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* Views expressed are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

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Macroeconomic effects of mortgage interest deduction*

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Abstract

This paper develops a general equilibrium model featuring tax deductible mortgage interest. There are two main results: (i) a higher mortgage interest deduction leads to higher house prices, more levered households, and a higher rate of mortgage default; (ii) when mortgage risk is high the presence of mortgage interest deduction leads to more volatile responses of the main macro-variables to exogenous shocks (i.e. preference, productivity, and mortgage riskiness shocks). The empirical and theoretical evidence presented support the idea that mortgage interest deductibility may be a relevant factor in the occurrence of homeowner foreclosures.

Keywords: Mortgage interest deduction, house prices, mortgage default, DSGE.
JEL classifications: E32, E44.

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1 Introduction

The economic developments during the Great Recession have taught us that mortgages and housing are fundamental elements to understand the nature of crises. An important feature of the housing market in the US is the tax treatment that promotes homeownership. There is wide evidence that mortgage interest deductibility increases house prices and household leverage (e.g. Hendershott and Pryce, 2006; Martins and Villanueva, 2006). During busts, due to the decline in the value of real estate, foreclosures rise. From a macro-prudential perspective, it is necessary to understand features that could potentially contribute to the building up of financial imbalances and excessive household debt, thereby magnifying the problem. Tax features, such as the mortgage interest deduction, necessarily favour debt over equity and therefore may encourage high leverage. For this purpose I construct a model where borrowing and lending by households leads to mortgage defaults in equilibrium. Within this setting I examine the general equilibrium effects of mortgage interest deduction on house prices, leverage, mortgage default, and real activity. I first develop a model featuring an economy with households, firms, and a government. Households issue loans and purchase mortgage portfolios and in addition deduct interest from their mortgage payments. The government funds the deduction of mortgage interest with lump-sum taxes. In order to model default there is an idiosyncratic shock to the value of housing after households have signed a mortgage contract. At maturity, depending on the realisation of the shock, some households default on their mortgage. To understand the consequences for the real economy I discuss the dynamics of the model with productivity, preference, and mortgage riskiness shocks. Since the model features tax-deductible mortgage payments it is appropriate for analysing the macroeconomic effects of mortgage interest deduction.

Deductibility of mortgage interest is a mean of extending the fundamental tax advantage of owner occupied housing. The primary reason for its existence is to incentivise homeownership. The subsidy is also claimed to have positive externalities such as lower crime rates, higher voting rates, better care and maintenance of property, investment in the local community, and social mobility through asset accumulation (see, for an overview, Dietz and Haurin, 2003). Despite its merits, the mortgage interest deduction has also been subjected to criticism. Opponents of the policy stress the pro-rata increase in governmental budget. House prices and household leverage seem to walk hand in hand with the mortgage interest deduction (Hendershott and Pryce, 2006; Martins and Villanueva, 2006; Ellis, 2010). Moreover, increasing house prices make homeownership less affordable for households with moderate to low incomes. From an empirical perspective there is evidence that deductibility feeds into house prices depending on housing supply conditions (Hilber and Turner, 2014). This is particularly the case in condensed regions. Section 2 elaborates in more detail on the microeconomic effects of preferential tax treatments.

The main findings can be summarised as follows. The model can account for some of the key features of the mortgage market. House prices are higher in the presence of deductions and households will lever more the more they can deduct from their mortgage payments. Lowering the level of mortgage interest deduction for households will tighten their collateral constraint and, in equilibrium, lead to fewer delinquencies. The mechanism endogenously follows from the household optimisation. The findings suggest that the preferential tax treatment that exists in the housing market may be a relevant factor for our understanding of the occurrence of foreclosures.

The paper is structured as follows. Section 2 briefly discusses some related literature and provides some empirical motivation. Section 3 describes a model of a mortgage market with mortgage interest deduction. Section 4 provides the findings. Finally, section 5 concludes.

2 Literature and empirical evidence

A voluminous literature examines housing market outcomes in the context of federal tax policy. First, a wide strand of the literature considers the incentives for homeownership (e.g. Rosen and Rosen, 1980; Poterba, 1984; Rosen, 1985; Smith et al., 1988; Hanson, 2012; Hilber and Turner, 2014) and associated (positive) externalities (e.g. Glaeser and Shapiro, 2003; Dietz and Haurin, 2003; Fetter, 2013). Although early studies argue that the mortgage interest deduction increases homeownership, later papers question this. For example, Hilber and Turner (2014) highlight the perverse effects of the mortgage interest deduction in highly regulated housing markets where the supply of housing is inelastic. Rather than boosting homeownership, much of the tax benefit seems to be capitalised into housing prices making the tax benefit an ineffective policy tool.

There have also been many papers that consider the distribution, limitation or otherwise abolishment of the preferential tax treatment for housing (e.g. Litzenberger and Sosin, 1978; Rosen, 1979; Rosen et al., 1984; Berkovec and Fullerton, 1992; Follain and Melamed, 1998; Anderson and Roy, 2001; Stroebel and Floetotto, 2011; Jeske et al., 2013; Sommer and Sullivan, 2014). Many papers stress the asymmetry in benefits for households with differing incomes. Other studies consider housing market outcomes in renting over ownership. For example, Poterba and Sinai (2008) argue that the subsidy rate is larger for households in higher marginal tax rate brackets implying that those who benefit from the deduction would own homes anyhow and the tax treatment therefore provides an incentive to live in more expensive houses rendering its purpose, promoting ownership over renting, in moot. Some papers consider the distribution of tax benefits in the context of Tax Reform Acts (e.g. Poterba, 1992; Pechman, 1987; Maki, 2001). In a different contribution Poterba (1992) argues that the tax-exempt imputed income changed for homeowners after the TRA86 altering the distribution of the mortgage interest deduction benefit in favour of high income households. The findings of this literature point out that house prices are higher in the presence of deductions increasing the cost of homeownership.

Finally, a smaller literature examines the demand for mortgage debt, leverage, and foreclosures (e.g. Hendershott et al., 2002; Hendershott and Pryce, 2006; Martins and Villanueva, 2006) in the context of preferential tax treatment. From an international perspective, Lea (2010) argues that countries with mortgage interest deductibility have exhibited faster mortgage growth.[1] Ellis (2010) notes that the deductibility of interest combined with prepayment penalties may have contributed to the rise in household leverage in the US. The findings of this literature suggest that the tax saving as a result of deductions on mortgage interest is a significant determinant of the amount of mortgage debt and household leverage.

There are, in comparison, relatively a few papers taking a macro approach. Gervais (2002) studies the impact of the preferential tax treatment of housing capital in a dynamic general equilibrium life-cycle economy and finds that tax treatments such as the mortgage interest deduction result in distortions to tax the implicit rental income from owner-occupancy. In a related study, Chatterjee and Eyigungor (2011) consider in a quantitative setting the housing market and the foreclosure crisis. They show that the decline in house prices and the rise in foreclosures are much more prominent in the presence of preferential tax treatments.

In contrast with these papers, I use a simple model to represent the US mortgage market prior to the financial crisis of 2008 in a dynamic stochastic general equilibrium setting and understand the macroeconomic effects of deductions. I model default in the mortgage market following an approach similar to Bernanke et al. (1999) by introducing idiosyncratic shocks to the value of housing. This set-up captures the inherent riskiness of mortgages. An additional key feature of the model is that agents are constrained in their borrowing by a collateral constraint following the seminal work of Kiyotaki and Moore (1997). The resulting model is capable of representing the dynamics observed for mortgage demand and mortgage rates, real house prices, and delinquency rates in the US.

