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Housing Taxation and Financial Intermediation

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Abstract

Through the lens of a multi-agent dynamic general equilibrium model, we examine the effects of four permanent changes in housing taxes and deductions on macroeconomic aggregates and welfare. We find that these changes have very small effects on economic activity in the short-run. The short-run tax multipliers that we find over a horizon of 20 quarters range from -0.02 to -0.13, while the long-run tax multipliers found range from -1.43 to -0.81. The presence of borrowing-constrained bankers dampen the negative consequences of housing taxation on output—especially in the short run. 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 only policy that generates gains in output.

JEL classification: E62, G28, H24, R38.

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1 Introduction

The importance of housing finance has grown substantially in the past decades in the United States. In 1970, mortgage debt corresponded to 26% of GDP; less than four decades later, in 2007, this ratio rose to 71%. Its weight on the commercial banks' balance sheets has also grown substantially. Specifically, mortgage lending as a fraction of total bank lending was 70% in 2007, up from 55% in 1970.[1] Throughout the same period, housing value as a proportion of GDP has almost doubled—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 favorable 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. Furthermore, owners of rental housing have access to a deduction for depreciation allowance. Making changes to the housing fiscal policies leads to greater tax revenues for the government, but at the expense of output losses. What are the effects of such changes in the short and long-run on aggregate variables and welfare? Alternatively, how would these variables react if the government decides to implement tax revenue neutral reforms?

In this paper, we pay special attention to the role of financial intermediaries in the transmission of permanent housing policy changes. Recent work that examine the role of banking on business cycles find that the presence of intermediaries amplify and propagate shocks[2]. 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.

Our model is closely based on Alpanda and Zubairy (2016). They incorporate to their framework the multi-agents structure and household borrowing constraints that are featured in Iacoviello's (2005) work.[3] 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 only affect the intensive margin of housing, since households cannot switch types.[4] Specifically, the

[1] See Jordà, Schularick and Taylor (2016) for the evolution of bank loans over a long horizon for 17 advanced countries.

[2] See *e.g.* Angeloni and Faia (2013), Brunnermeier and Sannikov (2014), Gertler and Karadi (2011), Gertler and Kiyotaki (2010), Meh and Moran (2010).

[3] Another paper that uses the structure of Iacoviello (2005) to examine housing tax policy is Ortega, Rubio and Thomas (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.

[4] As discussed by Alpanda and Zubairy (2016, pp. 508-510), this assumption is consistent with empirical evidence. Instituting partial taxation of imputed rents could even lead to an overestimation of output loss, as some impatient households would become renters. However, these changes are not large enough to modify the ranking of housing tax policies.

housing tax policies that we examine are (i) the deduction of mortgage interest payments I_{mt} for impatient households, (ii) the deduction of imputed rents I_{rt}, (iii) the property tax τ_{pt}, and (iv) the depreciation allowance $\tilde{\delta}_{ht}$. Note that the policy change (i) is of particular interest, since the tax plan proposed by the Trump administration in November 2017 encompasses a repeal of mortgage interest deductibility for the portion of mortgages that exceed $ 500,000—down from one million dollars.

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 long-run multipliers that range from -1.43 to -0.81. The size of these multipliers are not due to short-run transitions, since the multipliers that we find at a horizon of 20 quarters are much smaller—they range from -0.02 to -0.13. We also find that the new channels of propagation that arise with the introduction of a banking sector do not affect the ranking of long-run multipliers; however, as will be shown below, the presence of this sector dampens the adverse effects of changes in housing tax policies. Specifically, the less favorable policies are for impatient households, the more they are effective at limiting output losses. In fact, the distortion created by the deduction of interest mortgage payments is determinant. 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 -0.81). As for the mechanism, it works as follows. Since impatient households decrease their demand for housing, its price falls, which leads patient and renter households to consume more housing services.

On the opposite side 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, since 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 -1.43).

Even though the presence of banking does not modify the ranking of housing tax policies, it deflates the effects of these policies on output losses.[5] The causes of these smaller multipliers differ from one policy change to another. For the deduction of mortgage in-

[5]The multipliers that we find are much smaller than the ones put forward by Alpanda and Zubairy (2016), for whom they range from -2.21 to -1.52. However, as we report in Ghiaie and Rouillard (2018), there is a coding error in their model that greatly affects the dynamics of business investment, and thereby the multipliers that they obtain.

terest payments—policy (i)—the difference in multipliers is related to the interest rate spread incurred by the introduction of banking. In fact, the interest rate at which impatient households borrow is greater than the one that patient households receive on their deposits, as well as the equilibrium rate in a framework without banking. Therefore, the government does not need to reduce the deductibility of mortgages as much to increase its tax revenues, which results in smaller effects on housing. These effects are important to explain the dynamics of GDP, which includes a fraction of housing stock. Thus, smaller effects on housing implies smaller effects on output, and ultimately a smaller long-run multiplier.

For policies (ii) and (iii)—*i.e.* reduction in deduction of imputed rents and increases in property taxes—the lower output losses relative to the losses generated by the model without banking are also accounted by the smaller response of housing. Specifically, it is the housing stock held by impatient households that falls less. One important property of this fraction of housing is that it is used as collateral. Since they benefit from the spread between the deposit rate and the lending rate, bankers have some incentives to lend as much as possible. Following these policy changes, they absorb some of the negative consequences by consuming less. In contrast, in the model without banking, the agents that lend are the patient households. Since they are able to redirect their lending into capital investment or rental housing, loans fall by a greater margin. Hence, the type of agents that lends matters for the response of housing and GDP.

As noted above, the reversal of depreciation allowances for rental housing—policy (iv)—is beneficial for impatient households who increase their housing loans and consumption services. By lending more, bankers increase their profits and consumption. Hence, by facilitating financial intermediation, this policy change has less detrimental effects in our baseline model than for the model without banking.

