Housing tax expenditures and financial intermediation

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Abstract. Through the lens of a multi-agent dynamic general equilibrium model, we examine the effects of changes in preferential housing-related tax treatments on macroeconomic aggregates and welfare. Our first finding is that financial frictions on banks contribute to lowering tax multipliers. The multipliers that we find are smaller over a horizon of 20 quarters—they range from −0.55 to −0.35, while the long-run tax multipliers range from −1.12 to −0.74. We then find that the reduction in the deduction of mortgage interest payments delivers the lowest long-run multiplier. We also implement revenue-neutral tax reforms and find that the repeal of mortgage deductibility is the best housing tax policy because it generates small losses in output.

Résumé. Les dépenses fiscales en logement et l'intermédiation financière. Dans l'optique d'un modèle d'équilibre général dynamique multiagent, nous examinons les effets des changements apportés aux traitements fiscaux préférentiels sur le marché du logement, les agrégats économiques et le bien-être. Notre première conclusion, c'est que les frictions financières sur les banques contribuent à diminuer les multiplicateurs fiscaux. Les multiplicateurs que nous observons sont plus petits sur un horizon de 20 trimestres, allant de -0,55 à -0,35, tandis que les multiplicateurs fiscaux à long terme se situent dans une fourchette de -1,12 à -0,74. Nous constatons ensuite que la réduction de la déduction des versements d'intérêts hypothécaires procure le multiplicateur à long terme le plus faible. Nous appliquons également des réformes fiscales sans incidence sur les recettes et constatons que l'abrogation de la déductibilité de l'hypothèque constitue la meilleure politique fiscale en matière de logement, puisqu'elle génère de petites pertes de production totale.

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1. Introduction

THE IMPORTANCE OF housing finance has grown substantially in the past decades in the United States. In 2019, the residential mortgage debt-to-annual-GDP ratio was 50%, down from its peak in 2009 (74%), but still significantly higher than in 1970 (26%) (Board of Governors). Its weight on the commercial banks' balance sheets has also grown substantially. Specifically, mortgage lending as a fraction of total bank lending was as high as 70% prior to the Great Financial Crisis in 2007, up from 55% in 1970 (Jordà et al. 2017). It has gone down in the following decade, yet it was still accounting for 63% of total bank lending in 2016. Moreover, housing value as a proportion of GDP has almost doubled in less than 40 years—moving up from 0.9 in 1970 to 1.7 in 2007. This build-up in mortgage debt and housing value is partially due to the favourable treatment of housing in the US tax code. In fact, mortgage interest payments are deductible from taxable income and imputed rents on owner-occupied housing are exempted.[1]

According to the U.S. Department of the Treasury, these two tax expenditures alone will cost the government over $2 trillion in the next ten years (2020–2029).[2] The Tax Cuts and Jobs Act (TCJA) passed by the Trump administration in December 2017 has made the investigation of the effectiveness of housing tax treatments even more relevant.[3] In addition, such tax expenditures generally seem to be regressive. Curtailing the housing fiscal policies would lead to greater tax revenues for the government, but at the expense of output losses. Therefore, the key questions addressed by this paper are: What are the effects of such house tax expenditure reforms in the short and long run on aggregate quantity variables and welfare? Alternatively, how would these variables react if the government decides to implement tax revenue-neutral reforms?

Previous works examine the interactions of housing tax policies with other sectors of the economy. What distinguishes our paper from others is that we pay special attention to the role of financial intermediaries. In fact, recent work that examine the role of banking on business cycles find that the presence

1 Another important housing tax expenditure is the exemption of capital gains tax on main residence. We do not consider its effects simply because our framework, which features three types of representative households, does not capture transactions within each type. See Cunningham and Engelhardt (2008) and Shan (2011) for empirical contributions to the literature that specifically examine the effects of this tax expenditure.

2 Specifically, the exclusion of net imputed rental income, which is the second largest tax expenditures, will cost $1,643 billion and the mortgage interest deduction $600 billion.

3 The TCJA encompasses a repeal of mortgage interest deductibility for the portion of mortgages that exceed $750,000—down from $1 million.

of intermediaries strongly amplify and propagate shocks.[4] Contrary to this strand of the literature, our results suggest that the presence of banks can dampen the effects of permanent housing tax policy changes. Given this recent interest in the literature on the role of banks for business cycles, we believe that our work fills a gap in the literature by examining housing tax policies in conjunction with banking. Therefore, a third research question that we tackle in this paper is: How does the presence of financial frictions in the banking sector propagate changes in housing tax policies?

To answer these questions, we augment Alpanda and Zubairy's (2016) model. They incorporate in their framework the multi-agents structure and household borrowing constraints that are featured in Iacoviello's (2005) work.[5] In addition to patient, impatient and renter households that are present in their framework, we introduce bankers to the economy in a similar fashion to Iacoviello (2015). The policy changes that we examine affect only the intensive margin of housing because households cannot switch types. As we discuss in section 5.3, this assumption is consistent with the empirical evidence. Many papers in housing economics (discussed in the following section) feature heterogeneous agents and life-cycle models for which the extensive margin also plays a role. The latter modelling choice allows for tracking the effects of policy changes by age and income groups. However, for tractability reasons, the number of state variables is limited and these models typically do not consider the transitional dynamics of investment in non-durable goods, nor the inter-temporal budget constraint of the government.

The housing tax policies that we examine are: (i) the deduction of mortgage interest payments for impatient households, (ii) the deduction of imputed rents, (iii) the property tax and (iv) the depreciation allowance.[6] Housing tax policies are ranked according to the values of their long-run multipliers, which correspond to the ratio of the present value loss in output over the present value of tax revenues that are raised. We find short-run multipliers that range from -0.55 to -0.35 and long-run multipliers that range from -1.12 to -0.74.

We find that the presence of banking contributes to lowering the multipliers. This result is particularly interesting because much work in the macro-finance literature emphasizes the fact that bank capital instead amplifies the responses of aggregate variables to shocks. The widely cited study by Gertler and Karadi (2011) presents amplification effects due to financial

4 See, e.g., Angeloni and Faia (2013), Brunnermeier and Sannikov (2014), Gerali et al. (2010), Gertler and Karadi (2011), Gertler and Kiyotaki (2010), Iacoviello (2015), Meh and Moran (2010).

5 Another paper that uses the structure of Iacoviello (2005) to examine housing tax policy is Ortega et al. (2011). However, they focus on the Spanish housing market and their policy instruments differ. Specifically, they examine the role of subsidies on house purchases and rentals.

6 Owners of rental housing have access to a deduction for depreciation allowance.

intermediation for three shocks: technology, capital quality and monetary. For the latter shock, the maximal deviations from the steady states of output and investment are three times larger with the introduction of a banking sector. Meh and Moran (2010) also find large amplification and propagation effects; specifically, the responses of output and investment to technology shocks are almost doubled after 20 quarters with financial intermediation.

In contrast, we find that the presence of this sector dampens the adverse effects of changes in housing tax policies. Specifically, the less favourable policies are for impatient households, the more effective they are at limiting output losses. The distortion created by the deduction of interest mortgage payments is important to understand the degree of negative effects. When this distortion is directly partially eliminated, i.e., in the case of policy (i), the output loss that ensues is the smallest (the long-run multiplier is −0.74). On the opposite end of the spectrum, the reduction of the depreciation allowances for rental income (i.e., policy (iv)) directly affects renters since the rental price of housing increases. There is a shift from rental to owner-occupied housing that takes place, which is beneficial for impatient households. This leads to an increase in mortgage payments for the latter that does not benefit the government because these payments are fully deductible. Hence, depreciation allowances need to be further decreased in order for tax revenues to accrue. This reallocation of housing is detrimental in terms of output losses (the long-run multiplier is −1.12).

The results of this paper illustrate that the presence of the banking sector deflates the effects of these policies on output losses—especially in the short run. The causes of these smaller multipliers are somewhat similar for the first three experiments, which have strong adverse effects on the demand for housing and mortgages by impatient households. These results are related to the fact that banking gives rise to a spread between the borrowing and lending rates, which corresponds specifically to the mortgage and deposit rates in the baseline model. In the model without banking, the spread is absent, and therefore, there is only one interest rate. Following a change in a housing tax policy that increases tax revenues, the three rates mentioned above fall—the mortgage rate falls the most, followed by the interest and deposit rates. Since this leads to diminishing spread and bankers' profits, we assert that the banking sector partially shields both impatient and patient households from the adverse effects of housing tax policy changes. In fact, a lower deposit rate induces negative effects for patient households, which, taken in isolation, lead them to slow down their accumulation of capital and housing (owner-occupied and rental). The banking sector dampens this effect as the fall in the deposit rate is less severe than in the interest rate. In contrast, the fall in the mortgage rate is more severe, but this is a better outcome for impatient households as lower mortgage rates dampen the fall in demand for housing by these agents. In sum, the effects on patient and impatient households taken together translate into less downward pressure on GDP.

As for the reversal of the depreciation allowance, the responses of mortgages take the opposite sign than the three other experiments. Renters respond by reducing their demand for housing, which subsequently leads to a fall in housing prices and to a reallocation of housing in favour of patient and impatient households. Therefore, bankers need to provide more mortgages and, at the same time, their capital adequacy constraint compels them to attract more deposits. Hence, as they raise the deposit rate more than the mortgage rate, it triggers a similar income effect for patient households as described in the previous paragraph, which partially softens the fall in rental housing.

Finally, we implement three revenue-neutral tax experiments: the repeal of mortgage deductibility, the taxation of imputed rents at the same rate as labour income and the repeal of the depreciation allowance for rental income. The first two experiments are similar to the ones that Chambers et al. (2009), Cho and Francis (2011), Gervais (2002) and Sommer and Sullivan (2018) examine. For each of these experiments, we lower the labour income taxes, so that the present value of taxes is nil. Lower labour income taxes incentivize agents to work more hours; however, the rise in non-housing output is not large enough to overturn the effects of the fall in housing stock in the long run. In fact, out of the three reforms, the repeal of mortgage deductibility generates the smallest losses in output in the long run, which makes it the most appealing policy.

