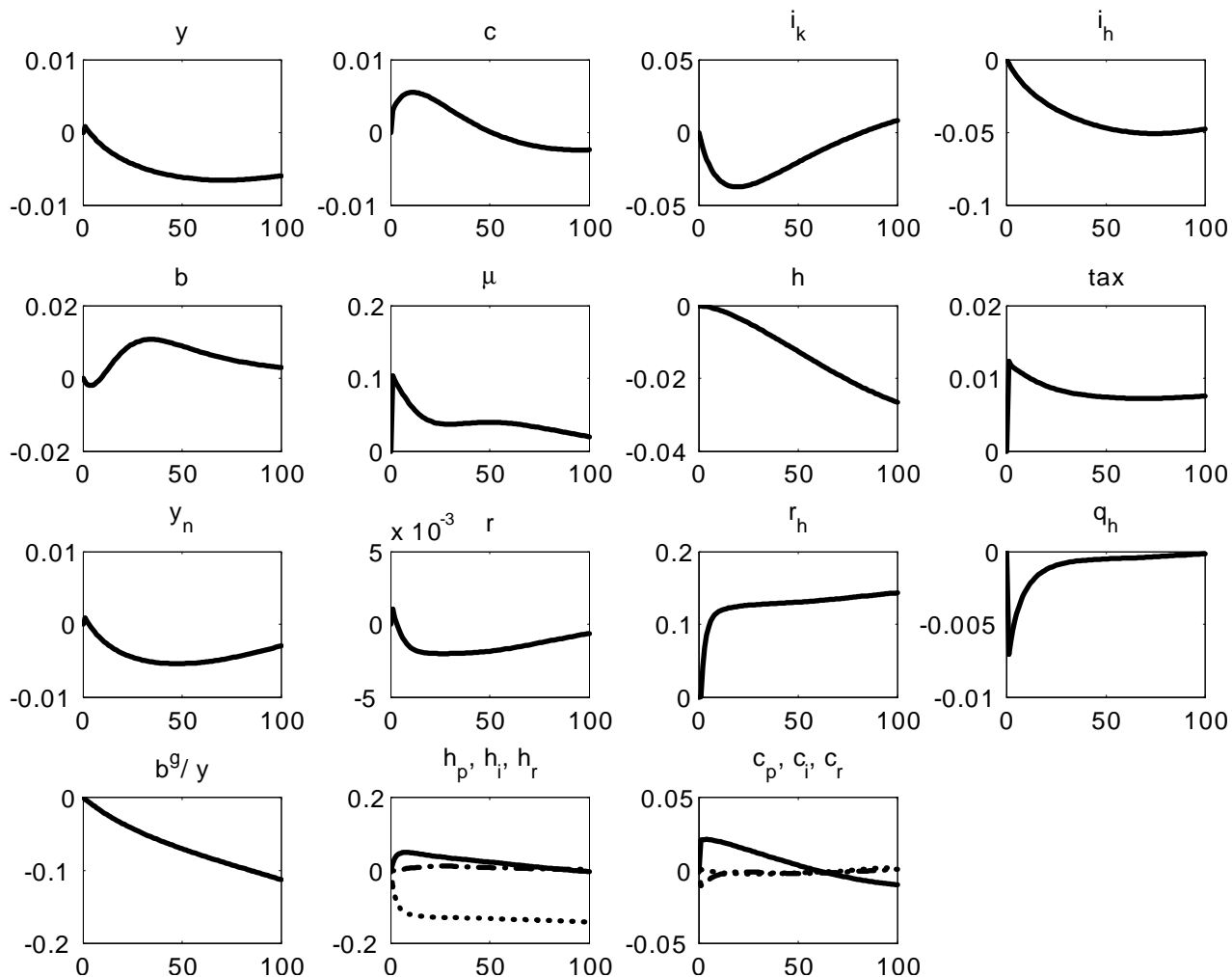


Figure 3: Elimination of depreciation allowance for taxes on rental income. *Note:* The y-axis measures percent deviation from steady state and the x-axis measures quarters from the shock. The last two panels give the patient household (solid), impatient household (dash) and renter (dot) responses.