Figure 1 characterises the US mortgage market in the past decades. The figure portrays the increasing indebtedness of households during the 1980s and the subsequent boom in real house prices in 2000s. Mortgage delinquency rates fall during 1990s following the rise in mortgage demand before they take off after 2006. Figure 2 plots the cyclical components of these series. The top panel displays the components of mortgages and house prices. Outstanding mortgages are somewhat more volatile than house prices. The series display a positive co-movement throughout the sample. The lower panel plots the cyclical components of the mortgage rate and delinquency rate. Delinquency rates are positively correlated with mortgage rates and are particularly more volatile following the boom and bust after 2000. Table 1 provides some exact figures on the correlation and standard deviations of these series relative to house prices. The delinquency rate shows a negative correlation with mortgage demand, mortgage rate and real house prices. The delinquency rate is also comparatively more volatile than house prices following the bust in 2007-08.

To understand the relation between house prices and default rates better it is useful to make a distinction between house price elasticities. Mian and Sufi (2011) show that most of the rise in house prices comes

[1] Most OECD countries allow for deduction in some form. The countries that allow itemisation in some form are Austria, Belgium, Czech Rep., Denmark, Estonia, Finland, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, and the US. The US allows nearly full deductibility without taxing imputed rent. Also see Andrews and Caldera Sánchez (2011) for the drivers of homeownership rates in OECD countries and Bourassa et al. (2013) for an international survey on mortgage interest deduction.

from MSAs with inelastic housing supplies. Figure 3 plots house prices for the ten most inelastic and the ten most elastic MSAs in the US, confirming this picture. As mentioned, Hilber and Turner (2014) argue that the extent to which the mortgage interest deduction affects house prices depends on local housing supply conditions. Much of the mortgage interest deduction seems to be capitalised into house prices in inelastic regions. Figure 4 provides evidence that the average mortgage subsidy rate does not contradict this illustration. The figure shows that for MSAs that have inelastic housing supply there is a positive associationship with the average mortgage subsidy rate over the period 1984–2007. Moreover, the variation in mortgage interest rate subsidies used for deductions is not common across states. Figure 5 shows that there is no particular uniform pattern.

In what follows, a model is presented which can describe the mortgage market. Subsequently, the effects of mortgage interest deductions are discussed.

3 Model

The structure of the model is as follows. There is a continuum of infinitely lived households that consumes housing services and non-durable goods in an endowment economy with perfect insurance among household members. Households are divided into two groups. A fraction of, ω, are impatient and borrow in the model. The remaining fraction, $1 - \omega$, are patient and are the lenders. Borrowers issue mortgage debt over which they pay interest net of mortgage interest deduction. Lenders purchase mortgage portfolios over which they receive gross returns. In order to understand the role of mortgage interest deduction in a business cycle setting, I introduce idiosyncratic shocks to the value of housing. If the realisation of this shock is below some cut-off value, to be specified below, the loan repayments will exceed the value of the house and therefore, borrowers will default on their mortgage.

3.1 Mortgage contract

There is a representative household with a continuum of members indexed by i. At period t, the household members engage in a one-period mortgage contract with collateral. At period t a household member decides on the amount of housing and the interest rate that will be paid on its mortgage in period $t+1$. Upon maturity of the mortgage contract, a borrower experiences an idiosyncratic depreciation (appreciation) shock, $\varphi_{i,t+1}$, to its housing value. The idiosyncratic shock $\varphi_{i,t+1}$ is i.i.d. across household members and follows a normal distribution with mean one and standard deviation σ. The cumulative distribution function and the probability density function are denoted by $F(\varphi_{i,t+1})$ and $f(\varphi_{i,t+1})$, respectively. At maturity, borrowers experience idiosyncratic shocks and either repay the loan or default. In case of default, the borrower hands over the entire stock of housing to the lender.

Let $d_{i,t}$ and $r_{i,t}$ be the amount of mortgage debt and the interest rate on mortgage debt, respectively. The transfer to the lender at period $t+1$ is,

$$\begin{array}{ll} (1+r_{i,t})d_{i,t} & \text{if the borrower repays,} \\ p_{h,t+1}\varphi_{i,t+1}h_{i,t} & \text{if the borrower defaults,} \end{array}$$

where $p_{h,t+1}$ is the house price at period $t+1$ and $h_{i,t}$ is period t housing. Note that the interest rate is predetermined. The optimal default policy implies a cut-off value for the idiosyncratic shock. If the realisation of the idiosyncratic shock is below the cut-off level, the borrower will default. If the realisation is above the cut-off level, the borrower will repay the lender. The cut-off level therefore represents the marginal borrower that is indifferent between defaulting on its mortgage and repaying the lender. The optimal default policy follows from,

$$(1+r_{i,t-1}(1-\tau))d_{i,t-1} = p_{h,t}\bar{\varphi}_{i,t}h_{i,t-1}, \tag{1}$$

where τ is the fraction of mortgage interest that is tax-deductible and $\bar{\varphi}_{i,t}$ is a cut-off value of the idiosyncratic shock for which the borrower is willing to pay the mortgage debt at the contractual interest rate $r_{i,t-1}$. Note that the constraint in equation (1) resembles a collateral constraint as in Kiyotaki and Moore (1997) and Iacoviello (2005). As mentioned, if the realisation of $\varphi_{i,t+1}$ is below the cut-off $\bar{\varphi}_{t+1}$, the borrower defaults. The rate of default is denoted by $F(\bar{\varphi}_i)$.

Now consider the lender's side of the mortgage contract, specifically the lender's participation constraint. Lenders purchase a mortgage portfolio and can fully diversify the idiosyncratic shock and therefore bear only aggregate risk. However, lenders incur a cost in case the borrower defaults as in Bernanke et al. (1999).[2] Borrowers, in turn, will reveal their idiosyncratic shock satisfying equation (1). The gross return on a mortgage portfolio for the lender is,

$$R_{m,t+1} = \frac{\left(1-F\left(\overline{\varphi}_{i,t+1}\right)\right)(1+r_{i,t})m_t + (1-\mu)\,p_{h,t+1}h_t\int_{-\infty}^{\overline{\varphi}_{i,t+1}}\varphi \mathrm{d}F(\varphi)}{m_t}, \tag{2}$$

where m_t denotes purchases of the mortgage portfolio and $0<\mu<1$ is a default cost parameter. The gross return on the mortgage portfolio is equal to the transfer at maturity in case the borrower repays and the housing stock net of default cost in case the borrower defaults. The expectation of the idiosyncratic shock in (2) represents the expected value of the idiosyncratic shock conditional on the shock being less than or equal to the cut-off value $\overline{\varphi}_{i,t+1}$. Note that the cut-off $\bar{\varphi}_{i,t}$ enters equation (2) exogenously since the default behaviour of the borrower is assumed to be known by the lender. The participation constraint of the lender is of the form,

$$1 = \mathbb{E}_t\Lambda_{t,t+1}\left\{R_{m,t+1}\right\} \tag{3}$$

[2] The cost of default can be thought of as a monitoring cost for the lender to assess and seize the collateral in case of default (cf. Bernanke et al. (1999)). In order to keep the model as simple as possible I refrain from possible agency problems that justify the introduction of a monitoring cost. In the presence of a default cost mortgage contracts may not be optimal contracts. However, agents have incentives to use contracts due to their fiscal treatment.

where $\Lambda_{t,t+1}$ is the stochastic discount factor of lenders. In the optimum, the utility derived from a marginal unit of current consumption equals the discounted expected value of the utility from the amount of future consumption. If equation (3) holds, the lender is indifferent between consumption today and investment in a mortgage portfolio delivering a return that is discounted using a stochastic discount factor. A binding participation constraint ensures the lender's optimality condition in equilibrium.