The rest of this paper is organized as follows. In section 2, we review the related literature. Sections 3 and 4 present the model and its calibration, respectively. Section 5 discusses the effects of permanent housing tax policy changes on the main aggregate variables and on welfare. Section 6 concludes.

2. Related literature

Our paper is related to the literature that examines the effects of changes in housing tax policy through the lens of theoretical models.[7] Gervais (2002) embeds the decisions of households to own or rent in a general equilibrium life-cycle model. His baseline model features the same properties of the US tax code for the housing sector and financial institutions are embedded to simplify the exposition. These institutions are a veil because they are zero-profit and unconstrained. In contrast, in our model, they play an active role in dampening the effects of policy changes. Gervais (2002) conducts two separate experiments: he introduces taxation for imputed rents and a repeal of mortgage interest deductions. Both of these experiments are tax revenue neutral given that the income tax rate is lowered simultaneously. By comparing steady state outcomes, he finds that both of these changes are welfare

7 For empirical contributions to the literature, see Glaeser and Shapiro (2003), Poterba (1992), Poterba and Sinai (2008), Rosen (1979).

improving because they allow households to better smooth their consumption. They result in significant shifts of resources from housing to business capital when imputed rents are taxed and when mortgage interest deductions are repealed. Homeownership declines significantly following these housing tax policy changes.

In a similar type of framework, Cho and Francis (2011) find that the same two policy changes do not reduce inequality, while Chambers et al. (2009), by focusing on the supply of rental property and the progressivity of the US tax system, corroborate a crowding-out effect. Specifically, the stock of housing falls and capital increases in response to the elimination of some asymmetries in housing taxation. Floetotto et al. (2016) emphasize the importance of considering transitional dynamics prior to undertaking housing tax policy changes. In fact, because in the short run, the fall in house prices overshoots its level in the terminal steady state, they find that taxing imputed rents is welfare improving in the long run for the economy, but not in the short run. Similarly, for the repeal of mortgage interest deduction, the positive effects on welfare are greater in the long run than in the short run. There are also important distributional effects that result from changes in these policies. Sommer and Sullivan (2018) underline the interaction between the progressivity of income taxation and the consequences of the repeal of mortgage interest deduction. In contrast, Floetotto et al. (2016) consider only a flat income tax. The decline in house prices in response to this tax policy change is welfare improving for 58% of households and contributes to an increase in homeownership for Sommer and Sullivan (2018).

Chatterjee and Eyigungor (2015) simulate a model with shocks that reproduce the house price and foreclosure dynamics of the recent financial crisis. From their counterfactual experiment, they find that the rise in foreclosures would have been 10 percentage points lower—and the crisis much smaller—without a preferential tax treatment of mortgage interest payments. The model that we simulate is based on Alpanda and Zubairy (2016) and the tax policy changes that we examine are similar to the ones that they present. We find much smaller long-run multipliers than them—precisely, they are from 49% to 52% smaller. However, as reported by Ghiaie and Rouillard (2021), there is a coding error in their model that greatly affects the dynamics of business investment and thereby the multipliers that they obtain. Alpanda and Zubairy (2017) compare the effectiveness of various policies that are aimed at reducing household indebtedness because a high level of debt poses threats to financial stability. They find that a reduction in mortgage interest deduction—via its effects on home equity loans—is more effective and less costly than an increase in property taxes and a tightening of monetary policy.

From the simulation of a housing search model that features geographical mobility and labour market frictions, Head and Lloyd-Ellis (2012) find that the elimination of mortgage interest deductibility leads to declining house prices and unemployment. Bielecki and Stähler's (2022) new Keynesian model also features housing search frictions. They find that labour tax reductions financed by a rise in property taxes generates the highest level of welfare.

As we have mentioned above, we show that the banks' balance sheet channel is important in explaining the dynamics of macroeconomic aggregates following changes in housing tax policy. In our model, the banking sector is not a veil, in contrast to most work in the macro-housing literature. Financial intermediation in the household mortgage market is present in other work; however, they focus on different objectives than our paper.[8] Iacoviello (2015) examines how the inclusion of a banking sector to a DSGE model amplifies and propagates financial shocks. Elenev et al. (2016) study the role of mortgage default insurance that is provided by the government on the amount of risk exposure by the banks. Contrary to their work, we do not consider home foreclosures. Finally, Landvoigt (2016) puts forward the role of mortgage loans' securitization to explain the US housing boom in the 2000s.

3. Model

In this section, we present the optimization problems of the agents, the firms and the capital and housing producers. We also show and discuss the tax instruments that the government possesses in the economy. We refer the reader to the appendix for a complete derivation of the first-order conditions. All agents consume non-durable goods. Patient, impatient and renter households also derive utility from housing services and leisure. Actions that are specific to each type of agents are as follows. Patient households rent a fraction of their housing stock to renters, accumulate housing and capital stocks and earn interest on deposits made to bankers and on their holdings of government bonds. Impatient households finance their consumption and housing investment by contracting mortgage loans from bankers. Their loans are constrained by the value of their housing stock which is their collateral asset. We assume that renters are *hand-to-mouth*, so that their consumption of non-durable goods and houses corresponds to their after-tax labour income. Bankers act as a transmission belt between impatient and patient households. They issue mortgages from the deposits made by patient households. However, they face a capital adequacy constraint that does not allow deposits to exceed a fraction of mortgages issued. Finally, the government collects taxes from various sources, borrows from patient households, makes transfer payments to agents and makes expenses.

3.1. Patient households

Patient households are savers because they have a greater discount factor than other agents ($\beta_P > \beta_i$, where $i = I, R, B$ and denotes impatient households,

8 For a review of the literature on the role of banking in dynamic general equilibrium models, see Galati and Moessner (2013).

renters and bankers, respectively). They maximize the following discounted sum of period utilities:

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \left\{ \log c_t^P + \varphi_h \log h_{t-1}^P - \varphi_l \frac{(l_t^P)^{1+\iota}}{1+\iota} \right\}, \tag{1}$$

where c_t^P corresponds to their consumption of non-durable goods, h_{t-1}^P to their housing stock chosen in period $t-1$ and l_t^P to their labour supply. The parameters φ_h and φ_l correspond to the weights allocated to housing and leisure and ι to the inverse of the Frisch elasticity of labour supply. The flow utility of housing or housing services are given each period by $\varphi_h \log h_{t-1}^P$.

Patient households' budget constraint is as follows:

$$\begin{aligned}
&(1+\tau_c)c_t^P + p_t^h \left[h_t^P - (1-\delta_h)h_{t-1}^P\right] + p_t^h \left[h_t^R - (1-\delta_h)h_{t-1}^R\right] \\
&\quad + p_t^k \left[k_t - (1-\delta_k)k_{t-1}\right] + d_t + b_t^g \leq w_t^P l_t^P + p_t^R h_{t-1}^R \\
&\quad + (1+r_{t-1}^d)d_{t-1} + (1+r_{t-1}^g)b_{t-1}^g + r_t^k k_{t-1} + \Gamma_t^P \\
&\quad - \tau_y [w_t^P l_t^P + (p_t^R - \tilde{\delta}_{ht})(h_{t-1}^R + I_{rt} h_{t-1}^P) - \tau_{pt} p_t^h (h_{t-1}^P + h_{t-1}^R)] \\
&\quad - \tau_d \left[r_{t-1}^d d_{t-1} + r_{t-1}^g b_{t-1}^g\right] - \tau_k (r_t^k - \delta_k) k_{t-1} \\
&\quad - \tau_{pt} p_t^h (h_{t-1}^P + h_{t-1}^R) - AC_t^P,
\end{aligned} \tag{2}$$

where h_t^R is the rental housing stock, k_t is the capital stock that they rent to firms at rate r_t^k. It depreciates at rate δ_k. The relative prices of housing and capital are p_t^h and p_t^k, respectively. Note that there are adjustment costs AC_t^P for choosing levels of housing that deviate from their values in the previous period.[9] Every period, patient households also choose the amount of deposits that they make to bankers d_t and the quantity of lending that they make to the government b_t^g. Interest accrue at rates r_{t-1}^d and r_{t-1}^g, respectively. Patient households are paid wages w_t^P for the hours that they work for firms. Their rental income corresponds to $p_t^R h_{t-1}^R$, where p_t^R is the rental price. There is a depreciation allowance for housing $\tilde{\delta}_{ht}$, which may differ from the depreciation rate of housing δ_h.

The government has many instruments to tax patient households: τ_c is the consumption tax rate, τ_y is the tax on labour and rental income, τ_d is the tax on interest income, τ_k is the tax on capital income and τ_{pt} is the property tax rate on housing. $0 \leq I_{rt} \leq 1$ is another policy instrument that is inversely proportional to the deduction of imputed rental income. Finally, the government transfers Γ_t^P to these households.

In order to examine the effects of tax policy changes, we present the first-order conditions with respect to owner-occupied and rental

9 We assume that these costs are quadratic:
$AC_t^P = \frac{\psi_a}{2\bar{h}^P} p_t^h (h_t^P - h_{t-1}^P)^2 + \frac{\psi_a}{2\bar{h}^R} p_t^h (h_t^R - h_{t-1}^R)^2$

housing.[10] The first-order condition with respect to owner-occupied housing is

$$\lambda_t^P p_t^h = \beta_P \mathbf{E}_t \left\{ \frac{\varphi_h}{h_t^p} + \lambda_{t+1}^P \left[(1 - \delta_h - \tau_{pt+1}(1 - \tau_y)) p_{t+1}^h - I_{rt+1} \tau_y (p_{t+1}^R - \tilde{\delta}_{ht+1}) \right] \right\}, \tag{3}$$

where λ_t^P is the Lagrange multiplier on the budget constraint. In equilibrium, it is equal to the marginal utility of consumption. The left-hand side of equation (3) corresponds to the cost in terms of consumption that the patient households incur to purchase an additional unit of owner-occupied housing stock, while the right-hand side presents the benefits of that additional unit. Patient households derive utility from consuming housing services and they also make capital gains that are taxed. One can see that the government distorts the decisions of investing in owner-occupied housing via its tax policy instruments. The government also distorts incentives for patient households to own rental housing. Specifically, the first-order condition with respect to rental houses is

$$\lambda_t^P p_t^h = \beta_P \mathbf{E}_t \left\{ \lambda_{t+1}^P (1 - \delta_h - \tau_{pt+1}(1 - \tau_y) p_{t+1}^h + (1 - \tau_y) p_{t+1}^R + \tau_y \tilde{\delta}_{ht+1}) \right\}. \tag{4}$$

In a similar fashion to owner-occupied housing, the left-hand side shows the marginal costs of increasing rental houses and the right-hand side the marginal benefits. Changes in tax policies can also affect the decisions of investing in rental housing.