Finally, we implement three revenue-neutral tax experiments: the repeal of mortgage deductibility, the taxation of imputed rents at the same rate as labor income, and the repeal of the depreciation allowance for rental income. For each of these experiments, we lower the labor income taxes, so that the net present value of taxes is nil. Since lower taxes incentivize agents to work more hours, 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. However, in the short-run, we find increases in the present value of GDP for all experiments.

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.[6] 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, since 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 these experiments are tax revenue neutral, as the income tax rate is lowered simultaneously. By comparing steady state outcomes, he finds that both these changes are welfare-improving, since it allows households to better smooth their consumption. They result in significant shifts of resources from housing (-8.56%) to business capital (+6.4%) when imputed rents are taxed, whereas housing is unchanged and business capital increases (+4%) when mortgage interest deductions are repealed. Homeownership declines significantly following these housing tax policy changes.

In a similar type of framework, Chambers, Garriga and Schlagenhauf (2009) examine the same two policy changes with special attention given to the supply of rental property and to the progressivity of the US tax system. They corroborate a crowding-out effect, as the stock of housing falls and capital increases, in response to the elimination of some asymmetries in housing taxation. Floetotto, Kirker and Stroebel (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

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

of income taxation and the consequences of the repeal of mortgage interest deduction. In contrast, Floetotto, Kirker and Stroebel (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.

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. Alpanda and Zubairy (2017) compare the effectiveness of various policies that are aimed at reducing household indebtedness, since 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 labor market frictions, Head and Lloyd-Ellis (2012) find that the elimination of mortgage interest deductibility leads to falls in house prices and in unemployment. Bielecki and Stähler's (2018) New Keynesian model also features housing search frictions. They find that labor 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 Gervais (2002), for example. Financial intermediation in the household mortgage market is present in other work; however, they focus on different objectives than our paper.[7] Iacoviello (2015) examines how the inclusion of a banking sector to a DSGE model amplifies and propagates financial shocks. Elenev, Landvoigt and Van Nieuwerburgh (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.

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

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 labor income. Bankers act as a transmission belt between impatient and patient households. They are able to issue mortgages from the deposits made by patient households. However, they face a capital adequacy constraint so that deposits cannot 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, since they have a greater discount factor than other agents ($\beta_P > \beta_i$ where $i = I, R, B$). They maximize the following discounted sum of period-utilities:

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

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 labor supply. The parameters φ_h and φ_l corresponds to the weights allocated to housing and leisure, and ι to the inverse of the Frisch elasticity of labor supply.

Their budget constraint is as follows:

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

where h_{Rt} 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 steady states.[8] 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 rate r_{t-1}^d. 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 labor 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. $0 < I_{rt} < 1$ 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 housing. For the sake of simplification, we set the parameter that governs housing adjustment costs ψ_h to zero when presenting the first order conditions. The first order condition with respect to owner-occupied housing is

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

where λ_t^P is the Lagrange multiplier of 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

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

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

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

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.

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

$$\begin{aligned} &(1+\tau_c)c_t^I + p_t^h(h_t^I - (1-\delta_h)h_{t-1}^I) + (1+r_{t-1}^b)M_{t-1} \leq w_t^I l_t^I + M_t \\ &+ \Gamma_t^I - \tau_y[w_t^I l_t^I - I_{mt} r_{t-1}^b M_{t-1} + I_{rt}(p_t^R - \tilde{\delta}_{ht})h_{t-1}^I - \tau_{pt} p_t^h h_{t-1}^I] \\ &- \tau_{pt} p_t^h h_{t-1}^I - \frac{\psi_a}{2\bar{h}^I} p_t^h (h_t^I - h_{t-1}^I)^2. \end{aligned} \tag{5}$$

Every period, they choose their consumption levels c_t^I, their housing stock h_t^I, their labor 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}^b 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:

$$M_t \leq \rho_m M_{t-1} + (1-\rho_m)\theta p_t^h h_t^I \tag{6}$$

where θ corresponds to a loan-to-value, and ρ_m to the persistence 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

$$\lambda_t^I p_t^h = (1-\rho_m)\theta\lambda_t^m p_t^h + \beta_I \mathbf{E}_t[\frac{\varphi_h}{h_t^I} + \lambda_t^I((1-\delta_h-\tau_{pt+1}(1-\tau_y))p_{t+1}^h - I_{rt+1}\tau_y(p_{t+1}^R - \tilde{\delta}_{ht+1})] \quad (7)$$

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:

$$\lambda_t^I = \lambda_t^M + \beta_I \mathbf{E}_t[\lambda_{t+1}^I(1 + (1 - I_{mt+1}\tau_y)r_t^b - \lambda_{t+1}^m \rho_m)]. \quad (8)$$

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:

$$(1 + \tau_c)c_t^R + p_t^R h_{t-1}^R \leq (1 - \tau_R)w_t^R l_t^R + \Gamma_t^R. \quad (9)$$

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 labor. Note that their labor 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:

$$p_t^R = \frac{\varphi_h}{\lambda_t^R h_{t-1}^R} \tag{10}$$

where λ_t^R is equal to the marginal utility of consumption of renters.

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:

$$\max E_0 \sum_{t=0}^{\infty} \beta_B^t \log c_t^B$$

subject to:

$$(1+\tau_c)c_t^B + (1+r_{t-1}^d)d_{t-1} + M_t = d_t + (1+r_{t-1}^b)M_{t-1} \tag{11}$$

where $\beta_B < \beta_P$. Since, in equilibrium the interest rate on mortgages r_t^b is greater than the interest rate on deposits r_t^d, they are able to make profits that they consume, *i.e.* c_t^B. In a similar fashion to Iacoviello (2015), bankers face a quadratic loan adjustment cost. Moreover, their issuance of liabilities is constrained by their asset holdings:

$$d_t \leq \phi M_t \tag{12}$$

where $0 < \phi < 1$ is a policy parameter typically set by regulatory agencies.[9]

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

$$\lambda_t^B = \lambda_t^\phi + \beta_B \mathbf{E}_t \lambda_{t+1}^B (1+r_t^d) \tag{13}$$

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

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

[9] See Appendix B of Iacoviello (2015) for the derivation of this constraint.

r_t^d accrued the following period. As for the first order condition with respect to mortgage loans, the left-hand side of equation (14) 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^b thereon. An additional benefit of greater mortgage loans is that it relaxes the borrowing constraint.