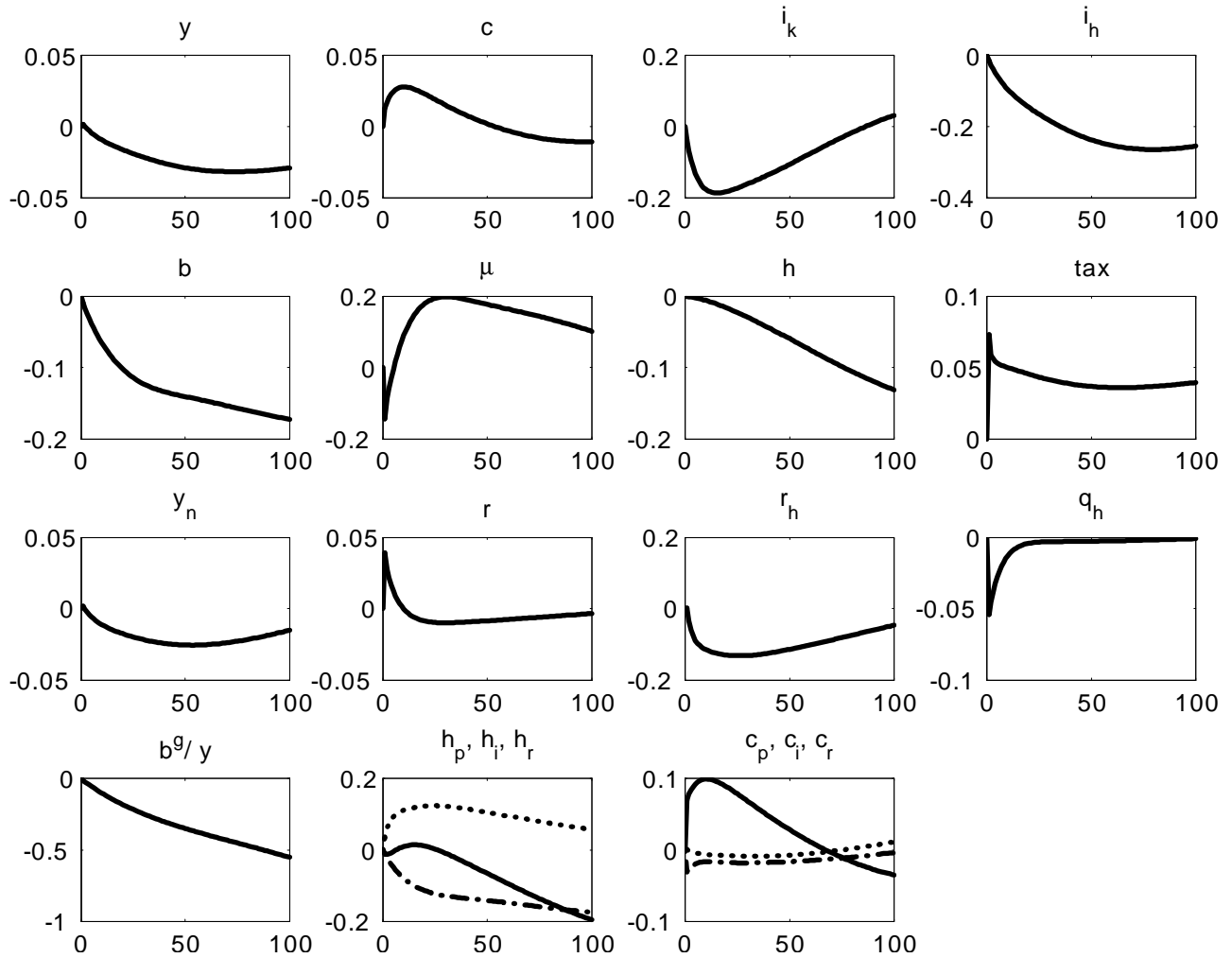


Figure 4: Instituting taxation of imputed rents. *Note:* The y-axis measures percent deviation from steady state and the x-axis measures quarters from the shock. The last two panels give the patient household (solid), impatient household (dash) and renter (dot) responses.