It is worth repeating the decision variables in the contract. The optimal mortgage contract involves sequences of durable and non-durable consumption, mortgage debt, mortgage interest rate, and the cut-off value of the idiosyncratic shock such that the lender's participation constraint (and the household budget constraint) are satisfied. By symmetry, all borrowers make the same choices in equilibrium and by construction households will sign a mortgage contract and not finance the durable good with their own funds.

3.2 Impatient households

Impatient households derive utility according to the following function,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t + \eta z_{h,t} \ln h_t - \theta \ln n_t \right\},$$

where β is the discount factor, c_t and h_t denote time t consumption of non-durables and housing, respectively, $z_{h,t}$ is a time t housing preference shock, η is a housing preference parameter, and n_t is the supply of labour.[3] The budget constraint of the households is,

$$c_t + p_{h,t} \left(h_t - h_{t-1} \right) + R_{d,t} d_{t-1} + T_t = w_t n_t + d_t, \tag{4}$$

where w_t denotes wage income, T_t is lump-sum tax, and $R_{d,t}$ is the gross interest rate paid on mortgage debt in period t for debt issued at time $t-1$. $R_{d,t+1}$ is denoted by,

$$R_{d,t+1} = \frac{\left(1 - F\left(\overline{\varphi}_{t+1}\right)\right)\left(1 + r_t \left(1 - \tau\right)\right) d_t + p_{h,t+1} h_t \int_{-\infty}^{\overline{\varphi}_{i,t+1}} \varphi \mathrm{d}F\left(\varphi\right)}{d_t}. \tag{5}$$

where τ is the mortgage interest that is tax-deductible. In equation (5) gross interest payments on mortgage debt equal the transfer at period $t+1$ to the lender net of tax-deductible mortgage interest and the value of collateral.

Households choose sequences of non-durable consumption $\{c_t\}$, durable consumption $\{h_t\}$, labour $\{n_t\}$, mortgage debt $\{d_t\}$, mortgage interest rate $\{r_t\}$, and the cut-off value of the idiosyncratic shock $\{\overline{\varphi}_t\}$ to maximise utility subject to the budget constraint (4), the participation constraint (3), and the gross returns on the mortgage portfolio and debt, equations (2) and (5), respectively.

[3] In a representative context the i index is omitted.

3.3 Equilibrium conditions

The first order condition for housing is,

$$\frac{p_{h,t}}{c_{i,t}} = \frac{\eta z_{h,t}}{h_{i,t}} + \mathbb{E}_t \beta \left\{ \frac{p_{h,t+1}}{c_{t+1}} \left(1 - \int_{-\infty}^{\overline{\varphi}_{t+1}} \varphi \mathrm{d}F(\varphi) \right) \right\}$$
$$+ \mathbb{E}_t \Lambda_{t,t+1} \left\{ \lambda_t (1-\mu) \frac{p_{h,t+1}}{d_t} \int_{-\infty}^{\overline{\varphi}_{t+1}} \varphi \mathrm{d}F(\varphi) \right\} - \lambda_{2,t}(1 + r_t(1-\tau)) \frac{d_t}{h_t^2}, \quad (6)$$

where λ_t and $\lambda_{2,t}$ are the Lagrange-multipliers on the participation constraint and the collateral constraint, respectively. The right hand side of equation (6) represents the shadow value of housing and consists of four terms. The first one is the direct utility gain from consuming an additional unit of housing. The second term is the utility derived from the continuation value of the house in period $t+1$. The last two terms stem from the additional burden to satisfy the lender's participation and collateral constraints. In equation (3) (and implicitly in equation (1)) a household with higher durable consumption is relatively less likely to default, and less likely to incur a default cost. At the optimum, the shadow value of housing must be equal to the utility derived from $p_{h,t}$ marginal units of non-durables. Households supply labour according to,

$$w_t / c_t = \theta / n_t. \quad (7)$$

The Euler equation for mortgage demand is given by,

$$\frac{1}{c_t} = \mathbb{E}_t \beta \left\{ \frac{\left(1 - F\left(\overline{\varphi}_{t+1}\right)\right)(1 + r_t(1-\tau))}{c_{t+1}} \right\}$$
$$+ \mathbb{E}_t \Lambda_{t,t+1} \left\{ \lambda_t (1-\mu) p_{h,t+1} \frac{h_t}{d_t^2} \int_{-\infty}^{\overline{\varphi}_{t+1}} \varphi \mathrm{d}F(\varphi) \right\} - \lambda_{2,t}(1 + r_t(1-\tau)) \frac{1}{h_t}. \quad (8)$$

In equation (8) an extra utility value of consumption today by the borrower must equal the right hand side which consists of three terms. The first term is the repayment at maturity adjusted for a default probability and mortgage interest deduction. The second term captures the additional burden of satisfying the lender's participation constraint. The final term stems from the collateral constraint. The demand and supply of mortgages are plotted in Figure 6. The first order condition for the interest rate on mortgage debt is,

$$\mathbb{E}_t \beta \left\{ \frac{\left(1 - F\left(\overline{\varphi}_{t+1}\right)\right)(1-\tau) d_t}{c_{t+1}} \right\} = \mathbb{E}_t \Lambda_{t,t+1} \left\{ \lambda_t \left(1 - F\left(\overline{\varphi}_{t+1}\right)\right) + \lambda_{2,t} (1-\tau) \frac{d_t}{h_t} \right\}. \quad (9)$$

Finally, the first order condition for the cut-off value of the idiosyncratic shock is given by,

$$p_{h,t} \overline{\varphi}_t h_{t-1} = (1 + r_{t-1}(1-\tau)) d_{t-1}.$$

3.4 Patient households

The remaining fraction of households $(1-\omega)$ has discount factor γ, with $\gamma > \beta$. In equilibrium patient households will lend to impatient households. Lenders choose sequences of non-durable consumption

$\{c'_t\}$, housing services $\{h'_t\}$, labour $\{n'_t\}$, and mortgage portfolios $\{m_t\}$ such that their budget constraint is satisfied. The optimality conditions for mortgage supply, housing, and labour supply are similar to (3), (6), and (7), respectively. The borrowing constraint however does not apply to the impatient households so that the lagrange multipliers are always zero.

3.5 Firms

Following Iacoviello and Neri (2010) labour enters the production function in a Cobb-Douglas fashion. The firms in the economy produce output according to,

$$y_t = z_{a,t} n_t^{\alpha} n_t'^{(1-\alpha)} \tag{10}$$

where $z_{a,t}$ is a technology shock. Profit maximisation implies $w_t = \alpha y_t / n_t$ and $w'_t = (1-\alpha) y_t / n'_t$.

3.6 Government

The role of the government in this economy is to ensure that mortgage interests are deductible from taxes. The government budget constraint is,

$$T_t = \left(1 - F\left(\overline{\varphi}_t\right)\right) r_{t-1} \tau d_{t-1}. \tag{11}$$

3.7 Exogenous processes

Production technology is modelled exogenously and the corresponding process evolves according to the following law of motion,

$$\ln z_{a,t} = \rho_a \ln z_{a,t-1} + \varepsilon_{a,t}, \tag{12}$$

where $\varepsilon_{a,t}$ is an i.i.d. innovation that has a normal distribution with mean zero and standard deviation σ_a. The housing preference shock $z_{h,t}$ is in essence a shift in the demand for housing. It evolves according to,

$$\ln z_{h,t} = \rho_h \ln z_{h,t-1} + \varepsilon_{h,t}, \tag{13}$$

where $\varepsilon_{h,t}$ is an i.i.d. innovation with normal distribution mean zero and standard deviation σ_h.

