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Distributional Implications of Government Guarantees in Mortgage Markets

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Abstract

We analyze the removal of the credit-risk guarantees provided by the government-sponsored enterprises (GSEs) in a model with agents heterogeneous in income and house price risk. We find that wealth inequality increases, driven by higher mortgage spreads and housing rents. Housing holdings become more concentrated. Foreclosures fall. The removal benefits high-income households, while hurting low- and mid-income households (renters and highly leveraged mortgagors with conforming loans). GSE reform requires compensating transfers, sufficiently high elasticity of rental supply, or linking GSE reform with the elimination of the mortgage interest deduction. (*JEL* E51, H81, G21, R2)

Introduction

Reforming the housing finance system is a pressing policy issue in the United States, but recent proposals have failed to gain Congressional support.[1] The status quo is that the federal government, directly or indirectly, insures the credit risk of most of the mortgage market.[2] Most policy reforms propose a dramatic size reduction of the government-sponsored enterprises (GSEs). The effect of the policy on inequality is a key element of the debate.

In this paper, we study the distributional implications of the GSEs. We analyze a quantitative general equilibrium model with endogenous mortgage spreads and agents heterogenous in idiosyncratic income, housing tenure choices, and idiosyncratic house value shocks. To focus on distributional questions, we abstract from aggregate shocks, which are a key element in the business-cycle analysis of Elenev, Landvoigt, and Van Nieuwerburgh (2016). We model all aspects of current U.S. housing policy relevant to studying inequality (FHA, GSE, and jumbo loans, mortgage interest deductibility, guarantee fees, progressive taxes, and social transfers).

This paper is novel because it integrates the aforementioned elements with the GSE-credit-risk subsidy model. Lenders pay a guarantee fee (g-fee) to the GSEs, which cover lenders' credit losses in case of borrower default. The literature analyzing the distributional implications of the GSEs have, so far, only focused on funding subsidies. That is, the GSEs have funding advantages that they pass to mortgage lenders and then to mortgagors. A funding subsidy works through the liability side of a lender's balance sheet; a credit-risk subsidy operates through the asset side. We show that this makes a difference when studying inequality. Ample evidence supports that the GSEs provide a subsidy for credit risk. For example, the Congressional Budget Office (CBO) and several authors have shown that the GSEs' guarantees are underpriced. For this reason, the CBO inputs the credit subsidies into the federal budget (CBO 2013; Lucas and McDonald 2010).

The model captures the different mortgage choices available to households and the housing tenure decision. Since all households have the same preferences, the renters are the low-income, low-wealth households who do not qualify for credit or prefer not to borrow given their credit conditions. The remaining households want to buy a house because it provides housing services, it has collateral value, it is an investment asset with positive excess return relative to the deposit rate and because mortgage interest rates are tax deductible. However, because there is a minimum size, housing prices are high relative to income and most households need credit to

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[1] For example, the U.S. Congress failed to approve the Corker-Warner bill and the Johnson-Crapo bill. The Obama administration put forward a white paper, but it was abandoned.

[2] For example, in 2014, the GSEs insured about 50% of the market, whereas other programs, such as the FHA, VA, RD, and PIH loans, insured around 20% of the market.

buy a house.

In the absence of government guarantees, the mortgage rate is banks' cost of funds (the deposit rate and origination costs) plus a mortgage spread that increases with the mortgagor's credit risk. This risk decreases with households' wealth, both in the model and in the data from the Survey of Consumer Finances. That is, low wealth households have higher debt-to-house value (DTV) and debt-to-income (DTI) ratios.[3] FHA and GSE guarantees provide a larger subsidy to those households with larger default risk. Thus, there are large cross-sectional differences on who benefits from the credit-risk subsidies. The average subsidy estimated in the housing finance literature (and that we match in the model) does not capture this substantial heterogeneity.

Closing the GSEs has a direct effect on GSEs' borrowers, and it triggers several general equilibrium effects. First, the direct effect is that GSE borrowers (who are usually mid-income, mid-wealth households with roughly 80% loan-to-value) lose their credit subsidy and move either to the rental market, or to FHA or jumbo mortgages. Both of these mortgages have spreads higher than GSE-insured mortgages, and these households cut their borrowing.[4] Second, lower demand for credit implies that deposit rates (the risk-free rate in our model) fall in order to decrease the supply of savings. Third, because the net flow among households is from homeownership to renting, housing rents increase and housing prices fall. Fourth, removing the GSEs lowers default rates and the deadweight costs from foreclosures. Thus, the economy has more output available for consumption. Fifth, since the government does not have to absorb the GSEs' credit losses, it can rebate those savings to households through lower taxes or higher transfers.

Who wins and who loses from the removal of the GSEs depends on the exposure of households to each of the previous channels. Renters suffer because rents increase, the return on their deposits is lower, and they can no longer expect a large credit subsidy from becoming a GSE-insured mortgagor. Mid-income households who are FHA borrowers enjoy lower housing prices and a drop in mortgage rates because deposit rates fall. However, they lose the possibility of transitioning to GSEs' mortgages with lower rates. Mid-income households who are high-leverage GSE mortgagors suffer the most because their mortgage spreads increase the most. High-income households who borrow in the jumbo market are the main winners from

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[3]Mortgage spreads depend on DTI because, in the model, lenders have partial recourse to borrower's income. Frame, Gerardi, and Tracy (2016) discuss that income levels (and related variables as the FICO score) are priced in mortgage spreads, even without recourse, because income affects default decisions, such as through its link to the cost of default.