To better illustrate these effects, we combine equations (3) and (4):

$$\frac{\varphi_h}{h_t^p} = \mathbf{E}_t \left\{ \lambda_{t+1}^P \left[p_{t+1}^R + (I_{rt+1} - 1) \tau_y (p_{t+1}^R - \tilde{\delta}_{ht+1}) \right] \right\} \tag{5}$$

The left-hand side is the marginal utility derived from housing services provided to homeowners, while the first term on the right-hand side corresponds to the marginal utility from renting out properties. If the imputed rents are fully taxed, i.e., $I_{rt+1} = 1$, then the latter two marginal utilities are equalized. Otherwise, the partial taxation of imputed rents gives some additional incentives to own. A reduction in depreciation allowances also leads to more incentives to owning compared with renting out.

3.2. Impatient households

As stated in the previous section, impatient households have a lower discount factor than patient households, and are also called borrowers. This is the only

10 For the sake of simplification, we set the parameters that governs adjustment costs to zero when presenting the first-order conditions. We refer the reader to the appendix for a complete derivation of the first-order conditions.

difference with regards to the function that they maximize. However, their budget constraint is different:

$$(1+\tau_c)c_t^I + p_t^h\left(h_t^I - (1-\delta_h)h_{t-1}^I\right) + (1+r_{t-1}^m)M_{t-1} \leq w_t^I l_t^I + M_t$$
$$+ \Gamma_t^I - \tau_y\left[w_t^I l_t^I - I_{mt}r_{t-1}^m M_{t-1} + I_{rt}(p_t^R - \tilde{\delta}_{ht})h_{t-1}^I - \tau_{pt}p_t^h h_{t-1}^I\right]$$
$$- \tau_{pt}p_t^h h_{t-1}^I - \frac{\psi_a}{2\overline{h}^I}p_t^h(h_t^I - h_{t-1}^I)^2 \qquad (6)$$

Every period, they choose their consumption levels c_t^I, their housing stock h_t^I, their labour l_t^I and their mortgage loans M_t. They face quadratic adjustment costs for changing their housing stock. They are paid at wage w_t^I, and they must repay their mortgage loan contracted the previous period in addition to the interest rate r_{t-1}^m due on these loans. They also receive transfers Γ_t^I from the government. Impatient households face four tax policy instruments. Three of them are similar to the ones faced by patient households. The fourth one is the deductibility of mortgage interest payments $0 \leq I_{mt} \leq 1$, where $I_{mt} = 1$ indicates that these payments are fully deductible. Their mortgage loans are constrained by their housing value as follows:

$$M_t \leq \rho_m M_{t-1} + (1-\rho_m)\theta p_t^h h_t^I, \qquad (7)$$

where θ corresponds to a loan-to-value and ρ_m to the degree of inertia in mortgage borrowing. Hence, if the value of their housing stock increases, impatient households are able to borrow more.

Setting housing investment adjustment cost to zero, the first-order condition with respect to housing is

$$\lambda_t^I p_t^h = (1-\rho_m)\theta\lambda_t^m p_t^h + \beta_I \mathbf{E}_t$$
$$\left\{\frac{\varphi_h}{h_t^I} + \lambda_t^I\left(1-\delta_h - \tau_{pt+1}(1-\tau_y)\right)p_{t+1}^h - I_{rt+1}\tau_y(p_{t+1}^R - \tilde{\delta}_{ht+1})\right\}, \qquad (8)$$

where λ_t^I is the Lagrange multiplier of the budget constraint that is equal to the marginal utility of consumption in equilibrium. λ_t^m is the Lagrange multiplier of the borrowing constraint. The marginal costs and benefits of increasing housing resemble those of the patient owner-occupied housing. The only difference is the additional benefit that allows impatient households to borrow more when they invest in housing.

The first-order condition with respect to mortgage loans is as follows:

$$\lambda_t^I = \lambda_t^m + \beta_I \mathbf{E}_t\left\{\lambda_{t+1}^I(1+(1-I_{mt+1}\tau_y)r_t^m - \lambda_{t+1}^m\rho_m)\right\} \qquad (9)$$

In a similar fashion to other first-order conditions, the left-hand side consists of the marginal gain from borrowing, while the right-hand side shows the marginal costs. There are costs related to the tightening of the borrowing constraint and the repayment of the mortgage loan in the following period.

Through the deduction of mortgage interest I_{mt}, the government can affect the effective interest rate at which impatient households repay their mortgage loans.

3.3. Renters

The renters' period-utility function is identical to those of patient and impatient households. We assume that they have a lower discount factor than the patient households. Their budget constraint is as follows:

$$(1+\tau_c)c_t^R + p_t^R h_{t-1}^R \leq (1-\tau_R)w_t^R l_t^R + \Gamma_t^R \tag{10}$$

They consume non-durable goods c_t^R, rent houses h_{t-1}^R from patient households at price p_t^R, work l_t^R, and receive transfers from the government Γ_t^R. They earn w_t^R for their labour. Note that their labour income is taxed at a different rate (τ_R) than patient and impatient households. Since they are not able to borrow or invest, they are considered as *hand-to-mouth* agents. Finally, the housing tax policy changes do not affect these agents directly, but indirectly through the changes in rental housing prices. The first-order condition with respect to rental housing is as follows:

$$p_t^R = \frac{\varphi_h}{\lambda_t^R h_{t-1}^R}, \tag{11}$$

where λ_t^R is equal to the marginal utility of consumption of renters. Since we do not allow renters to become homeowners and vice versa, we assume for simplification sake that renters derive utility from housing in a similar fashion to homeowners.[11]

3.4. Bankers

Bankers are the financial intermediaries in the economy. We assume that they are the only agents that have the technology to redirect funds between agents. Their assets are composed of mortgages contracted to impatient households and liabilities of deposits from patient households. They maximize the following problem:

$$\max \mathbf{E}_t \sum_{\tau=t}^{\infty} \beta_B^{\tau-t} u\left(c_\tau^B\right), \quad \text{where } u\left(c_\tau^B\right) = \begin{cases} \dfrac{\left(c_\tau^B\right)^{1-\sigma} - 1}{1-\sigma} & \text{if } \sigma \neq 1 \\ \log\left(c_\tau^B\right) & \text{if } \sigma = 1 \end{cases}$$

subject to

$$(1+\tau_c)c_t^B + (1+r_{t-1}^d)d_{t-1} + M_t = d_t + (1+r_{t-1}^m)M_{t-1} \tag{12}$$

$$d_t \leq \phi M_t, \tag{13}$$

11 In some housing literature, renters derive less utility of housing. In our model, this would result in lower rents in equilibrium since, from equation (11), the value of φ_h would be smaller for renters. The transition paths following changes in housing tax policies would remain the same; however, the changes in welfare for renters would be smaller in absolute value.

where $\beta_B < \beta_P$. Equation (12) corresponds to a budget constraint, while equation (13) is a borrowing constraint as we explain below. From the bankers' perspective, deposits are liabilities, while mortgages are assets. Since in equilibrium the interest rate on mortgages r_t^m is greater than the interest rate on deposits r_t^d, they are able to make profit that they consume. i.e., c_t^B. Since bankers have a lower discount factor than patient households, it would be optimal for them to borrow an infinite amount. This is why a capital adequacy constraint is needed. This constraint has foundations in typical regulatory requirements and even appears in the Basel Committee on Banking Supervision's core principles. Specifically, the bank capital-to-assets ratio must be greater than or equal to a certain fraction χ. Because bank capital in our model is defined as $M_t - d_t$, therefore $(M_t - d_t)/d_t \geq \chi$. With $0 < \phi \equiv (1+\chi)^{-1} < 1$, we express this constraint similar to a borrowing constraint as shown by equation (13).

The first-order conditions with respect to deposits and mortgage loans are as follows:

$$\lambda_t^B = \lambda_t^\phi + \beta_B \mathbf{E}_t \lambda_{t+1}^B (1 + r_t^d), \tag{14}$$

$$\lambda_t^B = \lambda_t^\phi \phi + \beta_B \mathbf{E}_t \lambda_{t+1}^B (1 + r_t^m), \tag{15}$$

where λ_t^B and λ_t^ϕ are the Lagrange multipliers on the budget constraint and on the capital adequacy constraint, respectively. An additional unit of deposits implies more consumption in the present period; however, there are costs to do so. Specifically, the borrowing constraint is tightened, and bankers need to repay the principal of deposits and the interest r_t^d accrued the following period. As for the first-order condition with respect to mortgage loans, the left-hand side of equation (15) represents the marginal costs of increasing mortgage loans, whereas the right-hand side shows the marginal benefits. Bankers gain from the repayment of the loans and the interest r_t^m thereon. An additional benefit of greater mortgage loans is that it relaxes the borrowing constraint. Finally, the first-order condition with respect to consumption is the following:

$$(1 + \tau_c)\lambda_t^B = \left(c_t^B\right)^{-\sigma} \tag{16}$$

3.5. Non-durable good producers

In a perfectly competitive environment, identical firms produce homogeneous non-durable goods. Their production functions feature constant returns to scale in capital and labour:

$$Y_t^f = k_{t-1}^\alpha \left((l_t^P)^{\iota_P} (l_t^I)^{\iota_I} (l_t^R)^{\iota_R}\right)^{1-\alpha}, \tag{17}$$

where Y_t^f is the production of non-durable goods, α is the capital-elasticity of output and ι_P, ι_I and ι_R correspond to the labour shares of the households that work. These parameters are calibrated so that their sum is equal to one ($\iota_P + \iota_I + \iota_R = 1$). Every period, firms maximize their profits:

$$\Pi_t^f = Y_t^f - w_t^P l_t^P - w_t^I l_t^I - w_t^R l_t^R - r_t^k k_{t-1} \tag{18}$$

Non-durable goods producers sell their production and incur labour and capital costs. From this profit maximization, wages and borrowing rates of capital are equal to their marginal products.