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 labor:

$$Y_t^f = k_{t-1}^{\alpha} \left((l_t^P)^{\iota_P} (l_t^I)^{\iota_I} (l_t^R)^{\iota_R} \right)^{1-\alpha} \tag{15}$$

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 labor 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:

$$\Pi_t^f = Y_t^f - w_t^P l_t^P - w_t^I l_t^I - w_t^R l_t^R - r_t^k k_{t-1} \tag{16}$$

Non-durable good producers sell their production, and incur labor, 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:

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

subject to:

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

$$h_t = (1-\delta_h) h_{t-1} + [1 - \frac{\psi_h}{2} (\frac{i_t^h}{i_{t-1}^h} - 1)^2] i_t^h. \tag{18}$$

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:

$$\begin{aligned} tax_t = {} & \tau_c C_t + \tau_y [w_t^P l_t^P + (p_t^R - \tilde{\delta}_{ht})(h_{t-1}^R + I_r h_{t-1}^P) - \tau_{pt}(h_{t-1}^P + h_{t-1}^R)] \\ & + \tau_d r_{t-1}^d (d_{t-1} + b_{t-1}^g) + \tau_{pt}(h_{t-1}^P + h_{t-1}^R) + \tau_k (r_t^k - \delta_k) k_{t-1} \\ & + \tau_y [w_t^I l_t^I - I_{mt} r_{t-1}^b M_{t-1} + I_r (p_t^R - \tilde{\delta}_h) h_{t-1}^I - \tau_{pt} h_{t-1}^I] + \tau_{pt} h_{t-1}^I + \tau_R w_t^R l_t^R \end{aligned} \tag{19}$$

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:

$$b_t^g + tax_t = (1 + r_{t-1}^d) b_{t-1}^g + \overline{g} + \Gamma_t^P + \Gamma_t^I + \Gamma_t^R. \tag{20}$$

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:

$$\Gamma_t^i = \vartheta_i Y_t^f - \rho_b b_{t-1}^g, \quad i = P, I, R. \tag{21}$$

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

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:

$$Y_t^f = C_t + i_t^h + i_t^k + \overline{g} \tag{22}$$

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

$$Y_t = (1 + \tau_c)C_t + p^R h_{t-1} + i_t^h + i_t^k + \overline{g}. \tag{23}$$

4 Calibration

The calibration of parameters is done at a quarterly frequency 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, *i.e.* endogenously calibrated parameters. Second, Table 2 presents the remaining set of parameters that are invariable to the steady state, *i.e.* exogenously calibrated parameters. Most steady state targets and exogenously calibrated parameters take the same values than the ones reported by Alpanda and Zubairy (2016).

Discount factors slightly differ from their calibrated values, since we follow Iacoviello (2015) for these parameters. Specifically, we set β_P and β_B to match annualized steady-state deposit and lending rates of 3 and 5 percent, respectively. As for the transfer shares, they are chosen to match the relative shares of labor and capital income of each agent. We pick the labor income tax rates to reproduce the progressivity of the tax code. In the exogenously calibrated parameters category, we also follow Iacoviello (2015) and set $\phi = 0.9$, so that the liabilities-to-assets ratio in the bankers' capital adequacy constraint is consistent with historical data on banks' balance sheets. To avoid repetition of the discussion of the remaining steady state targets and exogenously calibrated parameters,

Table 1: Endogenously calibrated parameters

	Symbol	Value	Steady state targets
Discount factors			
Patient households	β_P	0.9937	$\bar{r}^d$=0.03 (annualized)
Impatient households and renters	β_I, β_R	0.9852	250 basis points spread on $\bar{r}^d$ (annualized)
Bankers	β_B	0.9375	$\bar{r}^b$=0.05 (annualized)
Weights in the utility function			
Housing	φ_h	0.217	$\bar{h}/\overline{GDP} = 6$
Labor	φ_l	0.56	$\bar{l}^P = 1$
Factor shares in production			
Capital share	α	0.21	$\bar{k}/\overline{GDP} = 5.2$
Patient hhs labor share	ι_P	0.2	$\bar{h}^P/\bar{h} = 0.37$
Impatient hhs labor share	ι_I	0.56	$\bar{h}^I/\bar{h} = 0.43$
Renters labor share	ι_R	0.24	$\bar{h}^R/\bar{h} = 0.2$
Depreciation rates			
Housing	δ_h	0.0096	$\bar{i}^h/\overline{GDP} = 0.05$
Capital	δ_k	0.02	$\bar{i}^k/\overline{GDP} = 0.12$
Transfer shares			
Patient hhs	ϑ_P	0.038	**Total transfers**:
Impatient hhs	ϑ_I	0.035	$\left(\sum_{i=P,I,R}\bar{\Gamma}^i\right)/\overline{GDP} = 0.074$
Renters	ϑ_R	0.015	
Labor income tax rates			
Patient and impatient hhs	τ_y	0.3	**Average labor income tax rate**:
Renters	τ_R	0.2	$\frac{\tau_y(\bar{w}^P\bar{l}^P + \bar{w}^I\bar{l}^I) + \tau_R\bar{w}^R\bar{l}^R}{\sum_{i=P,I,R}\bar{w}^i\bar{l}^i} = 0.27$

we refer the reader to Alpanda and Zubairy's (2016) calibration section. The addition of a banking sector does not greatly alter these parameters.