3.8 Equilibrium

To close the model, aggregate housing is fixed and normalised to one,

$$\omega h_t + (1-\omega) h'_t = 1, \tag{14}$$

which is motivated by Hilber and Turner (2014) who argue that much of the mortgage interest deduction is capitalised into house prices in areas with inelastic supply of housing. Equilibrium in the mortgage market requires,

$$\omega d_t + (1-\omega) m_t = 0. \tag{15}$$

The aggregate resource constraint is,

$$y_t = \omega c_t + (1-\omega)c'_t - \mu p_{h,t+1} h_t \int_{-\infty}^{\overline{\varphi}_{i,t+1}} \varphi \mathrm{d}F(\varphi).$$

Equilibrium definition: *A competitive equilibrium are laws of motion for c_t, c'_t, h_t, h'_t, n_t, n'_t, d_t, m_t, $R_{d,t}$, $R_{m,t}$, r_t, T_t, $p_{h,t}$, $\overline{\varphi}_t$, y_t, $F(\overline{\varphi})$, λ_t, satisfying the system of equations (1)–(15), the focs of firms, and the cdf $F(\overline{\varphi}_t)$.* □

3.9 Calibration

The calibration for a quarterly model is presented in Table 2. The lender's discount factor is set equal to 0.99, which implies a steady state annual real interest rate of 4 percent. Borrowers are more impatient and have a discount factor of 0.97.[4] The weight of housing in the utility, η, measures the stock of housing over annual output. I set it equal to 0.05 in order to achieve a suitable steady state target. The default cost here is calibrated to 10 percent of the housing value. One could motivate this cost arising from three occurrences in housing markets. Foreclosures appear to have negative feedback effects on the values of neighbouring properties, worsening the decline in house prices (Campbell et al., 2011). A second matter is the real estate transfer tax, which a buyer incurs ipso facto on the privilege of transferring real property.[5] A further source of the default cost is the process of reselling, where resellers, who in case of foreclosures buy and resell houses below market value, add to the loss of the initial seller. I calibrate the mortgage interest deduction to a typical marginal tax bracket of 40 percent. In order to obtain a suitable steady state target for the default rate, the standard deviation of the idiosyncratic shock is set to 0.05. The persistence of the exogenous process parameters are set equal to 0.983 following Kydland and Prescott (1982).

4 Model findings

The model is solved using a first-order perturbation method and is subsequently simulated. Three types of simulations are discussed. First, I simulate the model with random sequences of productivity shocks and compare the business cycle statistics to those found in the data. Second, I discuss the dynamic responses to shocks in productivity and housing preferences. Finally, I simulate a default experiment and discuss the effects of mortgage interest deduction.

4.1 Business cycle statistics

Table 3 presents correlations and volatilities implied by the model. The model correctly predicts the sign of the correlations and volatilities. Quantitatively, the model comes close to correlations between house

[4] The patience and impatience of the agents is to some extent immaterial. What is needed to achieve equilibrium is $\gamma > \beta$. The equilibrium that will be discussed also holds for borrowers with higher discount factors, i.e. the 'more patient' impatient agents.

[5] The magnitude of this tax differs nationally. In the US it ranges from as low as 0.01 percent of the total value of the transfer in some states to 4 percent in others (Federation of Tax Administrators, 2006).

prices and mortgages found in the data but exceeds those in the correlations between mortgage rates and delinquency rates. The model also predicts higher volatilities for mortgage demand, mortgage rate, and the delinquency rate than they are found in the data. The findings show that although the model presented captures the essential mechanisms in the housing market, its stylised nature may not match the data completely.[6] Next, the analysis considers the effects of mortgage interest deductions.

4.2 The effects of mortgage interest deduction

4.2.1 Model steady state

What is the role of mortgage interest deduction in this economy? The equilibrium is presented in Table 4. In the baseline economy, with a mortgage interest deduction of $\tau = 0.4$, the annual default rate is 3.7 percent. Leverage, defined as the ratio of debt to housing value, is a little over 87 percent. The quarterly mortgage interest rate paid by borrowers is 1.12 percent. The steady state effects of a lower ($\tau = 0.2$) mortgage interest deduction are presented in the last column of Table 4. Following a lower deduction policy, households benefit less from their tax-deductible interest payments. Their borrowing constraint becomes more binding. As a result, the demand for mortgage debt and mortgage supply show a decline. The interest rate on mortgages and house prices declines as well. The default rate on mortgages declines 2.28 percent on an annual basis. With lower tax treatment, household leverage declines. The default rate decreases since the risk, that the value of the collateral in case of foreclosure will be insufficient to cover the remaining principal of the loan, declines.

4.2.2 Dynamic responses

Preference shock When household borrowing behaviour is influenced by house price swings there could be real effects on the economy through consumption and mortgage defaults. To characterise the magnitude and dynamics of shocks in this economy, I simulate the effects of a decrease in housing preference in Figure 7.[7] The baseline calibration follows Table 2 where the mortgage interest deduction τ is set to 0.4. The baseline model responds with a decrease in non-durable consumption of borrowers. The shock decreases the borrowing capacity of constrained households and decreases the demand for mortgages. Mortgage rates increase on impact. Since borrowers have high marginal propensities to consume aggregate consumption (not plotted) rises, even though the consumption of lenders falls. The fall in house prices decreases the house value and consequently there is more default on household mortgages. The model is able to describe the dynamics observed in Figure 1 and is conform the cyclical properties in Figure 2.

How come households decumulate housing services following a preference shock? Following a decline in housing preference, the households who are more credit constrained in the economy have less incentives to buy housing services. A unit of housing now provides fewer collateral services. In contrast, the

[6] The lack of capital investment, unemployment, labour market mobility, and nominal rigidities are some examples of the stylised nature of the model.

[7] One interpretation of a housing preference shock is that it captures the cyclical variations in the availability of resources that are needed to purchase housing services relative to non-durable goods (Iacoviello and Neri, 2010).

patient households in the economy, who are not affected by a credit constraint now have more incentives to hold additional housing stock. As a result, the impatient households become wealthier when house prices recover.

Now consider the low deduction calibration. Structural changes in mortgage markets that facilitate lower deduction clearly dampen the responses. Impatient households can now increase their non-durable consumption because a higher deduction loosens their constraint. Patient households accumulate less housing stock when the mortgage interest deduction is lower. House prices drop less compared to the situation with a higher deduction. This allows a higher fraction of the borrowers in the model to meet their payments resulting in lower default rates.

Productivity shock The dynamic responses to one-percent decline in productivity are presented in Figure 8. I discuss two calibrations. In the baseline calibration the responses show that a fall in productivity leads to a fall household consumption for both agents. House prices drop and mortgage demand declines. This decline in the asset base and the rise in mortgage payments lead to a higher fraction of borrowers who are not able to meet their payments, thereby increasing the rate of default on impact. Impatient households decumulate housing services while patient households, who are not credit constrained, accumulate housing stock.

In the second calibration, the level of deduction in the economy is lower ($\tau = 0.1$). The volatility in the response of defaults is small. Although house prices fluctuations are somewhat more responsive, the feedback effects on default rates and most of the other variables seem limited. Varying the mortgage interest deduction does not impact the dynamics of the variables following a shock to productivity.

4.2.3 Default experiment

This section considers the properties of the model following an increase in mortgage riskiness. I simulate the effects of an exogenous increase in the standard deviation of the idiosyncratic shock φ_t denoted σ_t. An increase in φ_t will disperse the distribution of the underlying asset. Due to a given cut-off level, an increase in σ will lead to more defaults. The default shock $z_{\sigma,t}$ enters the model through $\sigma_t = \sigma \ln z_{\sigma_t}$ and evolves according to the following law of motion,

$$\ln z_{\sigma,t} = \rho_\sigma \ln z_{\sigma,t-1} + \varepsilon_{\sigma,t}, \tag{16}$$

where $\varepsilon_{\sigma,t}$ is an i.i.d. innovation with normal distribution mean zero and standard deviation σ_σ.