3.6. Capital and housing producers

We assume that capital and housing producers also operate in a perfectly competitive environment. Patient and impatient households sell to them the undepreciated part of the installed capital and housing at prices p_t^k and p_t^h, respectively. In the same period—once production is completed—these agents buy the new stocks of capital and housing at the same prices that they sold the undepreciated parts. The producers purchase capital and housing investment (i_t^k and i_t^h) from the non-durable goods firms at a unitary price. Hence, their maximization problem is as follows:

$$\max E_0 \sum_{t=0}^{\infty} \beta_P^t \frac{\lambda_t^P}{\lambda_0^P} \left[\sum_{x=k,h} p_t^x (x_t - (1-\delta_x) x_{t-1}) - i_t^x \right]$$

subject to

$$k_t = (1-\delta_k) k_{t-1} + \left[1 - \frac{\psi_k}{2} \left(\frac{i_t^k}{i_{t-1}^k} - 1 \right)^2 \right] i_t^k, \tag{19}$$

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

where $h_t = h_t^P + h_t^I + h_t^R$. We assume that capital and housing producers use the patient households' stochastic discount factor to discount future profits. Their profit maximization is subject to the laws of motion of capital and housing that are characterized by quadratic investment adjustment costs.

3.7. Government

The government collects taxes on consumption, income revenue, deposits, government bonds, capital and housing properties. Total taxes tax_t correspond to the following sum:

$$\begin{aligned} tax_t = {} & \tau_c C_t + \tau_y \left[w_t^P l_t^P + (p_t^R - \tilde{\delta}_{ht})(h_{t-1}^R + I_r h_{t-1}^P) - \tau_{pt}(h_{t-1}^P + h_{t-1}^R) \right] \\ & + \tau_d \left[r_{t-1}^d d_{t-1} + r_{t-1}^g b_{t-1}^g \right] + \tau_{pt}(h_{t-1}^P + h_{t-1}^R) + \tau_k (r_t^k - \delta_k) k_{t-1} \\ & + \tau_y \left[w_t^I l_t^I - I_{mt} r_{t-1}^m M_{t-1} + I_r (p_t^R - \tilde{\delta}_h) h_{t-1}^I - \tau_{pt} h_{t-1}^I \right] \\ & + \tau_{pt} h_{t-1}^I + \tau_R w_t^R l_t^R, \end{aligned} \tag{21}$$

where $C_t = c_t^P + c_t^I + c_t^R + c_t^B$ is the sum of consumption of all agents. The government's budget constraint is as follows:

$$b_t^g + tax_t = (1 + r_{t-1}^g) b_{t-1}^g + \overline{g} + \Gamma_t^P + \Gamma_t^I + \Gamma_t^R \tag{22}$$

Every period, from taxes that they collect and the new borrowing that they contract from patient households, they make transfer payments (Γ_t^P, Γ_t^I and Γ_t^R) to three types of agents. We assume that government expenditures $\overline{g}$ are fixed. Transfer payments are attributed according to the following rule:

$$\Gamma_t^i = \vartheta_i Y_t^f - \rho_b b_{t-1}^g, \quad i = P, I, R, \tag{23}$$

where ϑ_i are parameters specific to the type of households and ρ_b denotes the response of transfer payments to government debt. This coefficient is necessary to ensure the stability of the model following policy changes.

3.8. Market clearing and equilibrium

In equilibrium, all non-durable goods are sold to the agents, the capital and housing producers and the government, so that the market clearing condition is

$$Y_t^f = C_t + i_t^h + i_t^k + \overline{g}, \tag{24}$$

where $C_t = \sum_{i=P,I,R,B} c_t^i$. However, the production of non-durable goods is not consistent with the measure of GDP that is published by the Bureau of Economic Analysis in the NIPA. Consumption needs to be adjusted to take into account the effects of consumption taxes and the consumption services provided by housing. Therefore, NIPA-consistent GDP, Y_t, corresponds to

$$Y_t = (1+\tau_c)C_t + p^R h_{t-1} + i_t^h + i_t^k + \overline{g}. \tag{25}$$

Moreover, in equilibrium, the interest rates on deposits and government bonds are equalized when solving the maximization problem of patient households.

3.9. Model without banking

In order to get a better understanding of the role played by bankers, we also show results for which the banking sector is shut down. Without financial intermediation, patient households lend directly to impatient households. Only equations (13) to (16) need to be modified. We add a switch parameter Υ to these equations, so that $\Upsilon = 1$ corresponds to the equations of the benchmark model with banking, and $\Upsilon = 0$ to the equations of the model without banking. The equations that change are as follows:

$$d_t = (\phi + (1-\phi)(1-\Upsilon))\, M_t \tag{26}$$

$$\lambda_t^B = \Upsilon \lambda_t^\phi + \beta_B \mathbf{E}_t \lambda_{t+1}^B (1 + r_t^d) \tag{27}$$

$$\lambda_t^B = \Upsilon \lambda_t^\phi \phi + \beta_B \mathbf{E}_t \lambda_{t+1}^B (1 + r_t^m) \tag{28}$$

$$(1+\tau_c)\lambda_t^B = \left(c_t^B\right)^{-\sigma\Upsilon} + \Upsilon - 1 \tag{29}$$

When $\Upsilon = 0$, equation (26) is simplified to $d_t = M_t$, while the combination of equations (27) and (28) equalizes the interest rates: $r_t^d = r_t^m$. This implies that bankers' consumption must be nil from their budget constraint and that $\lambda_t^B = 0$ from equation (29).

4. Calibration

The calibration is based on the NIPA (Bureau of Economic Analysis), the Flow of Funds Accounts (Federal Reserve Board), the 2001 Residential Finance Survey (Census Bureau) and the 2011 American Housing Survey (Census Bureau) and is split into two parts. First, we show in table 1 the calibrated values of parameters that are chosen by jointly matching steady-state targets from quarterly data that spans from 1960 to 2012, i.e., endogenously chosen parameters. The first column presents the parameters and the corresponding targets appear in the last column. These targets are also exactly met. Second, table 1 presents the remaining set of parameters that are invariant to the steady state, i.e., assigned parameters. The discount factors of the patient households and bankers, β_P and β_B, are set to match annualized steady-state deposit and lending rates of 3% and 5%, respectively. The size of the spread (200 basis points) also corresponds to the target proposed by Alpanda and Zubairy (2016) to set the discount factors of impatient households and renters: β_I and β_R. We assume that the parameters that govern the choices of all agents except bankers are the same. We pick φ_h to match the average housing stock to GDP. As for φ_l, we choose it so that patient households supply one unit of labour in the steady state.

In the production function, the elasticity of output with respect to capital, α, is pinned down to match the ratio of capital to the production of non-durable goods. We calibrate the labour shares of each type of households to match their relative shares of the total housing stock, which are 43% for borrower (impatient) households and 20% for renters. The remaining labour and housing shares are allocated to patient households. We pin down the depreciation rates of housing and capital to match the shares of residential and nonresidential investment in GDP, respectively. Our target for the sum of transfers from the government to households is 7.4% as in the data. The share of transfers for different types of agents is given by their relative share of labour and capital incomes.[12]

We assume for simplification sake that government expenditures are wasteful and do not vary throughout time. In this economy, the government expenditures-to-GDP ratio in the steady state is as follows:

$$\overline{g}/\overline{Y} = 100\% - \text{total } \overline{C}/\overline{Y} - \overline{i}^h/\overline{Y} - \overline{i}^k/\overline{Y} \tag{30}$$

Both the investment-to-GDP ratios are already steady state targets. We set the total consumption-to-GDP ratio to its average in the US, i.e., 65%.

12 The size of the specific transfers to each type of households does not play an important role for our results to the various housing tax experiments that we examine in the next section. These transfers do not distort the model economy because they do not enter any first-order condition. Moreover, they are relatively small and conditional on non-housing output, which does not respond strongly to any of the experiments that we study.

TABLE 1
Endogenously chosen parameters

Symbol		Value	steady state targets
Discount factors			
Patient households	β_P	0.9937	$\overline{r}^d = 3\%$ (annualized)
Impatient households and renters	β_I, β_R	0.9877	200 basis points spread on $\overline{r}^d$ (annualized)
Bankers	β_B	0.9456	$\overline{r}^b = 5\%$ (annualized)
Weights in the utility function			
Housing	φ_h	0.208	$\overline{h}/\overline{GDP} = 5.2$
Labour	φ_l	0.56	$\overline{l}^P = 1$
Factor shares in production			
Capital share	α	0.21	$\overline{k}/\overline{GDP} = 6$
Patient households labour share	ι_P	0.2	$\overline{h}^P/\overline{h} = 0.37$
Impatient households labour share	ι_I	0.56	$\overline{h}^I/\overline{h} = 0.43$
Renters labour share	ι_R	0.24	$\overline{h}^R/\overline{h} = 0.2$
Depreciation rates			
Housing	δ_h	0.0096	$\overline{i}^h/\overline{GDP} = 0.05$
Capital	δ_k	0.02	$\overline{i}^k/\overline{GDP} = 0.12$
Transfer shares			
Patient households	ϑ_P	0.038	Total transfers:
Impatient households	ϑ_I	0.035	$\left(\sum_{i=P,I,R}\overline{\Gamma}^i\right)/\overline{GDP} = 7.4\%$
Renters	ϑ_R	0.015	
Labour income tax rates			
Patient and impatient households	τ_y	0.3	Average labour income tax rate:
Renters	τ_R	0.2	$\dfrac{\tau_y(\overline{w}^P\overline{l}^P + \overline{w}^I\overline{l}^I) + \tau_R\overline{w}^R\overline{l}^R}{\sum_{i=P,I,R}\overline{w}^i\overline{l}^i} = 0.27$

Therefore, the government expenditures-to-GDP ratio is 18%. Finally, to reproduce the progressivity of the US tax code, homeowners are not taxed at the same rate as renters—30% for the former group and 20% for the latter group. Given these rates, the average labour income tax rate is 27%, as in Zubairy (2014).