5 Results

In this section, we present the effects of changing housing tax policies. First, the size of the changes are set so that all of them generate a present value of tax revenues that corresponds to 50%.[10] 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,

[10]We use the discount factor of patient households to measure the present value of changes in tax revenues: $PV_{tax} = \frac{1}{tax_0}\sum_{t=0}^{T=20,\infty}\beta_P^t(tax_t - tax_0)$. $T = 20$ when we compute the short-run multipliers, and $T = \infty$ the long-run multipliers.

Table 2: Exogenously calibrated parameters

	Symbol	Value
Inverse of Frisch elasticity of labor supply	ι	1
Loan-to-value ratio	θ	0.70
Persistence of mortgage	ρ_m	0.85
Liabilities to assets ratio for bankers	ϕ	0.9
Investment adjustment costs	ψ_k, ψ_h	$8, 30$
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	$\overline{I}_m, \overline{I}_r$	$1, 0$

we present revenue neutral experiments that eliminate the distortions created by policies (i), (ii), and (iv). The additional tax revenues are used to lower the labor income tax rates of the households. For all these experiments, we discuss the mechanisms that generate the results, and pay particular attention to the role of banking.

5.1 Equivalent revenue generating experiments

Table 3: Fiscal policy values

	Symbol	Initial	New	
			Baseline	**Model without banking**
Reduction of mortgage interest deductions	I_{mt}	1	0.85	0.72
Instituting partial taxation of imputed rents	I_{rt}	0	0.067	0.066
Property tax increase	τ_{pt}	0.014	0.015	0.015
Reduction of depreciation allowance	$\tilde{\delta}_{ht}$	0.0096	0.0065	0.0066

Table 4: 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}	-0.13	-0.81	-0.22	-0.96
Instituting partial taxation of imputed rents	I_{rt}	-0.12	-1.14	-0.22	-1.26
Property tax increase	τ_{pt}	-0.1	-1.2	-0.2	-1.3
Reduction of depreciation allowance	$\tilde{\delta}_{ht}$	-0.02	-1.43	-0.12	-1.45

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 the 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.

Table 3 presents the changes in housing tax policies that are implemented for the baseline model and the model without banking[11], so that the present value of tax revenues increases by 50%. 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 $PV_Y = \sum_{t=0}^{T=20,\infty} \beta_P^t (Y_t - Y_0)/Y_0$, Y_0, and tax_0 are the present value of changes in GDP, and the initial steady state values of GDP, and tax revenues, respectively. Over a horizon of 20 quarters, the multipliers that we obtain are very small, and even more so for the baseline model. Therefore, we can assert that changing housing tax policies is not very detrimental for economic activity in the short-run. This is not the case in the long-run, as multipliers are larger. We find that the order of desirability of policies is the same for the baseline model and the model without banking; however, the presence of banking contributes to lowering the multipliers. We discuss its role in the following sections.

Table 5: Percent changes in the steady state

	Y	Y^f	C	i_k	i_h	M	p^R
Reduction of mortgage interest deductions	−0.11	−0.05	−0.01	−0.05	−0.63	−1.47	0
Instituting partial taxation of imputed rents	−0.15	−0.05	0	−0.05	−0.85	−0.89	0
Property tax increase	−0.15	−0.06	0.002	−0.05	−0.9	−0.67	1.13
Reduction of depreciation allowance	−0.17	−0.06	0.01	−0.06	−1.07	0.09	5.4

Table 6: Welfare effects of housing tax policies

	Savers	Borrowers	Renters	Bankers
Reduction of mortgage interest deductions	0.10	−0.29	0.28	−0.64
Instituting partial taxation of imputed rents	−0.21	−0.11	0.33	−0.38
Property tax increase	−0.17	−0.05	0.11	−0.29
Reduction of depreciation allowance	−0.02	0.13	−0.7	0.05

We present the transitional dynamics of key variables to permanent policy changes for the first 100 quarters in Figure 1, while Table 5 shows the changes in the steady states of key variables. Finally, Table 6 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

[11]This model consists in the baseline model stripped out of its banking sector, which implies that patient households lend directly to impatient households. The calibration that we use is the same for both models.