Figure 9 displays the findings. In the baseline economy with $\tau = 0.4$, following a one standard deviation shock to the value of housing, house prices drop. Non-durable consumption and mortgage demand decline on impact. As previously, there is a wealth effect with impatient households decumulating housing stock as they are credit constrained. The fall in house prices leads to more delinquencies.

What are the implications of a structurally lower mortgage interest deduction policy in the mortgage market? Lowering the deductibility ($\tau = 0.1$) shows that, overall, there is much less volatility in the mortgage market. Impatient households now have less incentives to take on mortgage debt because their collateral constraint becomes more binding. The drop in house prices, and the associated delinquency rate, is much less on impact. From a policy perspective, the model suggest that a government's policy to loosen the borrowing constraints of households, by a higher deduction, depends also on the nature of the shocks in the economy. It seems that especially in an environment with high mortgage risk the presence of deductions leads to more volatile responses.

Eliminating the deduction in the model will not result in an equilibrium without any defaults simply because constrained agents still have incentives to borrow due to their impatience. As the responses illustrate, the key feature of the model stems from the presence of deductions and their effects on the borrowing constraint of households.

5 Conclusion

Understanding housing market outcomes is one of the central questions in macroeconomics. In this paper I have developed a model where the macroeconomic effects of mortgage interest deductions are analysed. The model findings suggest that lowering the amount of mortgage interest deduction for households will drop house prices and, in equilibrium, lead to fewer households in delinquency. Both the empirical and the theoretical evidence presented support the idea that mortgage interest deductibility can be an important policy tool through which changes in house prices spill over to the real economy.

However, since the set-up of my model is rather basic I do not answer other questions raised in the housing market. The model does not feature mobility or unemployment aspects of households in relation with the tax benefit thereby not accounting for decisions driven by these factors. Moreover, the simplicity of the model does not allow room for a discussion on the distribution of the mortgage interest deduction policy.

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Figures and Tables

Figure 1
The US mortgage market

Notes: This figure provides an overview of some key mortgage market series for the US considered in this study. The mortgage debt outstanding is for all holders, denoted in mln dollars. The mortgage rate is the 30-year conventional mortgage rate. The real house price index denotes the quarterly all-transactions House Price Index for the United States, deflated with the GDP deflator. The delinquency rate denotes quarterly single-family residential mortgages booked in domestic offices for all commercial banks. Data on mortgage rates and mortgage debt outstanding, and the GDP deflator are retrieved from Federal Reserve Economic Data, Federal Reserve Bank of St. Louis. The House Price Index is retrieved from the Federal Housing Finance Agency.

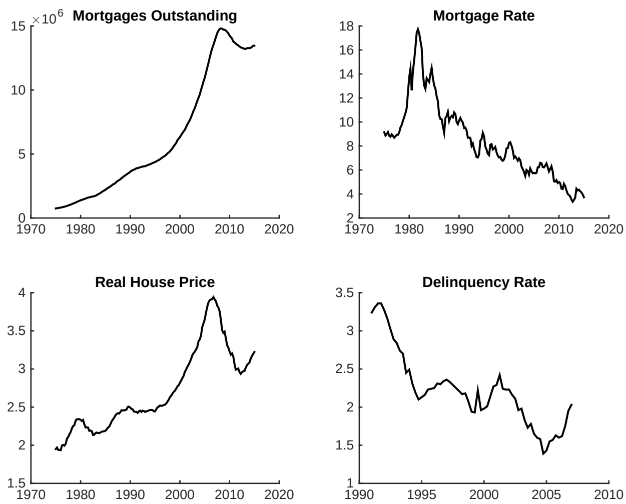

Figure 2
Cyclical components

Notes: This figure plots the cyclical components of mortgage debt outstanding, real house prices, delinquency rates, and mortgage rates. Series are log deviations from trend. Variables are HP-detrended with smoothing parameter 1600. For sources see Figure 1. NBER business cycle peaks and troughs are denoted by vertical dots above and below the time-axis, respectively.

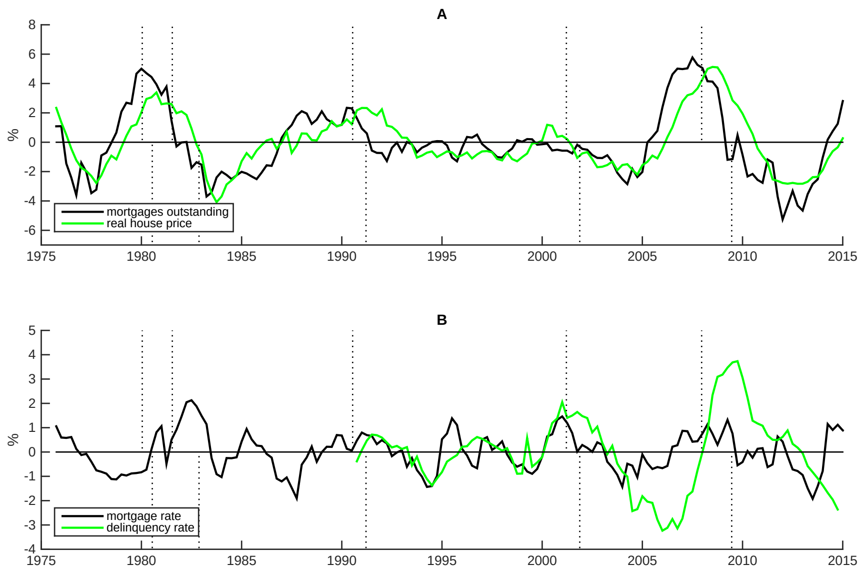

Figure 3
House Price Index for selected MSAs

Notes: This figure plots the movements in house prices categorised according to the most ten inelastic and the ten most elastic Metropolitan Statistical Areas in the US with population greater than 500,000. Housing supply elasticities used follow Saiz (2008) (and Mian and Sufi (2011)). See Table A2 for an overview. House prices denote the quarterly all-transactions House Price Index for the United States retrieved from the Federal Housing Finance Agency.

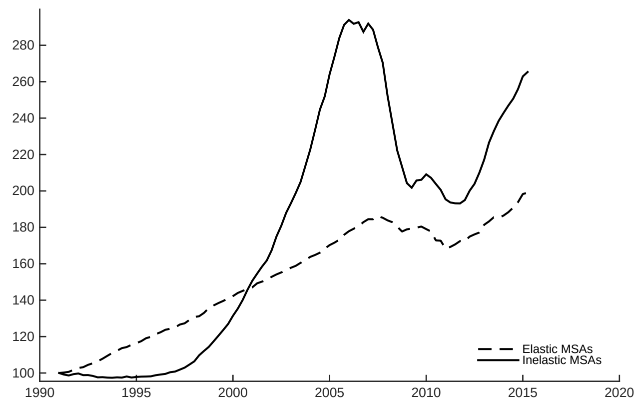

Figure 4

Mortgage subsidy rate and housing inelasticity

Notes: This figure plots the relation between the average mortgage subsidy rate over 1984–2007 and housing supply inelasticities following Saks (2008). The scatterplot excludes MSAs where the mortgage interest deduction is not present. The plot only considers Metropolitan Statistical Areas in the US with population greater than 500,000. Housing regulation figures are retrieved from Saks (2008). See Table A2 for an overview.