We present the assigned parameters in table 2. We set the inverse of the Frisch elasticity of labour supply ι equal to 1. The loan-to-value ratio $\theta = 0.7$ corresponds to the average ratio for the median borrower in the AHS data, while $\rho_m = 0.977$ reflects the high level of inertia in household debt. For the liabilities-to-assets ratio ϕ, we follow Iacoviello (2015) and set it to 0.9, so that the liabilities-to-assets ratio in the bankers' capital adequacy constraint is consistent with historical data on the banks' balance

TABLE 2
Assigned parameters

	Symbol	Value
Inverse of Frisch elasticity of labour supply	ι	1
Loan-to-value ratio	θ	0.70
Persistence of mortgage	ρ_m	0.977
Liabilities to assets ratio for bankers	ϕ	0.9
Responses of transfers to government debt	ρ_b	0.005
Tax rates	$\tau_k, \tau_c, \tau_p, \tau_d$	0.4,0.05,0.0035,0.15
Tax deductions	$\bar{I}_m, \bar{I}_r$	1,0
Housing transaction cost	ψ_a	0.1
Investment adjustment costs	ψ_k, ψ_h	2.5,0.4

sheets. We calibrate the parameter that governs the response of transfers to government ρ_b to 0.005 to avoid indeterminacy, as in Leeper et al. (2010). For the remaining tax rates and the parameter that governs the transaction cost of housing between the types of agents, we follow Zubairy (2014) and Alpanda and Zubairy (2016). Finally, we assume that, in accordance with the US tax code, households can fully deduct the interest on their mortgages ($\bar{I}_m = 1$) and that imputed rents are not taxable ($\bar{I}_r = 0$). For the parameter that governs the investment adjustment costs of business capital, we use the intermediate value $\psi_k = 2.5$ obtained by Christiano et al. (2005) from the estimation of a business cycles model. Alpanda and Zubairy (2016) use $\psi_k = 8$ from the structural estimation of Smets and Wouters (2007). However, this value implies an elasticity of investment with respect to the price of capital $(1/\psi_k)$ that is much lower than the one found by Groth and Khan (2010) from industry-level data. Its elasticity is also much lower when compared with point estimates from the estimation of business cycle models in the literature.[13]

The use of residential investment adjustment costs is not as widespread in the literature as for business capital. Specifically, the inverse of ψ_h corresponds to the short-run elasticity of housing supply. We estimate it by GMM from the log-linearized first-order condition of housing producers, which corresponds to the following:

$$\tilde{p}_t^h = \psi_k \left((1 + \beta_P)\tilde{i}_t^h - \tilde{i}_t^h - \beta_P \mathbf{E}_t \tilde{i}_t^h \right) + u_t, \tag{31}$$

where $\tilde{p}_t^h$ and $\tilde{i}_t^h$ are the deviations in logs from a linear trend of housing prices and investment, respectively. To be consistent with the literature on Tobin's q, housing prices are given by the ratio of the all-transactions price index

13 As shown in table 5 of the sensitivity analysis section, the long-run multipliers are not very sensitive to an investment adjustment cost parameter $\psi_k = 2.5$ or $\psi_k = 8$.

(FHFA) over the construction price index of single family houses (Census Bureau). Real residential investment is taken from the BEA. The instrumental variables must be correlated with residential investment, but uncorrelated with housing prices. We find that the three lags of an index on buying conditions for houses (Survey of Consumers of the University of Michigan), which is constructed from a survey targeting households, satisfy these two conditions. From the availability of the data, we estimate equation (31) from 1975Q1 to 2019Q4. The point estimate is $\hat{\psi}_h = 0.4$ with a robust standard error of 0.34.[14] The 95% confidence interval includes the implied short-run elasticity of 0.9 and 1.0, estimated by Topel and Rosen (1988) and Sommer and Sullivan (2018), respectively. In table 5, we assess the sensitivity of our results by presenting results for a higher value for $\psi_h = 30$, as assumed by Alpanda and Zubairy (2016).

Panel A of table 3 presents steady state ratios of key variables for the baseline model. As mentioned at the beginning of this section, the average ratio of consumption over GDP is a moment that we target. The share of bankers in non-housing consumption is small (2%), so this indicates that the calibration of endogenously chosen parameters is not very sensitive to the presence of these agents. Therefore, for the model without banking, we use exactly the same parameters as for the baseline model. The ratio of mortgages over GDP is close to the post-war US average, which is 1.48. Tax revenues that represent 25% of GDP correspond to the average observed for the last 45 years in the US by the OECD. Public debt over GDP is 30%, similar to levels observed from the mid-1970s to the early 1980s. However, since these times, this ratio has increased tremendously, so that the average level from 1966 to 2019 is 58% (Federal Reserve Bank of St. Louis). One reason why we are not matching the level of public debt is that we abstract from open-economy variables. In fact, a higher fiscal deficit can be financed by a higher trade deficit.[15]

Panel B of table 3 presents the size of housing tax expenditures relative to quarterly GDP. Given the size of tax revenues in GDP, the repeal of mortgage interest deductions would lead, all else equal, to an increase in tax revenues of 2.43%. The full taxation of imputed rents and the repeal of depreciation imply a larger share of tax revenues than the first type of housing tax expenditure, while the share of total property taxes stand between the latter two.

14 We also test the over-identification restrictions. The p-value of the J-test is 0.16; therefore, we do not reject the validity of the instrumental variables.

15 Moreover, the steady-state level of public debt is very sensitive to the level of fiscal deficit; increasing the ratio of government expenditures over GDP by one percentage point results in an increase in public debt of 33 percentage points. We simulate our model with government expenditures 3 percentage points higher ($\overline{g}/\overline{GDP} = 0.21$) and we do not find significant differences in the results compared with the ones obtained from our baseline calibration.

TABLE 3

Aggregate quantity variables and the size of housing tax expenditures in the steady state

Panel A: Aggregate quantity variables

	Steady state ratio	Value
Total consumption	$\left((1+\tau_c)\overline{C}+\overline{p}^R\overline{h}\right)/\overline{GDP}$	0.65
Non-housing consumption	$\overline{C}/\overline{GDP}$	0.50
Share of patient households	$\overline{c}^P/\overline{C}$	0.31
Share of impatient households	$\overline{c}^I/\overline{C}$	0.46
Share of renters	$\overline{c}^R/\overline{C}$	0.21
Share of bankers	$\overline{c}^B/\overline{C}$	0.02
Household debt (mortgages)	$\overline{M}/\overline{GDP}$	1.62
Tax revenues	$\overline{T}/\overline{GDP}$	0.25
Public debt	$\overline{b}_g/\overline{GDP}$	1.32
Transfers	$\overline{\Gamma}/\overline{GDP}$	0.074
Share of patient households	$\overline{\Gamma}^P/\overline{\Gamma}$	0.46
Share of impatient households	$\overline{\Gamma}^I/\overline{\Gamma}$	0.43
Share of renters	$\overline{\Gamma}^R/\overline{\Gamma}$	0.11

Panel B: Housing tax expenditures

	Symbol	Value
Mortgage interest deductions	I_{mt}	0.61%
Imputed rents	I_{rt}	1.57%
Property taxes	τ_{pt}	1.27%
Depreciation allowances	$\tilde{\delta}_{ht}$	1.19%

5. Results

In this section, we present the effects of changing housing tax policies.[16] First, the size of the changes are set so that all of them generate a 50% increase in the present value of tax revenues.[17] The following four policies are considered: we (i) reduce the mortgage interest deductions I_{mt}, (ii) institute partial taxation of imputed rents I_{rt}, (iii) increase the property tax rate τ_{pt} and (iv) reduce the depreciation allowances $\tilde{\delta}_{ht}$. Second, we present revenue-neutral experiments that eliminate the distortions created by policies (i), (ii) and

16 We use Dynare to perform the deterministic simulations. Since Lagrange multipliers associated with borrowing constraints are always in positive territory, these constraints are binding for all periods of the simulations.

17 We use the average of the agents' discount factors weighted by their share of total consumption to measure the present value of changes in tax revenues: $PV_{tax} = \frac{1}{tax_0}\sum_{t=0}^{T=20,1000}\beta^t(tax_t - tax_0)$. $T = 20$ when we compute the short-run multipliers and $T = 1000$ the long-run multipliers.

(iv). The additional tax revenues are used to lower the labour income tax rates of the households. For all of these experiments, we discuss the mechanisms that generate the results and pay particular attention to the role of banking. The calibration that we use is the same for both models. Because bankers' consumption accounts for only 2% of total consumption, the steady state ratios listed in panel A of table 3 do not differ much across models.

5.1. Equivalent revenue generating experiments

The tax policy changes that we implement are permanent. We assume that the economy is at its initial steady state in period 0. In period 1, the government surprises all agents with new housing tax policies that last permanently. Agents have perfect information and foresight. We compute the transition of all variables from periods 0 to 1,000—as we consider that the economy attains its new steady state at this long horizon. Panel A of table 4 presents the changes in housing tax policies that are implemented for the baseline model and the model without banking, so that the present value of tax revenues increases by 50%. The policy changes are approximately the same for both models, except for the mortgage interest deductions. The reason for this discrepancy is that the borrowing rate for impatient households is larger in the baseline model because bankers require a premium for lending.

Panel B of table 4 presents the corresponding short and long-run tax multipliers generated by both models. Specifically, these multipliers are measured as follows: $(PV_Y \cdot Y_0)/(PV_{tax} \cdot tax_0)$, where $PV_Y = \sum_{t=0}^{T=20,\infty} \beta^t (Y_t - Y_0)/Y_0$, Y_0 and tax_0 are the present value of changes in GDP, the initial steady state values of GDP and tax revenues, respectively.[18] We find that the order of desirability of policies is the same for the baseline model and the model without banking. The negative effects on GDP are smaller in the short run, especially for the baseline model. We explain the underlying mechanisms that drive these results specifically for each experiment below. In fact, the effects of the addition of a banking sector on transitional dynamics differ from one experiment to another. As for the long-run multipliers, they are below one for the first three experiments.