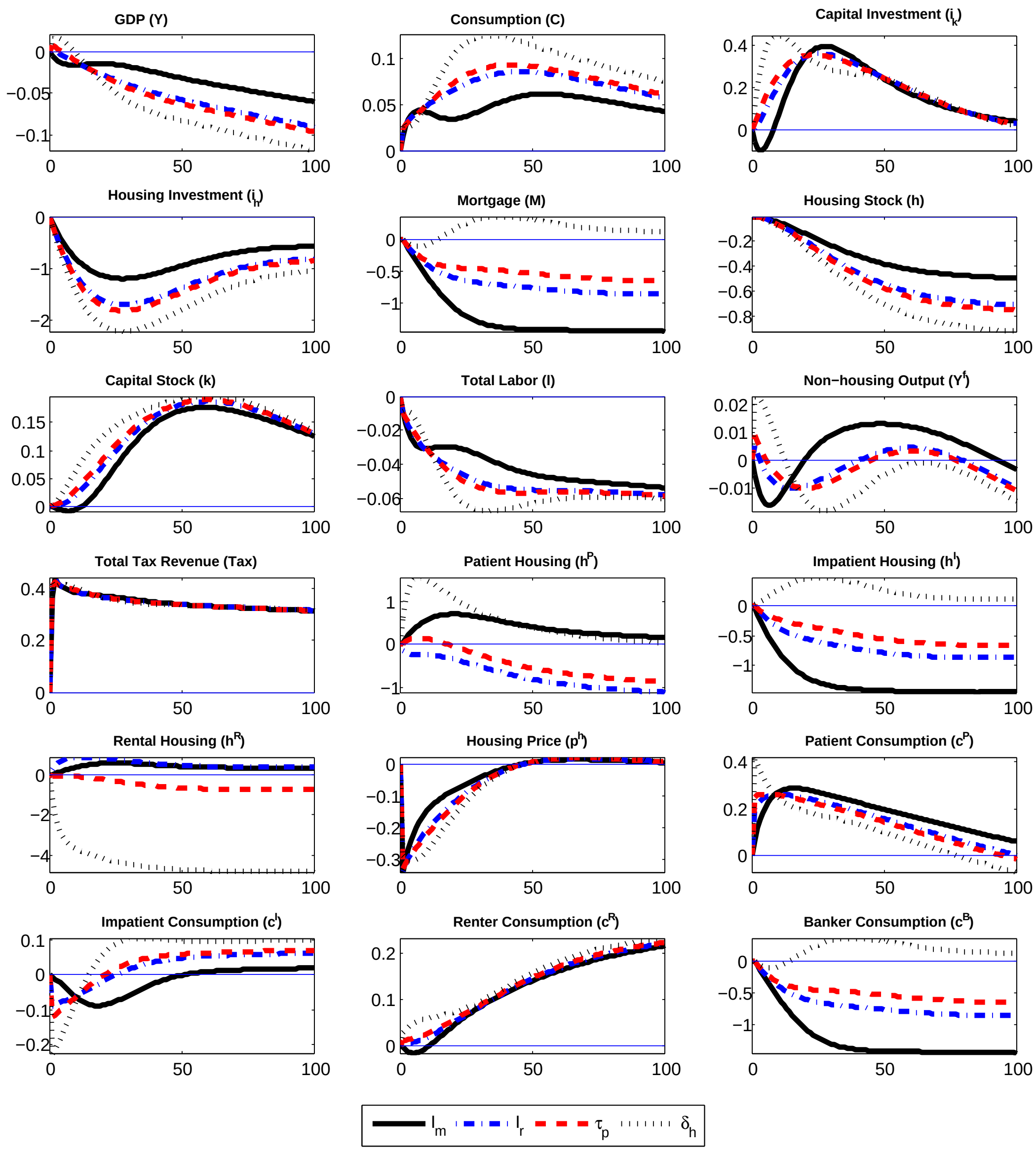

Figure 1: Responses to four housing tax policy changes (I_{mt}, I_{rt}, τ_{pt}, and $\tilde{\delta}_{ht}$) imeasured in percent deviation from their initial steady states

annual consumption units that is calculated from the following equation:

$$\sum_{t=0}^{\infty} \beta_i^t U((1+\Lambda_i)c_0^i, h_0^i, l_0^i) = \sum_{t=0}^{\infty} \beta_i^t U(c_t^i, h_t^i, l_t^i) \tag{24}$$

where c_0^i, h_0^i, l_0^i are consumption, housing, and labor in the initial steady state.[12] A positive value of Λ_i implies that agents are better off following the policy change. All signs of the welfare changes are similar to Alpanda and Zubairy (2016), with the exception of the increase in property taxes for borrowers. The heterogeneity of these effects are important to appreciate the output losses. In fact, policy changes that lead to negative outcomes for the welfare of impatient households are inversely related with 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 borrowers 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. As for bankers, less mortgage implies less gains from financial intermediation, and thus lower consumption and welfare.

In the first ten 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.

Since bankers take advantage of financial intermediation, a wedge between the mortgage and deposit rates arises. In the steady state, the annualized mortgage rate is 5%, whereas the deposit rate is 3%. With a higher borrowing rate, the deduction from mortgage payments is even more important. Therefore, instead of reducing the mortgage deduction to 0.72 (as is the case for the model without banking), the government cuts

[12] Since we assume that bankers do not derive utility from housing services and do not work, housing and labor are set equal to zero.

it down almost halfway to 0.85. As a consequence, housing does not fall as much, and accounts for the smaller short and long-run multipliers.

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. 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 demand from borrowers implies fewer originations of mortgages, and thus less revenues from financial intermediation.

The short and long-run multipliers attached to this policy change are also lower than the ones obtained from the model without banking. The smaller response of borrowers' housing accounts for the gap between the multipliers. Since housing enters GDP in two ways—through housing investment and consumption of housing services—the response of this variable is key. In fact, the lending process matters in its dynamics. In the baseline model, there is no substitute to lending for bankers. They have incentives to keep its value high, because it directly affects their consumption. In some ways, they absorb the losses incurred by additional taxation. In contrast, per the model without banking, lending is conducted by savers. Since they also invest in physical capital, more substitution between the types of investment takes place, which implies that lending and housing fall by a greater margin.

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, welfare does not fall for all these agents, as they substitute for more consumption. Specifically for borrowers and renters, the effects on consumption dominate those of declining housing consumption, and thus their change in welfare is positive. In contrast, the effects on patient households are negative. As for bankers, similar to the two previous policy changes, they suffer from less financial intermediation. Finally, since all agents reduce their demand for housing, its total stock further decreases, which accounts for a slightly lower long-run multiplier than for taxing imputed rental income.

In comparison to the multipliers generated by the model without banking, the baseline model generates short and long-run multipliers that are smaller. The mechanism at play is the same as for the previous tax policy change: more substitution towards capital investment arises—especially in the short-run—when patient households lend directly to impatient households.

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 almost half—it drops from 0.0096 to 0.0065. Such a large policy change is necessary because it only affects 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 ensue from a decrease in total housing. In the short-run, they reduce their consumption, since 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 reaction 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.

The long-run multipliers attached to this tax policy change generated by the baseline model and the model are almost the same for the baseline model and the model without banking. However, the short-run multiplier generated by the baseline model (-0.02) is smaller. This result is also the consequence of a larger decrease in housing stock for the model without banking. Specifically, rental housing diminishes more for them, since savers reallocate their funds towards more lending. In our case, savers do not lend as much through deposits, since the presence of bankers creates a friction. In fact, by consuming a fraction of mortgages they compress lending, and thereby dampen the fall in housing, which leads to a greater multiplier than the model without banking.