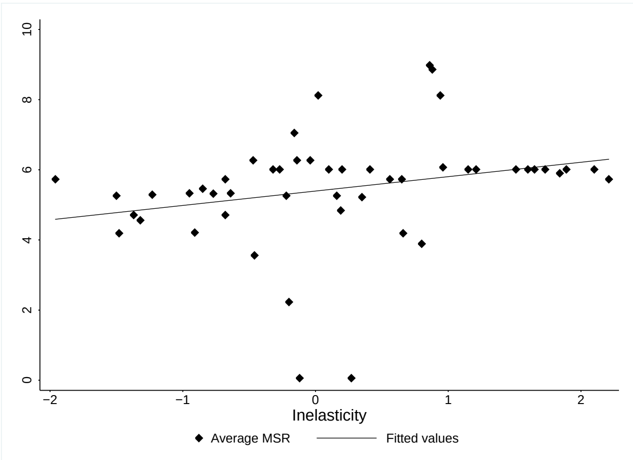

Figure 5

Mortgage subsidy rate by state

Notes: This figure characterises the mortgage deduction subsidy rates for US states over the period 1984–2007 as calculated by the NBER TAXSIM model from micro data for a sample of US taxpayers. See Feenberg and Coutts (1993) for a description of TAXSIM.

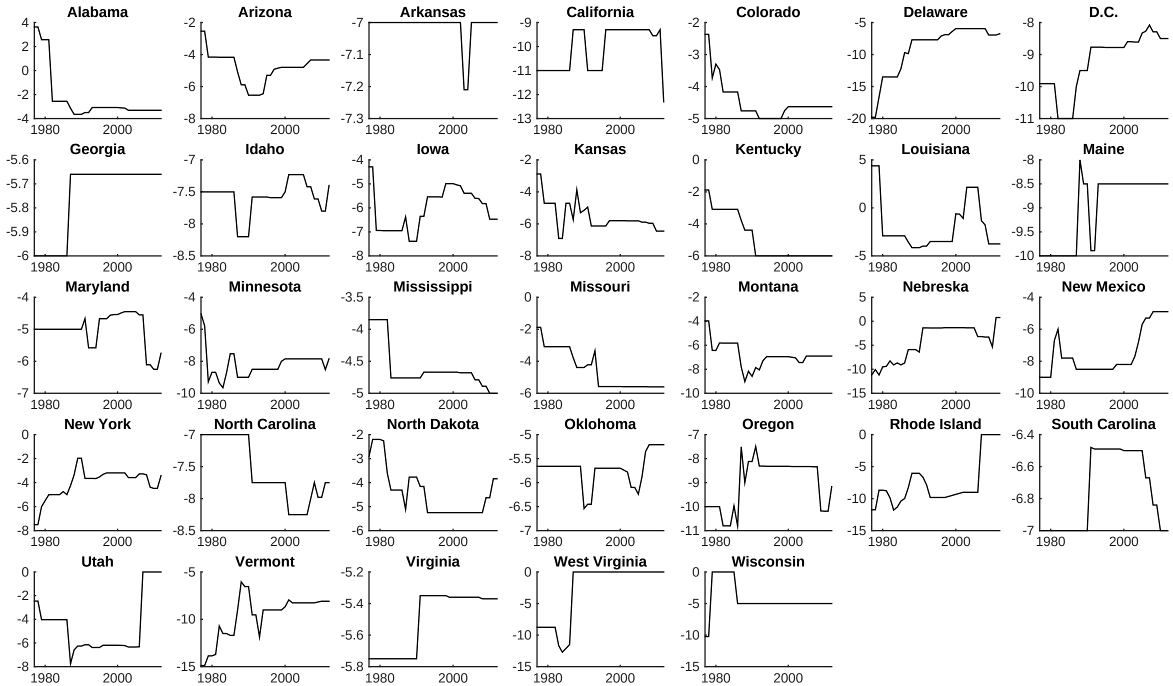

Figure 6

Demand and supply of mortgages

Notes: This figure plots the demand and supply of mortgages using the Euler conditions of the lender and borrower following Equations (3) and (8), respectively.

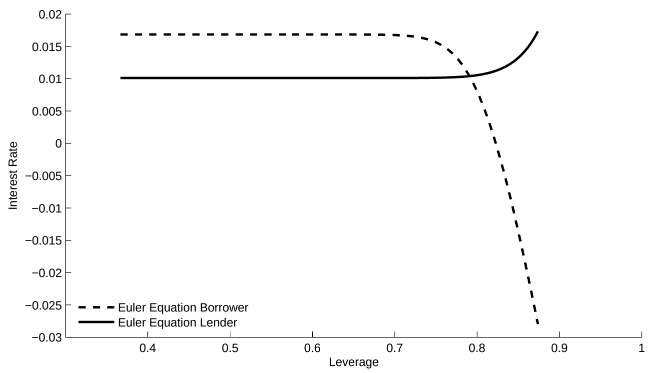

Figure 7
Responses to a housing preference shock

Notes: This figure plots the impulse responses for a decline in housing demand. Baseline calibration follows Table 2. In the low deduction economy there is lower mortgage interest deductibility ($\tau = 0.1$).

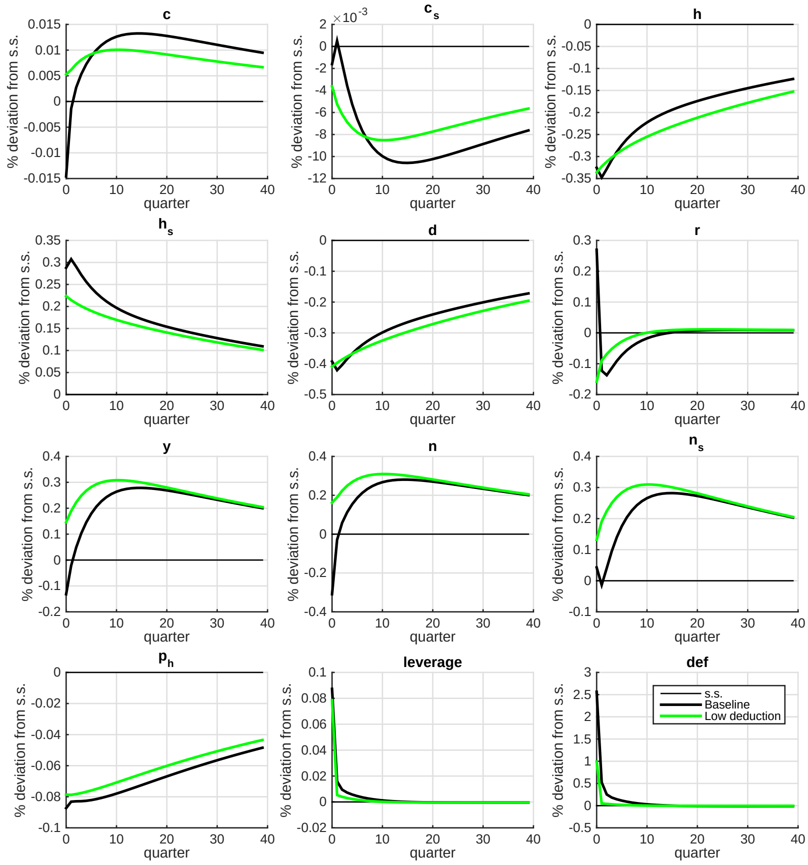

Figure 8
Responses to a productivity shock

Notes: This figure plots the impulse responses for a 1% decline in productivity. Baseline calibration follows Table 2. In the low deduction economy there is lower mortgage interest deductibility (τ = 0.1).