We present the transitional dynamics of key variables to permanent policy changes for the first 40 quarters in figure 1. A result that is common to all four experiments is that the economy experiences a shift from its housing stock to its business capital stock. Since the housing sector is getting more heavily taxed, this result is sensible. Changes in taxation also affect the rate of return of business capital relative to deposits for patient households. From the simulation of a life-cycle model, Gervais (2002) obtains similar findings. Specifically, when imputed rents are taxed, resources shift

18 Since a priori it is not clear if an increase in tax revenues would shift GDP up or down in the context of our model, we do not report multipliers in absolute values.

TABLE 4

Results of the equivalent revenue generating experiments

Panel A: Fiscal policy values

	Symbol	Initial	Baseline	New model without banking
Reduction of mortgage interest deductions	I_{mt}	1	0.729	0.487
Instituting partial taxation of imputed rents	I_{rt}	0	0.1123	0.119
Property tax increase	τ_{pt}	0.0035	0.004	0.004
Reduction of depreciation allowance	$\tilde{\delta}_{ht}$	0.0096	0.0042	0.0039

Panel B: Short- and long-run tax multipliers

		Baseline		Model without banking	
	Symbol	Short run	Long run	Short run	Long run
Reduction of mortgage interest deductions	I_{mt}	−0.55	−0.74	−0.73	−0.87
Instituting partial taxation of imputed rents	I_{rt}	−0.53	−0.96	−0.7	−1.06
Property tax increase	τ_{pt}	−0.49	−0.99	−0.64	−1.08
Reduction of depreciation allowance	$\tilde{\delta}_{ht}$	−0.35	−1.12	−0.45	−1.13

Panel C: Percent changes in the steady state

	Y	Y^f	C	i_k	i_h	M	p^R
Reduction of mortgage interest deductions	−0.23	−0.09	−0.01	−0.09	−1.28	−2.85	0
Instituting partial taxation of imputed rents	−0.27	−0.1	0.004	−0.1	−1.62	−1.76	0
Property tax increase	−0.28	−0.1	0.009	−0.1	−1.67	−1.32	2.1
Reduction of depreciation allowance	−0.31	−0.11	0.027	−0.11	−1.93	0.17	10.4

Panel D: Welfare effects of housing tax policies

	Savers	Borrowers	Renters	Bankers
Reduction of mortgage interest deductions	0.17	−0.49	0.51	−1.34
Instituting partial taxation of imputed rents	−0.37	−0.17	0.56	−0.79
Property tax increase	−0.29	−0.08	0.16	−0.59
Reduction of depreciation allowance	−0.02	0.27	−1.34	0.14

NOTES: Panel A presents the changes in housing tax parameters for the four experiments and panel B the corresponding short and long-run multipliers evaluated at 20 and 1,000 quarters, respectively. Panel C displays the percent changes from the initial to the final steady states for key variables and panel D the welfare effects of experiments, which are expressed in percent deviation of lifetime consumption equivalent units for each type of agents.

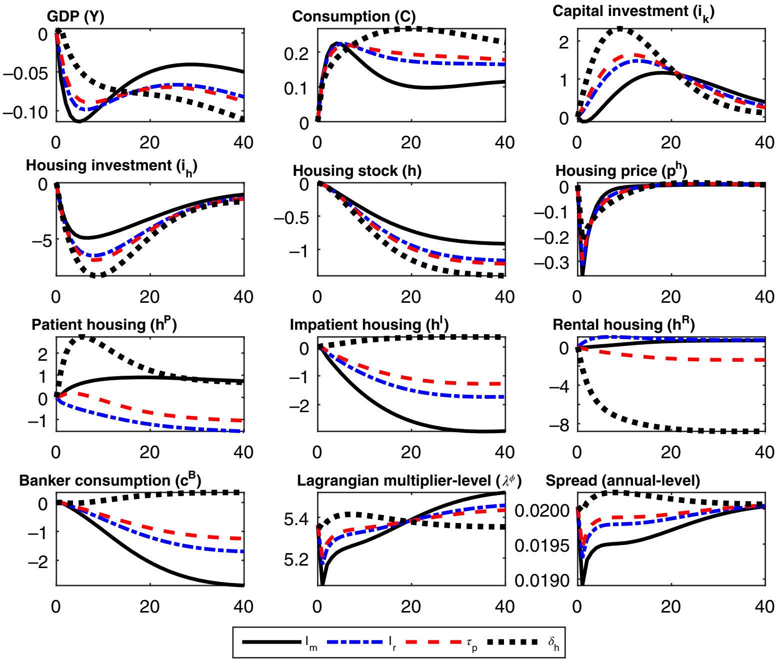

FIGURE 1 Responses to four housing tax policy changes (I_{mt}, I_{rt}, τ_{pt} and $\tilde{\delta}_{ht}$)
NOTES: The responses are measured in percent deviation from their initial steady states. Patient and impatient housing correspond to housing owned by patient and impatient households, respectively. [Colour figure can be viewed at wileyonlinelibrary.com.]

from housing (-8.56%) to business capital ($+6.4\%$) in the steady state. When mortgage interest deductions are repealed, the housing stock does not change, while business capital increases by 4% in his model. Another observation is that, in spite of the changes in borrowing, the Lagrange multipliers on the bankers' borrowing constraint always stay in positive territory. This implies that this constraint is always binding. Moreover, we do not show this result, but the borrowing constraint of impatient households is also always binding.

Since it is not possible to evaluate the effects of the experiments in the long run from the transition paths shown in figure 1, panel C of table 4 shows the changes in the steady states of key variables. The differences with changes generated by the model without banking are negligible. Finally, panel D of table 4 displays the effects on welfare for all agents. Specifically, the amplitude of these effects is given by Λ_i, where $i = P, I, R, B$, which is a measure in annual consumption units that is calculated from the following equation:

$$\sum_{t=0}^{\infty} \beta_i^t U\left((1+\Lambda_i)c_0^i, h_0^i, l_0^i\right) = \sum_{t=0}^{\infty} \beta_i^t U(c_t^i, h_t^i, l_t^i), \tag{32}$$

where c_0^i, h_0^i, l_0^i are consumption, housing and labour, respectively, in the initial steady state.[19] A positive value of Λ_i implies that agents are better off following the policy change. These values correspond to lifetime equivalent gains in consumption units. The heterogeneity of these effects is important to appreciate the output losses. In fact, policy changes that lead to negative outcomes for the welfare of impatient households are inversely related to the size of the long-run multipliers for the economy.

5.1.1. Reducing the mortgage interest deduction

The reduction of the deduction of mortgage payments implies that the marginal cost of holding an additional unit of mortgage increases. Hence, this policy change directly targets the impatient households' mortgage decision and, consequently, is the one that decreases their housing stock and welfare the most. As demand for housing from these agents decreases, the equilibrium housing price falls in the short run. As a consequence of lower prices, housing is reallocated to savers and renters, whose welfare increases. Changes in welfare for households go hand in hand with changes in their stock of housing. As for bankers, less mortgage implies less gains from financial intermediation and thus lowering consumption and welfare. This policy is the one that reduces the most the welfare of impatient households (-0.49%) and bankers (-1.34%).

In the first 10 quarters or so, non-housing output falls, partly as a result of lower capital investment. In fact, savers cut back their investment in order to smooth out their consumption. In the long run, however, GDP is dragged down mainly by diminishing levels of housing stock. It appears that this policy change is the least distortionary on the housing market, as the fall in total housing in the long run is the smallest out of the four policy changes. Considering that output losses are the smallest, this makes it the most efficient one in accruing tax revenues.

5.1.2. Taxing imputed rental income

The second-best policy change in terms of minimizing output losses is to institute partial taxation of imputed rents. This affects both the impatient and patient households who need to pay taxes on the consumption that they derive from housing services. Consequently, their housing demand and welfare fall. As for the previous experiment, welfare is linked to changes in housing. Savers substitute away from owner-occupied housing by investing in capital and by supplying more rental housing. This causes prices to fall, thereby making it beneficial for renters. This shift of housing towards renters also contributes to dampening the negative effects of a housing stock reduction on GDP. As for bankers, they lose out from this policy change as less housing

19 Since we assume that bankers do not derive utility from housing services and do not work, housing and labour are set equal to zero.

demand from borrowers implies fewer originations of mortgages, and thus less revenues from financial intermediation. Their welfare shifts down (−0.79%), but not as much as in the previous experiment.

5.1.3. Increasing the property tax rate

Contrary to other policies, property taxes affect owner-occupied and rental housing. When the government increases them, all agents reduce their housing stock. While impatient and patient households are hit directly, renters are impacted indirectly through a hike in rents. However, the effects on welfare of these latter agents are positive as the effects on non-durable consumption dominate those of declining housing. In contrast, the effects on patient and impatient households are negative (−0.29% and −0.08%). As for bankers, similar to the two previous policy changes, they suffer from less financial intermediation as their welfare drops by 0.59%. Finally, because all agents reduce their demand for housing, its total stock further decreases, which accounts for a slightly lower long-run multiplier than in the case of taxing imputed rental income.

5.1.4. Reducing the depreciation allowance

Another distortion introduced by the tax system in the US lies in the depreciation allowance of rental income that savers can deduct. In our experiment, this allowance was reduced to more than half—it drops from 0.0096 to 0.0042. Such a large policy change is necessary because it affects only rental housing, which is a small fraction of total housing. Since incentives to rent out housing shrink, its supply is reduced, leading to higher rental prices.

Consequently, renters are the big losers, while borrowers take advantage of a lower housing price that ensues from a decrease in total housing. In terms of welfare, renters lose 1.34% and borrowers gain 0.27%. In the short run, they reduce their consumption because the value of their collateral falls as a result of lower house prices. However, in the long run, the quantity effects dominate those of the price, and therefore, the value of their collateral and consumption soar. Patient households' decisions also fluctuate throughout time. A lower house price makes them consume more non-durable goods and housing services in the short run. However, once house prices revert to the steady state level, their total consumption falls so much that it leaves their welfare unchanged. They also invest more in non-durable goods than in response to the other policy changes, which implies that the multiplier is the lowest. As for bankers, their consumption evolves according to the dynamics of mortgages. Overall, the discounted sum of their period utilities rises.