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 labor 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 labor income, and (iii) the repeal of depreciation allowance for rental income. The first two experiments are similar to the ones that Chambers, Garriga and Schlagenhauf (2009), Gervais (2002), and Sommer and Sullivan (2018) examine. In Table 7, we report the new labor income tax rates of patient and impatient households τ_y, and of renters τ_R. Since the experiments are revenue neutral, multipliers are nonexistent. Therefore, we present the present values of GDP and non-housing output. To obtain a better understanding of these present values, we display the transitional dynamics of key variables in Figure 2.

Table 7: Effects of revenue neutral experiments

		New tax values		**Present value**			
				short-run		long-run	
	Symbol	τ_y	τ_R	Y	Y^f	Y	Y^f
Repeal of mortgage interest deductions	I_{mt}	0.288	0.192	0.033	0.042	-0.005	0.522
Taxing fully imputed rents	I_{rt}	0.277	0.185	0.063	0.083	-0.553	0.879
Repeal of depreciation allowance	$\tilde{\delta}_{ht}$	0.294	0.196	0.021	0.028	-0.226	0.2

For all three experiments, the responses of most variables are amplified compared to the equivalent revenue generating experiments, since the housing tax changes are much larger. The amplification is particularly more sizable for policy change (ii), because it 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, except for the dynamics of labor. In fact, as a result of lower labor income tax rates, hours worked increase. This explains the positive responses of non-housing output and GDP in the short-run. In fact, the changes in the present value of both these aggregate variables are positive at a horizon of 20 quarters. However, since total housing falls gradually, the present values of GDP decrease in the long-run. This fall in housing is not compensated by the higher levels of non-housing output. Based on long-run present values of GDP, the repeal of mortgage interest deductions stands out as

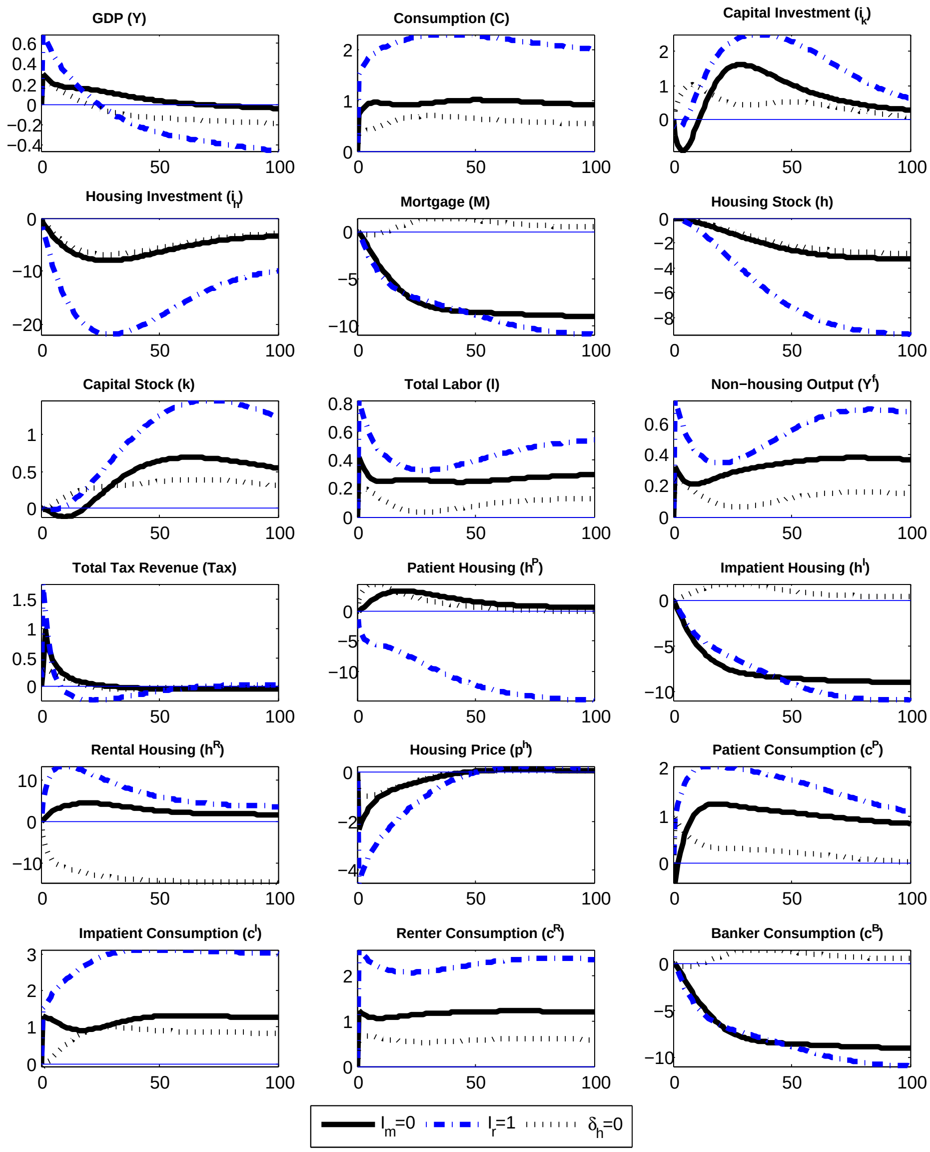

Figure 2: Responses to three revenue neutral experiments (I_{mt}, I_{rt}, and $\tilde{\delta}_{ht}$) measured in percent deviation from their initial steady states

the superior policy change.

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, since bankers face a capital adequacy constraint.