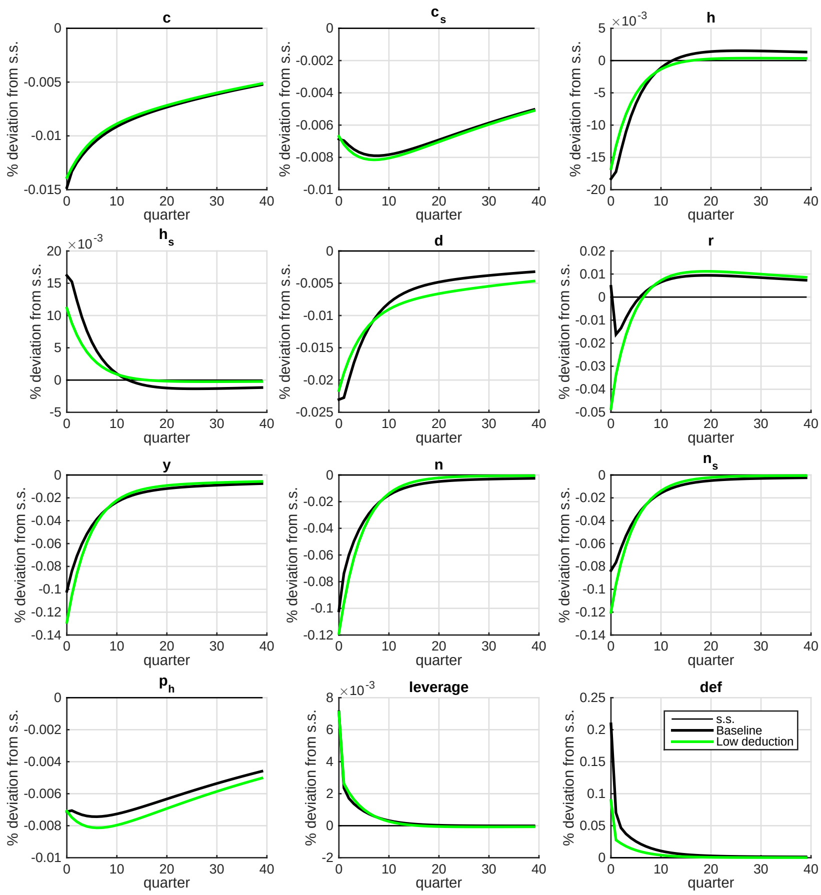

Figure 9
Responses to an increase in mortgage riskiness

Notes: This figure plots the impulse responses for an increase in mortgage riskiness (i.e. an increase in the standard deviation of the idiosyncratic shock). Baseline calibration follows Table 2. In the low deduction economy there is lower mortgage interest deductibility (τ = 0.1).

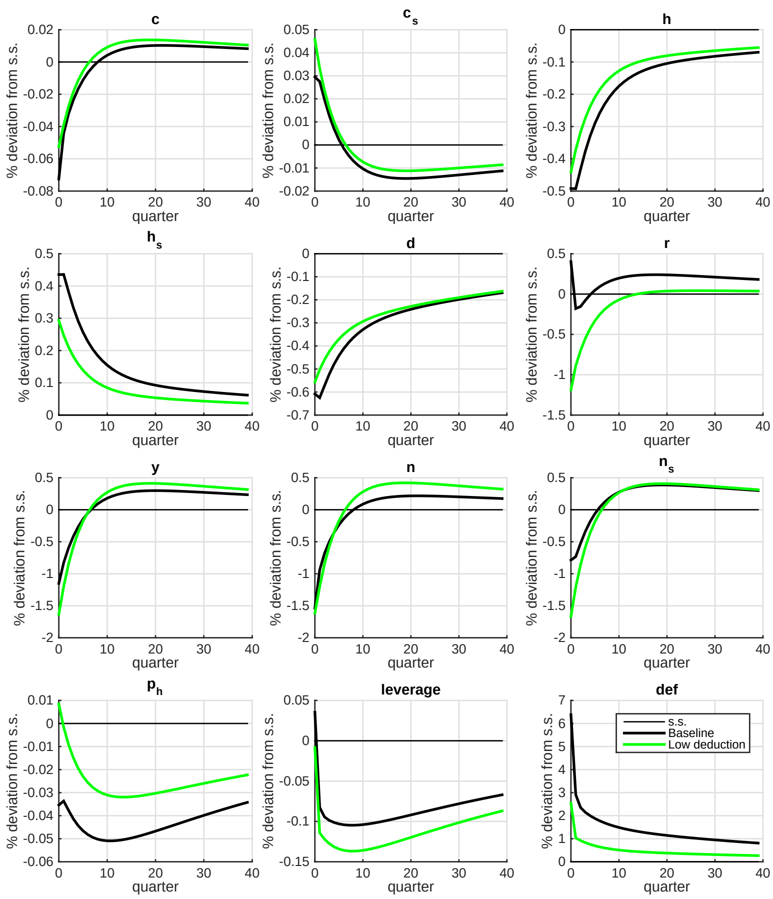

Table 1
Correlations and standard deviations in the data

Notes: All displayed values are for quarterly logged data. Variables are HP-detrended with smoothing parameter 1*e*5.

	House price	**Mortgages outstanding**	**Mortgage rate**	**Delinquency rate**
Correlations				
Mortgages outstanding	.8296	1		
Mortgage rate	.3958	.3618	1	
Delinquency rate	-.6145	-.1207	-.1979	1
Std dev relative to house price	1	1.422	1.259	4.825

Table 2
Model calibration

Notes: All displayed values are for a quarterly calibration.

Description	**Parameter**	**Value**	**Source/Target**
Discount factor borrowers	β	0.97	Check for robustness
Discount factor lenders	γ	0.99	Check for robustness
Housing preference	η	0.05	Steady state
Standard deviation idiosyncratic shock	σ	0.05	Steady state
Default cost	μ	0.1	Bernanke et al. (1999)
Mortgage interest deduction from taxes	τ	0.4	Marginal tax bracket
Exogenous process parameters	ρ	0.983	Kydland and Prescott (1982)
Inverse Frish elasticity of labour supply	θ	1	Check for robustness
Share of impatient agents	ω	0.2	American Housing Survey

Table 3
Correlations and standard deviations in the model

Notes: This table provides the average correlation and standard deviation statistics across 10 000 simulations following productivity shocks. Each simulation is for 40 years. All displayed values are for quarterly logged data. Variables are HP-detrended with smoothing parameter $81 \cdot 1e5$. Standard deviations are displayed between brackets.

	House price		**Mortgages outstanding**		**Mortgage rate**		**Delinquency rate**	
Correlations								
Mortgages outstanding	.9874	(.004)	1	(0)				
Mortgage rate	.378	(.124)	.4462	(.118)	1	(0)		
Delinquency rate	-.4265	(.086)	-.4302	(.075)	-.6744	(.0248)	1	(0)
Std dev relative to house price	1	(0)	3.9	(.194)	1.6	(.358)	15	(.117)

Table 4
Model steady state

Notes: All displayed values are quarterly results. The rate of default, $F(\bar{\varphi})$, is denoted annually.

Description	**Variable**	**Baseline**	τ **= 0.2**
Consumption impatient households	c	.9750	.9800
Consumption patient households	c'	1.0465	1.038
Housing impatient households	h	1.0015	.9156
Housing patient households	h'	.9985	1.084
Mortgage debt	d	4.598	3.796
House price	p_h	5.240	4.788
Gross return mortgage debt	R_d	1.006	1.009
Gross return mortgage portfolio	R_m	1.010	1.010
Mortgage interest rate	r	.0112	.0108
Tax	T	.0205	.0081
Labour	n	1.026	1.020
Lagrange multiplier pc	λ	17.32	22.39
Lagrange multiplier cc	λ'	.9723	.9788
Annual default probability	$F(\bar{\varphi})$	.0368	.0228
Leverage	$d/p_h h$	.8763	.8660

A

Table A1

Average Mortgage Subsidy Rate by State

Notes: This table provides an overview of the NBER mortgage subsidy rate in percentages by state over the period 1984-2007. Not all states subsidise. For those that do, there is a significant variation in the subsidy rate across US states with an average subsidy rate ranging from 8.12 cents for every dollar of mortgage interest to as low as 3.28 cents.