5.1.5. The role of the banking sector

Prior to discussing the role of the banking sector, it is instructive to manipulate the first-order conditions of bankers. We combine equations (14) and (15), so that

$$\lambda_t^{\phi}(1-\phi) = \beta_B \mathbf{E}_t\left(s_t \lambda_{t+1}^B\right), \tag{33}$$

where $s_t = \left(r_t^m - r_t^d\right)$ corresponds to the spread between lending and borrowing rates for bankers. Combining the previous equation with equation (16) and log-linearizing it gives

$$\tilde{s}_t = \tilde{\lambda}_t^{\phi} + \sigma \mathbf{E}_t \tilde{c}_{t+1}^B, \tag{34}$$

where $\tilde{s}_t$, $\tilde{\lambda}_t^{\phi}$ and $\tilde{c}_{t+1}^B$ correspond to deviations from the same variables in logs from their steady state.

The spread responds downwards to the first three experiments, and as seen in figure 1, both the Lagrange multiplier on the capital adequacy constraint and bankers' consumption fall. This is the outcome of impatient households being more strongly affected than patient households. In fact, both the deposit and mortgage rates diminish, and so does the unique interest rate in the model without banking. The presence of a time-varying spread is important to understand the differences in the multipliers generated by the baseline model and the model without banking. First, a lower deposit rate is detrimental for patient households because it affects their income. All else equal, they respond by reducing their accumulation of capital and housing (rental and owner-occupied). As the deposit rate does not fall as much as the mortgage rate, bankers partially shield off these adverse effects. Second, they also act as shock absorbers for impatient households. Specifically, becausw the mortgage rate falls more than the interest rate in the model without banking, the housing stock and mortgages of impatient households do not contract as much. In figure 2, we compare the transitional paths of GDP, housing investment and housing of impatient households for both models. As can be seen, the presence of bankers limits the losses in GDP related to housing investment. In contrast, without banking, the absence of an interest rate spread leads to a more pronounced adjustment of housing.

As for the reduction in the depreciation allowance, the short-run multiplier generated by the model without banking is lower. This result is also the consequence of a larger decrease in the housing stock, specifically rental housing. Specifically, patient households benefit from a larger spread in the baseline model, which leads them to invest more in rental housing. In this case, the spread reacts to the greater demand of mortgages that also triggers the need for more deposits according to the capital adequacy constraint. Even though the effects generated by the banking sector are important in the short run, they dissipate in the long run.

5.1.6. Sensitivity analysis

In table 5, we present the sensitivity of the long-run multipliers to five different cases. First, we reduce the spread between mortgage and deposit rates from 200 to 50 basis points in the steady state. The only parameter that changes is the discount factor of bankers, which shifts up to 0.975. This implies a smaller banking in the economy that is not able to absorb the losses in housing as much as it does in the baseline model. The multipliers are still greater than for

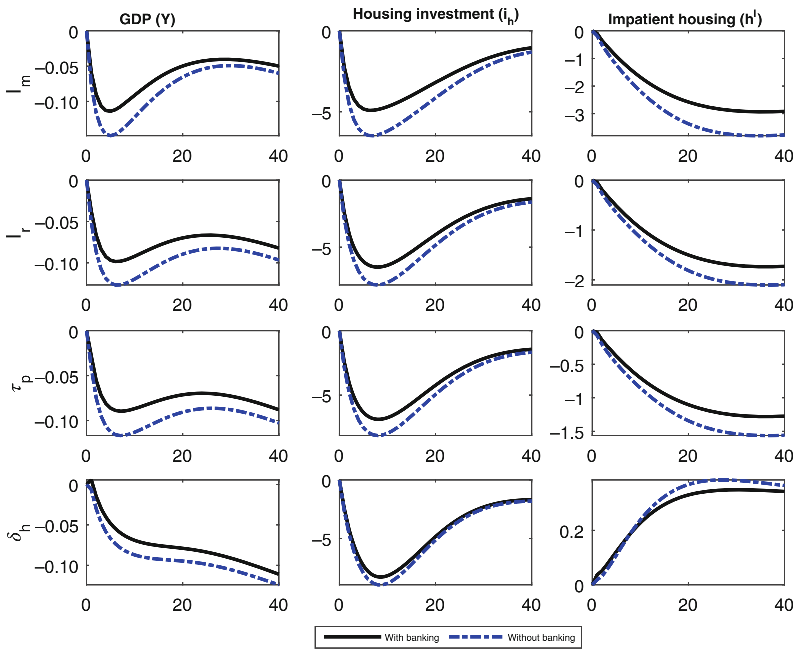

FIGURE 2 Comparison of the responses of GDP, housing investment and impatient housing for the baseline model and the model without banking

NOTES: The experiments are listed in the rows and the columns correspond to the responses of these three aggregate quantity variables. Patient and impatient housing correspond to housing owned by patient and impatient households, respectively. [Colour figure can be viewed at wileyonlinelibrary.com.]

TABLE 5

Sensitivity analysis: effects on long-run multipliers

	Symbol	Baseline	(1)	(2)	(3)	(4)	(5)
Reduction of mortgage interest deductions	I_{mt}	−0.74	−0.82	−0.66	−0.59	−0.75	−0.68
Instituting partial taxation of imputed rents	I_{rt}	−0.96	−1.02	−0.89	−0.87	−0.99	−0.88
Property tax increase	τ_{pt}	−0.99	−1.04	−0.93	−0.93	−1.02	−0.91
Reduction of depreciation allowance	$\tilde{\delta}_{ht}$	−1.12	−1.14	−1.08	−1.13	−1.17	−1.02

NOTES: We compare the long-run multipliers of the baseline model with three different cases. In column (1), we assume an annual spread between the mortgage and deposit rates of 50 basis points, which implies that $\beta_B = 0.975$. In column (2), we lower the liabilities to assets ratio in the banking sector to $\phi = 0.7$. In column (3), we exclude bankers' consumption from the measure of GDP. Finally, in columns (4) and (5), we assume higher business capital and housing investment adjustment costs, specifically, $\psi_k = 8$ and $\psi_h = 30$, respectively.

the model without banking. Second, to emphasize the propagation mechanism brought forward by the banking sector once again, we check the robustness of our results to a lower assets-to-liabilities ratio, specifically, $\phi = 0.7$. By definition, this change implies a larger bank capital stock, and that bankers consume more in the steady state. Hence, the banking sector has a greater capacity of absorbing the adverse effects of the housing tax policies. The multipliers presented in column (2) confirm this outcome.

We create a new measure of GDP that excludes the consumption of bankers, and present the multipliers generated from the simulation of the baseline in column (3). The reason for doing so is to assess how much of the fall in consumption of these agents is reflected in the multipliers. Compared with the baseline model's multipliers, they are not that much greater, simply because the share of bankers' consumption in total consumption is small. Finally, we present the multipliers for greater business capital and housing investment adjustment costs in columns (4) and (5) separately. The values of these parameters correspond to the ones chosen by Alpanda and Zubairy (2016), i.e., $\psi_k = 8$ and $\psi_h = 30$, respectively. We find that increasing the importance of adjustment costs have only negligible effects on multipliers. With higher housing investment adjustment costs, housing slowly shifts in the short run, which accounts for the weaker adverse effects on GDP.

5.2. Revenue-neutral experiments

In the previous section, all policy changes deliver lower levels of GDP. Can these results be offset if the government uses its additional revenues to lower labour income taxes? To answer this question, we conduct three experiments that eliminate the asymmetric tax treatment of housing. Specifically, we consider (i) the repeal of mortgage interest deductions, (ii) the taxation of imputed rents at the same rate as labour income and (iii) the repeal of depreciation allowance for rental income. We lower the labour income tax rates proportionally, so that the present value of tax revenues remains unchanged. In panel A of table 6, we report these rates and the changes in present values of GDP. Since the experiments are revenue neutral, multipliers are nonexistent. Therefore, we present the present values of GDP. In panel B of the same table, we show the changes in the steady state for GDP, business investment and housing investment, as well as the changes in welfare for the four types of agents. To obtain a better understanding of changes in these present values, we display the transitional dynamics of key variables in figures 3 to 5. Specifically, we show the decomposition of the effects caused by changes in housing taxation as opposed to changes in labour income taxation.

For all three experiments, the responses of most variables without income tax adjustments are amplified compared with the equivalent revenue generating experiments because the housing tax changes are much larger. The amplification is particularly more sizable for policy change (ii), because it

TABLE 6
Effects of revenue-neutral experiments

Panel A: New tax values and present values

	Symbol	τ_y	τ_R	Short run GDP	Long run GDP
Repeal of mortgage interest deductions	I_{mt}	0.29	0.193	−0.004	−0.04
Taxing fully imputed rents	I_{rt}	0.271	0.185	−0.017	−0.31
Repeal of depreciation allowance	$\tilde{\delta}_{ht}$	0.295	0.197	0.004	−0.10

Panel B: % changes in the steady state and welfare effects

	Symbol	GDP	i_k	i_h	Savers	Borrowers	Renters	Bankers
Repeal of mortgage interest deductions	I_{mt}	−0.12	0.31	−3.55	0.67	−0.76	1.42	−4.30
Taxing fully imputed rents	I_{rt}	−0.63	0.54	−9.99	−2.58	0.55	3.29	−5.09
Repeal of depreciation allowance	$\tilde{\delta}_{ht}$	−0.20	0.12	−2.80	0.01	0.91	−2.40	0.39

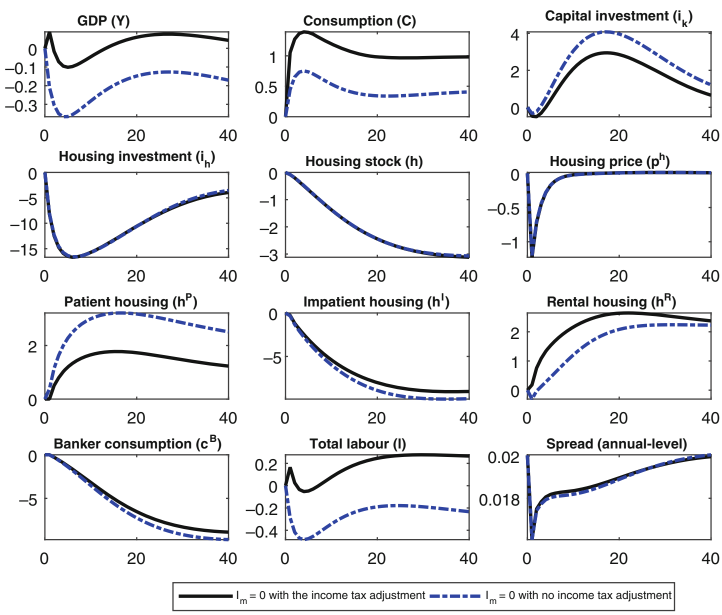

FIGURE 3 Responses of key variables to the repeal of mortgage interest deductions $I_{mt} = 0$

NOTES: These responses are measured in % deviation from their initial steady states. Patient and impatient housing correspond to housing owned by patient and impatient households, respectively. [Colour figure can be viewed at wileyonlinelibrary.com.]