One key finding is that the economy substitutes residential investment for capital investment in response to the four experiments. The transitional effects on GDP are very small in the short-run for all 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. 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 substantial decreasing levels of housing, and only long-run output gains for the repeal of mortgage deductibility.

An extension to our work would be to embed the financing of the production of non-durable goods and housing. Firms would borrow from bankers and offer capital and land as collateral. Interesting dynamics may emerge, as bankers would redirect their funds towards firms in the event of a policy change. A financial accelerator mechanism, similar to the one put forward by Liu, Wang and Zha (2013) would arise as the value of firms' land and capital are likely to increase.

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A The equations of the model

Patient Households

$$\max E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \{\log c_\tau^P + \varphi_h \log h_{\tau-1}^P - \varphi_l \frac{(l_\tau^P)^{1+\iota}}{1+\iota}\}$$

s.t.

$$(1+\tau_c)c_t^P + p_t^h[(h_t^P - (1-\delta_h)h_{t-1}^P) + (h_t^R - (1-\delta_h)h_{t-1}^R)] + p_t^k[k_t - (1-\delta_k)k_{t-1}] + d_t + b_t^g =$$
$$w_t^P l_t^P + p_t^R h_{t-1}^R + (1+r_{t-1})b_{t-1} + r_t^k k_{t-1} + \Gamma_t^P - \tau_y[w_t^P l_t^P + (p_t^R - \tilde{\delta}_{ht})(h_{t-1}^R + I_{rt} h_{t-1}^P)$$
$$- \tau_{pt} p_t^h (h_{t-1}^P + h_{t-1}^R)] - \tau_d r_{t-1}(d_{t-1} + b_{t-1}^g) - \tau_k (r_t^k - \delta_k) k_{t-1} - \tau_{pt} p_t^h (h_{t-1}^P + h_{t-1}^R)$$
$$- \frac{\psi_h}{2\overline{h}^P}(h_t^P - h_{t-1}^P)^2 - \frac{\psi_h}{2\overline{h}^R}(h_t^R - h_{t-1}^R)^2 \tag{25}$$

FOCs

h_t^P :

$$(1 + \frac{\psi_h}{\overline{h}^P}(h_t^P - h_{t-1}^P))p_t^h = \beta_P \mathbf{E}_t[\frac{\varphi_h}{\lambda_t^P h_t^p}$$
$$+ \frac{\lambda_{t+1}^P}{\lambda_t^P}((1 - \delta_h - \tau_{pt}(1-\tau_y))p_{t+1}^h - I_{rt}\tau_y(p_{t+1}^R - \tilde{\delta}_{ht}) + \frac{\psi_h}{\overline{h}^P} p_{t+1}^h (h_{t+1}^P - h_t^P))] \tag{26}$$

h_t^R :

$$(1 + \frac{\psi_h}{\overline{h}^R}(h_t^R - h_{t-1}^R))p_t^h = \beta_P \mathbf{E}_t[\frac{\lambda_{t+1}^P}{\lambda_t^P}$$
$$((1 - \delta_h - \tau_{pt}(1-\tau_y)p_{t+1}^h + (1-\tau_y)p_{t+1}^R + \tau_y \tilde{\delta}_{ht} + \frac{\psi_h}{\overline{h}^R} p_{t+1}^h (h_{t+1}^R - h_t^R))] \tag{27}$$

d_t, b_t^g :

$$1 = \beta_P \mathbf{E}_t[\frac{\lambda_{t+1}^P}{\lambda_t^P}(1 + (1-\tau_d)r_t)] \tag{28}$$

k_t :

$$p_t^k = \beta_P \mathbf{E}_t[\frac{\lambda_{t+1}^P}{\lambda_t^P}((1-\delta_k)p_{t+1}^k + (1-\tau_k)r_{t+1}^k + \tau_k \delta_k)] \tag{29}$$

l_t^P :

$$\varphi_l (l_t^P)^\iota = \lambda_t^P (1-\tau_w) w_t^P \tag{30}$$

c_t^P :

$$(1+\tau_c)\lambda_t^P = 1/c_t^P \tag{31}$$

Impatient Households

$$\max E_t \sum_{\tau=t}^{\infty} \beta_I^{\tau-t} \{\log c_\tau^I + \varphi_h \log h_{\tau-1}^I - \varphi_l \frac{(l_\tau^I)^{1+\iota}}{1+\iota}\}$$

s.t.

$$\begin{aligned}&(1+\tau_c)c_t^I + p_t^h[h_t^I - (1-\delta_h)h_{t-1}^I] + (1+r_{t-1}^b)M_{t-1} = \\ &w_t^I l_t^I + M_t + \Gamma_t^I - \tau_y[w_t^I l_t^I - I_{mt} r_t^b M_t + I_{rt}(p_t^R - \tilde{\delta}_{ht})h_{t-1}^I - \tau_{pt} p_t^h h_{t-1}^I] \\ &- \tau_{pt} p_t^h h_{t-1}^I - \frac{\psi_h}{2\overline{h}^I}(h_t^I - h_{t-1}^I)^2\end{aligned} \tag{32}$$

$$M_t = \rho_m M_{t-1} + (1-\rho_m)\theta p_t^h h_t^I \tag{33}$$

FOCs

h_t^I :

$$\begin{aligned}&(1 - \frac{\lambda_t^m}{\lambda_t^I}(1-\rho_m)\theta + \frac{\psi_h}{\overline{h}^I}(h_t^I - h_{t-1}^I))p_t^h = \beta_I \mathbf{E}_t[\frac{\varphi_h}{\lambda_t^I h_t^I} \\ &+ \frac{\lambda_{t+1}^I}{\lambda_t^I}((1-\delta_h - \tau_{pt}(1-\tau_y))p_{t+1}^h - I_{rt}\tau_y(p_{t+1}^R - \tilde{\delta}_{ht}) + \frac{\psi_h}{\overline{h}^I} p_{t+1}^h (h_{t+1}^I - h_t^I))]\end{aligned} \tag{34}$$