State	MSR	Std dev	Min	Max
ALABAMA	3.56	0.12	3.29	3.72
ALASKA	0	0	0	0
ARIZONA	4.21	0.86	3.37	5.61
ARKANSAS	5.46	0.83	3.81	6.43
CALIFORNIA	6.01	0.32	5.43	6.54
COLORADO	4.71	0.27	4.44	5.28
CONNECTICUT	.06	0.07	0	0.22
DELAWARE	6.41	0.87	5.1	8.56
D.C.	8.98	0.56	7.94	10.17
FLORIDA	0	0	0	0
GEORGIA	5.32	0.11	5.21	5.56
HAWAII	8.86	0.67	7.57	9.46
IDAHO	5.74	0.37	4.96	6.56
ILLINOIS	0	0	0	0
INDIANA	0	0	0	0
IOWA	5.59	0.21	5.25	5.81
KANSAS	5.33	0.84	3.07	6.19
KENTUCKY	5.26	0.72	3.96	5.83
LOUISIANA	2.23	1.37	-1.45	3.08
MAINE	7.28	0.36	6.31	7.78
MARYLAND	3.89	1.70	0.06	4.69
MASSACHUSETTS	0	0	0	0
MICHIGAN	0	0	0	0
MINNESOTA	7.05	1.08	5.34	9.59
MISSISSIPPI	4.04	0.31	3.47	4.53
MISSOURI	4.19	0.53	3.38	4.93
MONTANA	5.25	0.86	3.56	6.19
NEBRASKA	5.02	0.52	4.17	6.3
NEVADA	0	0	0	0
NEW HAMPSHIRE	0	0	0	0
NEW JERSEY	0	0	0	0
NEW MEXICO	5.29	0.80	3.69	6.22
NEW YORK	5.73	1.21	4.44	8.49
NORTH CAROLINA	6.27	.	.	
NORTH DAKOTA	3.28	0.17	3.08	3.58
OHIO	0	0	0	0
OKLAHOMA	4.56	2.44	0.4	6.41
OREGON	8.12	0.51	6.7	8.86
PENNSYLVANIA	0	0	0	0
RHODE ISLAND	5.22	0.50	4.31	6.07
SOUTH CAROLINA	5.90	0.44	5.3	6.52
SOUTH DAKOTA	0	0	0	0
TENNESSEE	0	0	0	0
TEXAS	0	0	0	0
UTAH	6.07	0.41	5.41	7.34
VERMONT	5.72	0.70	4.4	6.76
VIRGINIA	5.29	0.12	5.15	5.49
WASHINGTON	0	0	0	0
WEST VIRGINIA	0.87	2.06	0	5.6
WISCONSIN	4.84	0.79	3.73	7.15
WYOMING	0	0	0	0

Table A2
Housing Supply Elasticities and Regulation

Notes: This table provides an overview of housing supply elasticity and regulation for Metropolitan Statistical Areas in the US with population greater than 500,000. Higher figures indicate a higher degree of housing supply regulation. Housing regulation figures are retrieved from Saks (2008). Housing supply elasticities are retrieved from Saiz (2008).

MSA	**Elas.**	**Reg.**	**MSA**	**Elas.**	**Reg.**
Los Angeles-Long Beach, CA	0.57	1.21	Albany-Schenectady-Troy, NY	1.45	0.56
Miami, FL	0.57	0.47	Wilmington-Newark, DE-MD	1.48	
San Francisco, CA	0.59	2.1	Buffalo-Niagara Falls, NY	1.49	-1.96
New York, NY	0.64	2.21	Raleigh-Durham-Chapel Hill, NC	1.5	-0.14
Boston-Worcester-Lawrence, MA-NH	0.65	0.86	Stockton-Lodi, CA	1.53	
Oakland, CA	0.66	0.1	Allentown-Bethlehem-Easton, PA	1.54	-0.45
San Diego, CA	0.68	1.6	Albuquerque, NM	1.58	
Fort Lauderdale, FL	0.71	0.23	Gary, IN	1.59	1.23
Ventura, CA	0.73	1.15	Ann Arbor, MI	1.7	
Chicago, IL	0.73	-1.01	Birmingham, AL	1.79	-0.46
San Jose, CA	0.75	1.65	Las Vegas, NV-AZ	1.82	
Seattle-Bellevue-Everett, WA	0.78	1.48	Baton Rouge, LA	1.86	
Norfolk-Virg.Beach-Newport N., VA-NC	0.78		Columbus, OH	1.88	-0.07
New Orleans, LA	0.83	-0.2	Dallas, TX	1.88	-1.18
Salt Lake City-Ogden, UT	0.86	0.96	Akron, OH	1.9	
Baltimore, MD	0.86	0.8	Grand Rapids-Musk.-Hol., MI	1.93	-0.65
New Haven-Brdgprt-Stmfrd-D.-W., CT	0.86	0.27	Toledo, OH	1.93	
Milwaukee-Waukesha, WI	0.86	0.19	Atlanta, GA	1.94	-0.77
Cleveland-Lorain-Elyria, OH	0.9	-0.25	Syracuse, NY	1.97	0.65
Newark, NJ	0.92	1.02	Houston, TX	2.01	-0.52
Riverside-San Bernardino, CA	0.92	1.73	Louisville, KY-IN	2.02	-0.22
Tacoma, WA	0.96		Nashville, TN	2.03	-1.65
Providence-Warwick-Pawtucket, RI	0.97	0.35	St. Louis, MO-IL	2.1	-0.66
West Palm Beach-Boca Raton, FL	0.99	0.51	Youngstown-Warren, OH	2.12	
Pittsburgh, PA	0.99	0.26	Cincinnati, OH-KY-IN	2.15	0.16
Sarasota-Bradenton, FL	0.99	0.08	Mobile, AL	2.16	
Portland-Vancouver, OR-WA	1.01	0.94	Richmond-Petersburg, VA	2.19	-1.23
Tucson, AZ	1.03		San Antonio, TX	2.26	-0.66
Tampa-St. Petersburg-Clearwater, FL	1.03	0.16	Fort Worth-Arlington, TX	2.27	
Detroit, MI	1.04	-0.69	Greensboro-Winston-S.-H.P., NC	2.39	-0.47
Vallejo-Fairfield-Napa, CA	1.06	-0.27	Austin-San Marcos, TX	2.41	0.48
Jacksonville, FL	1.06		Columbia, SC	2.57	
Philadelphia, PA-NJ	1.1	0.47	Oklahoma City, OK	2.58	-1.32
Orlando, FL	1.15	0.5	Charlotte-Gastonia-Rock Hill, NC-SC	2.59	-0.04
Springfield, MA	1.16		Greenville-Spartanburg-Anderson, SC	2.7	
Jersey City, NJ	1.16		Little Rock-North Little Rock, AR	2.73	-0.85
Memphis, TN-AR-MS	1.17		McAllen-Edinburg-Mission, TX	2.81	
Denver, CO	1.18	-0.68	Kansas City, MO-KS	2.82	-0.95
Minneapolis-St. Paul, MN-WI	1.18	-0.16	Omaha, NE-IA	2.83	
Hartford, CT	1.19	-0.12	Dayton-Springfield, OH	2.91	-1.26
Rochester, NY	1.2	-0.68	Tulsa, OK	3.02	
Harrisburg-Lebanon-Carlisle, PA	1.27		Indianapolis, IN	3.36	-0.55
Washington, DC-MD-VA-WV	1.28	0.86	Fort Wayne, IN	5.13	
Phoenix-Mesa, AZ	1.29	-0.91	Wichita, KS	5.16	
Fresno, CA	1.31	0.2			
Colorado Springs, CO	1.31				
Bakersfield, CA	1.34				
Scranton-Wilkes-Barre-Hazleton, PA	1.34				
Charleston-North Charleston, SC	1.38	1.84			
Knoxville, TN	1.42				
El Paso, TX	1.42				

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