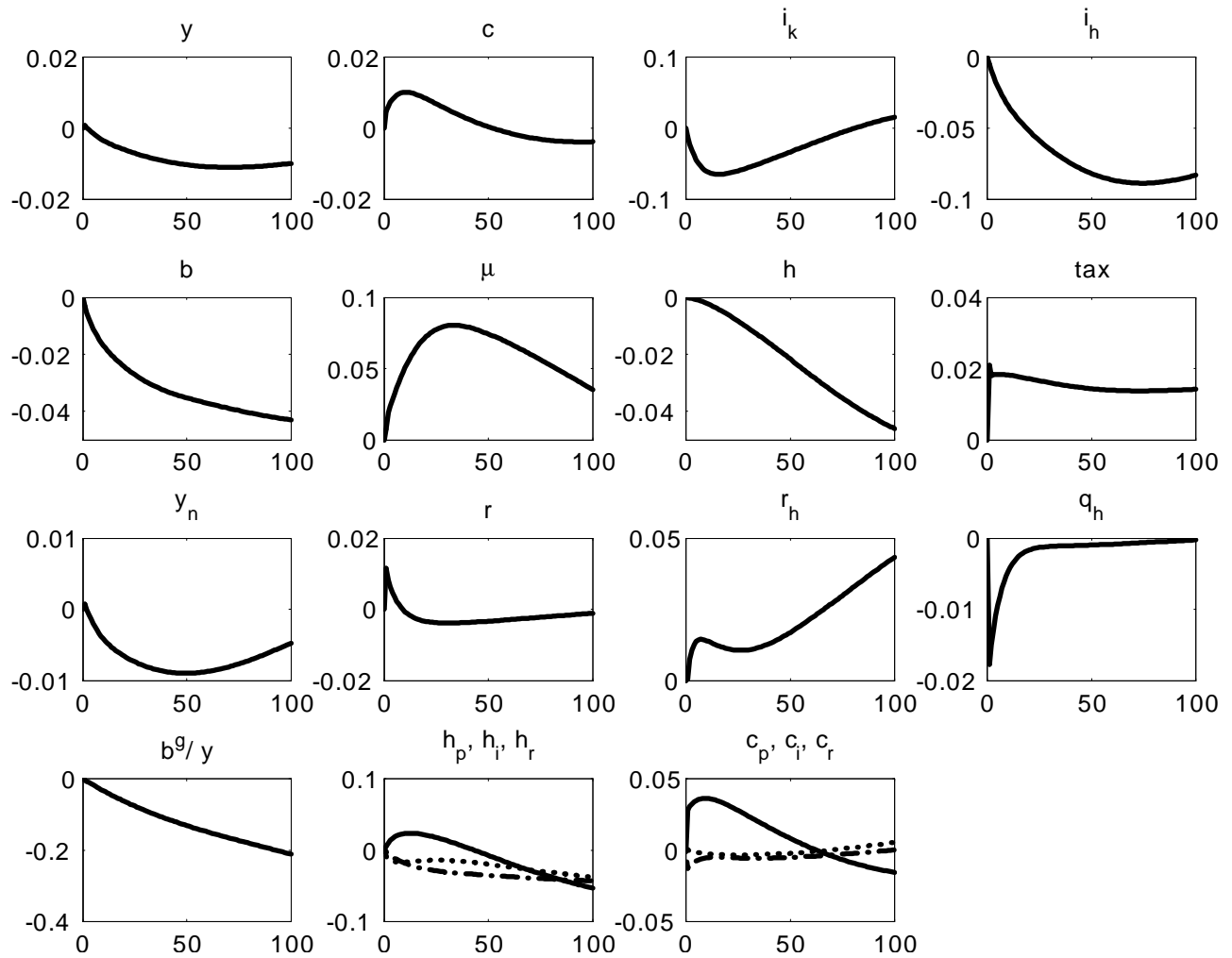


Figure 5: Elimination of property tax deduction. *Note:* The y-axis measures percent deviation from steady state and the x-axis measures quarters from the shock. The last two panels give the patient household (solid), impatient household (dash) and renter (dot) responses.