M_t :

$$1 - \frac{\lambda_t^m}{\lambda_t^I} = \beta_I \mathbf{E}_t[\frac{\lambda_{t+1}^I}{\lambda_t^I}(1 + (1 - I_{mt}\tau_y)r_{t+1}^b - \frac{\lambda_{t+1}^m}{\lambda_t^I}\rho_m)] \tag{35}$$

l_t^I :

$$\varphi_l (l_t^I)^\iota = \lambda_t^I (1-\tau_w) w_t^I \tag{36}$$

c_t^I :

$$(1+\tau_c)\lambda_t^I = 1/c_t^I \tag{37}$$

Renter Households

$$\max E_t \sum_{\tau=t}^{\infty} \beta_I^{\tau-t} \{\log c_\tau^R + \varphi_h \log h_{\tau-1}^R - \varphi_l \frac{(l_\tau^R)^{1+\iota}}{1+\iota}\}$$

s.t.

$$(1+\tau_c)c_t^R + p_t^R h_{t-1}^R = (1-\tau_R)w_t^R l_t^R + \Gamma_t^R \tag{38}$$

FOCs

h_t^R :

$$p_t^R = \frac{\varphi_h}{\lambda_t^R h_{t-1}^R} \tag{39}$$

l_t^R :

$$\varphi_l (l_t^R)^\iota = \lambda_t^R (1-\tau_R) w_t^R \tag{40}$$

c_t^R :

$$(1+\tau_c)\lambda_t^I = 1/c_t^R \tag{41}$$

Bankers

$$\max E_t \sum_{\tau=t}^{\infty} \beta_{\tau-t}^B \log c_\tau^B$$

s.t.

$$(1+\tau_c)c_t^B + (1+r_{t-1})d_{t-1} + M_t = d_t + (1+r_{t-1}^b)M_{t-1} \tag{42}$$

$$d_t = \phi_t M_t \tag{43}$$

FOCs

d_t :

$$1 = \frac{\lambda_t^\phi}{\lambda_t^B} + \beta_B \mathbf{E}_t \frac{\lambda_{t+1}^B}{\lambda_t^B}(1+r_t) \tag{44}$$

M_t :

$$1 = \frac{\lambda_t^\phi}{\lambda_t^B}\phi_t + \beta_B \mathbf{E}_t \frac{\lambda_{t+1}^B}{\lambda_t^B}(1+r_t^b) \tag{45}$$

c_t^B :

$$(1+\tau_c)\lambda_t^B = 1/c_t^B \tag{46}$$

Firms

$$Y_t^f = A_t k_{t-1}^{\alpha}((l_t^P)^{\iota_P}(l_t^I)^{\iota_I}(l_t^R)^{\iota_R})^{1-\alpha} \tag{47}$$

$$\alpha\frac{Y_t^f}{k_{t-1}} = r_t^k \tag{48}$$

$$(1-\alpha)\iota_i\frac{Y_t^f}{l_t^i} = w_t^i, \quad i = P, I, R \tag{49}$$

Capital and housing producer

$$[1-\frac{\psi_x}{2}(\frac{i_t^x}{i_{t-1}^x}-1)^2]i_t^x = x_t - (1-\delta_x)x_{t-1} \quad x = k, h \tag{50}$$

$$p_t^x - \psi_x p_t^x(\frac{i_t^k}{i_{t-1}^k}-1)\frac{i_t^k}{i_{t-1}^k} - p_t^x\frac{\psi_x}{2}(\frac{i_t^k}{i_{t-1}^k}-1)^2$$
$$+\beta_P\mathbf{E}_t[\frac{\lambda_{t+1}^P}{\lambda_t^P}\psi_x p_{t+1}^x(\frac{i_{t+1}^k}{i_t^k}-1)(\frac{i_{t+1}^k}{i_t^k})^2] = 1 \quad x = k, h \tag{51}$$

Government

$$C_t = c_t^P + c_t^I + c_t^R + c_t^B \tag{52}$$

$$tax_t = \tau_c C_t + \tau_y[w_t^P l_t^P + (p_t^R - \delta_h)(h_{t-1}^R + I_{rt}h_{t-1}^P) - \tau_{pt}(h_{t-1}^P + h_{t-1}^R)] + \tau_d r_t d_{t-1}$$
$$+\tau_{pt}(h_{t-1}^P + h_{t-1}^R) + \tau_l(h_t^P + h_t^R) + \tau_k(r_t^k - \delta_k)k_{t-1}$$
$$+\tau_y[w_t^I l_t^I - I_{mt}r_{t-1}^m M_{t-1} + I_{rt}(p_t^R - \delta_h)h_{t-1}^I - \tau_{pt}h_{t-1}^I] + \tau_{pt}h_{t-1}^I + \tau_l h_t^I$$
$$+\tau_R w_t^R l_t^R \tag{53}$$

$$b_t^g + T_t = (1+r_t^b)b_{t-1}^g + \overline{g} + \Gamma_t^P + \Gamma_t^I + \Gamma_t^R \tag{54}$$

$$\Gamma_t^i = \vartheta_i Y_t^f - \rho_b b_{t-1}^g, \quad i = I, P, R \tag{55}$$

Market clearing conditions

$$Y_t^f = C_t + i_t + \overline{g} \tag{56}$$

$$Y_t = (1 + \tau_c)C_t + p^R h_{t-1} + i_t + \overline{g} \tag{57}$$

$$h_t = h_t^P + h_t^I + h_t^R \tag{58}$$

$$i_t^k = k_t - (1 - \delta_k)k_{t-1} \tag{59}$$

$$i_t^h = h_t - (1 - \delta_h)h_{t-1} \tag{60}$$

$$i_t = i_t^k + i_t^h \tag{61}$$