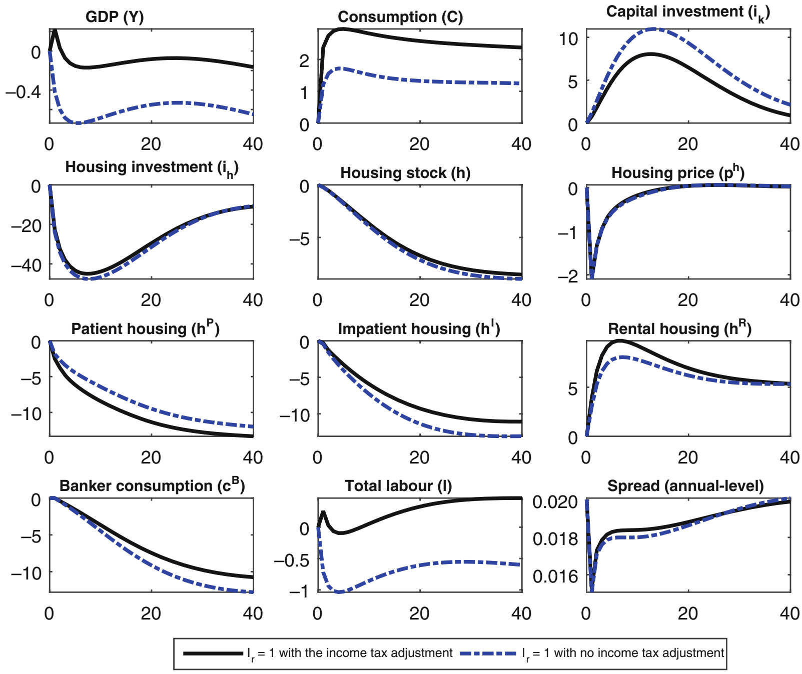

FIGURE 4 Responses of key variables to taxing fully imputed rents $I_{rt} = 1$
NOTES: These responses are measured in % deviation from their initial steady states. Patient and impatient housing correspond to housing owned by patient and impatient households, respectively. [Colour figure can be viewed at wileyonlinelibrary.com.]

directly affects patient and impatient households, whereas policy changes (i) and (iii) target only one type of household. The mechanisms at play are similar to the ones described in the previous section for the changes in housing tax policies. When labour income taxes are lowered, hours worked increase, and this explains the initial positive responses of consumption, non-housing output and GDP. However, these initial responses are not enough to generate positive present values of GDP in the short run for all experiments except for the repeal of the depreciation allowance. In the long run, the fall of housing is too important to be reversed by lower labour income taxes. From the size of changes in the present value and in the steady state of GDP, the repeal of the mortgage interest deduction is the superior policy. Even though the effects of this policy are negative, they are quite small. As for its effects on welfare, they are multiplied by a factor close to 3 for all agents, except for borrowers whose welfare falls by 25%. This result is related to the fact that the decrease in labour income taxes allows them to consume much more. For the same reason, the sign of welfare effects on borrowers changes for the full taxation of imputed rents revenue-neutral experiment. Finally, all agents except renters benefit from the repeal of the depreciation allowance.

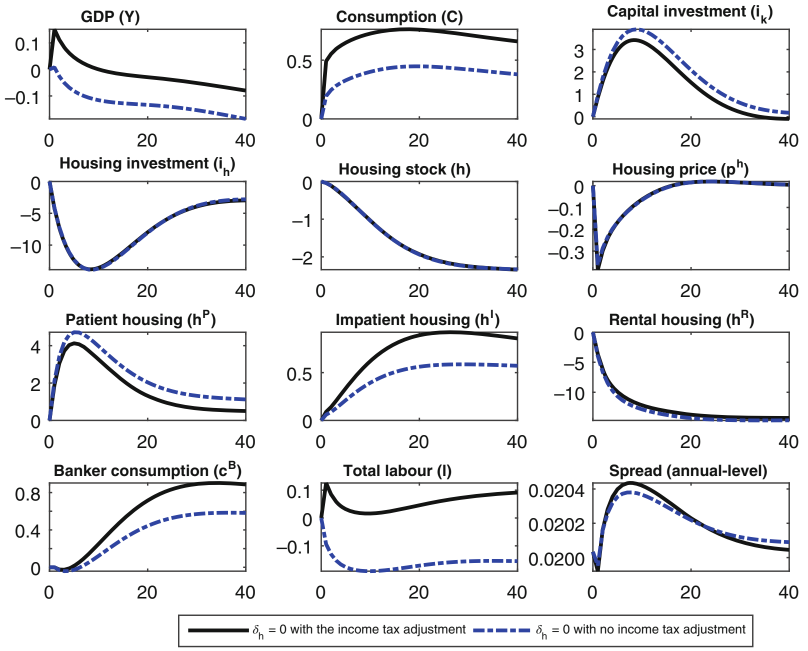

FIGURE 5 Responses of key variables to the repeal of depreciation allowance $\tilde{\delta}_{ht} = 0$
NOTES: These responses are measured in % deviation from their initial steady states. Patient and impatient housing correspond to housing owned by patient and impatient households, respectively. [Colour figure can be viewed at wileyonlinelibrary.com.]

5.3. Discussion of the results

The repeal of mortgage interest deductions and the full taxation of imputed rents are the two policies that are given the most attention in the literature. To the best of our knowledge, all work that perform revenue-neutral experiments for these two housing tax expenditures feature life-cycle models within which households face the decision of becoming home owners each period. For Gervais (2002), Cho and Francis (2011), Chambers et al. (2009) and Sommer and Sullivan (2018), these two policies improve aggregate welfare, whereas the repeal of mortgage interest deductions worsens it for Floetotto et al. (2016) when they take into account the transition path.[20] Sommer and Sullivan (2018) point out that Floetotto et al. (2016) assume a flat income tax rate, which can explain their findings with regards to welfare.

Contrary to these works, we do not have an aggregate measure of welfare. Nevertheless, the multipliers and the changes in the present value of GDP are

20 However, these authors find that a majority of households would benefit from the repeal of mortgage interest deductions and aggregate welfare would increase.

good indicators of the effects of these policies on the economy. In the long run, all policies have negative effects even when labour income taxes are adjusted. For both types of experiments, we find that the reduction of mortgage interest deductions is the best policy. A change of 0.04% in the present value of GDP is after all very small and this value could well bounce in positive territory if we allow for a greater degree of heterogeneity in the income of agents with the corresponding progressivity of taxation, for example. Similar to the literature, changes in housing tax policies generate winners and losers. Most experiments make bankers worse off and there is at least one experiment for which the welfare of each type of households is lessened. That makes it hard to propose a clear-cut policy recommendation. It really depends on how decision-makers weigh the welfare of each type of agents. However, in terms of the feasibility of implementing the policies, we believe that changes in the mortgage interest deductions and in property taxes are easier to put in place.

Another dimension of particular importance for us is the response of homeownership. In fact, because we assume that the shares of each type of households are fixed, the extensive margin is muted. If borrowers were able to "escape" from the repeal of mortgage interest deductions by deciding to rent for example, then our results would be biased. However, Chambers et al. (2009) and Sommer and Sullivan (2018) find that it is the other way around—homeownership increases in response to this policy change because the low-wealth credit-constrained benefit from lower tax rates, interest rates and housing prices. These findings are also in line with the empirical housing literature (Glaeser and Shapiro 2003, Hanson 2012, Hilber and Turner 2014). Chambers et al. (2009) also find that taxing imputed rents leads to an increase of 3 points of percentage in homeownership. As for the reduction or elimination of the depreciation allowance in our model, it results in a significant fall in rental housing. However, Poterba (1994) argues that landlords also change their investment decisions based on the value of other taxes, especially for corporations. Therefore, following this policy change, it is not clear that a significant fraction of households would own instead of rent. Since this policy experiment already results in the smallest long-run multiplier out of the four equivalent revenue experiments, the ranking of policies would not be affected if some renters would become borrowers.

6. Conclusion

In the United States, housing receives a preferential tax treatment. We examine the effects of four policy changes that target this sector and increase the government's revenues. We employ a multi-agent general equilibrium model to simulate these policy changes. A fixed share of households are renters and others are homeowners—either borrowers or savers. An important feature of our framework is the presence of financial intermediation, which is not a veil, because bankers face a capital adequacy constraint.

One key finding is that the economy substitutes housing investment for capital investment in response to the four experiments. The transitional effects on GDP are smaller in the short run than in the long run for all of the experiments. In the long run, we find multipliers that are close and below unity for some of them. Banking plays a role in lowering these multipliers—especially in the short run. The tax policy change that delivers the smallest long-run multiplier is the reduction of the deduction of mortgage payments. Furthermore, the welfare outcomes diverge significantly according to the types of households. We also consider the implementation of three revenue-neutral experiments. We find substantially decreasing levels of housing and that the smallest output losses in the long run are for the repeal of mortgage deductibility.

Supporting information

Supplementary material accompanies the online version of this article. The data and code that support the findings of this study are available in the Canadian Journal of Economics Dataverse at https://doi.org/10.5683/SP3/7PAOLT.

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