[4]Removing the GSEs increases average mortgage rates by 22 bp. Elenev, Landvoigt, and Van Nieuwerburgh (2016) obtain a similar result.

the removal. Their spreads are not affected and their mortgage rates decrease as lenders pass on their lower deposit rates. Lower price-to-rent ratios and return on deposits make it more attractive to be a landlord. High-income households shift their portfolios toward housing. However, if the drop in deposit rates is large enough then the welfare of wealthy households with large holdings of deposits may decrease. We compare alternative modeling choices that alter the strength of the different channels.

The previous discussion implies an uneven distribution of the welfare gains or losses from eliminating the GSEs. However, some channels are beneficial for everybody. (1) Average leverage decreases, although the cross-sectional distribution of leverage changes: low- and mid-income mortgagors decrease leverage while high-income mortgagors increase it. Every household benefits from an economy with less deadweight losses from default. (2) Everyone benefits from the government lowering taxes or increasing transfers. Nevertheless, these channels are not strong enough to compensate the low- and mid-income households who lose from the removal of the GSEs.

Wealth inequality measured by the Gini index increases when the GSEs are removed. Most of the increase is due to higher housing costs (higher rents or larger mortgage payments) and lower return on savings of the low and mid-income households. These households need to devote some of their previous savings to cover the higher housing costs, which lowers their ability to accumulate wealth. This is especially important for previous GSE borrowers who pass from paying a mortgage and accumulating housing wealth to paying rents and not accumulating any wealth. Moreover, as deposit savings lose value, the wealthy households can shift their portfolios toward housing (because the return from being a landlord is higher). The low and mid-income households cannot do this because access to and cost of mortgage credit act as entry barriers. Housing holdings therefore become more concentrated.

If the supply of rental housing is not elastic enough (for example, if landlords are mom-and-pop investors unable to diversify housing risk) then we find that most households oppose the removal of the GSEs. This result may explain why all proposals to reduce the guarantees have so far failed. Most renters and leveraged homeowners are against the removal. The median wealth of the households who favor the reform is about three times larger than the median wealth of the households who oppose it.

GSE reform requires fiscal transfers to compensate the losers, policies to encourage rental supply, or to link GSE reform to the elimination of the mortgage interest deduction. This last result is mainly due to the renters, who are the major losers of the mortgage interest deduction and would vote in favor of GSE reform if it comes with the repeal of the deduction.

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1 Related Literature

This paper is related to the growing literature which uses models of heterogeneous agents with idiosyncratic labor income risk to study housing and/or mortgage markets.[5] Several papers in this area, such as Chambers, Garriga, and Schlagenhauf (2009); Floetotto, Kirker, and Stroebel (2016); Gervais (2002); Jeske, Krueger, and Mitman (2013); or Sommer and Sullivan (2015) analyze distributional effects of housing policies. This paper contributes to this literature in many aspects. For example, aspects, such as the modeling of the mortgage guarantees as a credit risk subsidy; the modeling of the housing tenure choice with endogenous mortgage spreads, house prices and rents; or the presence of FHA, GSEs, and nonconforming mortgages.

Through the questions that we study, our paper contributes to the literature analyzing housing finance reform and the role of the government in mortgage markets. Frame, Wall, and White (2013), Glaeser and Gyourko (2008), and Levitin and Wachter (2013) survey the U.S. housing finance policy. Passmore, Sparks, and Ingpen (2002) and McKenzie (2002) have estimated the average implicit subsidy from the GSEs. Our calibrated model matches those estimates and highlights that average subsidies hide substantial heterogeneity across households. The largest subsidies are for the GSE mortgagors with high leverage. To our knowledge, the empirical literature on housing finance has not studied this cross-sectional heterogeneity.

Our paper complements Jeske, Krueger, and Mitman (2013) by showing that a different way to model the GSEs' subsidies leads to different distributional implications. Jeske, Krueger, and Mitman (2013) analyze mortgage guarantees in a model with heterogeneous agents and idiosyncratic risk. They conclude that eliminating the guarantees is a progressive policy that would hurt high-income, high-wealth households. As we discuss in Section 4, we obtain the opposite distributional results because we model the GSEs as a credit-risk subsidy to the lenders, while Jeske, Krueger, and Mitman (2013) model the GSEs as a funding subsidy. The different modeling choice determines who are the borrowers who benefit the most from the subsidy. In Jeske, Krueger, and Mitman (2013), the funding subsidy from the GSEs lowers the cost of credit equally for all borrowers. Thus, the high-income households that borrow the most receive the largest subsidy. In our model, it is not the amount of borrowing but the risk of the borrower that determines who gets the largest subsidy. Low-income mortgagors receive the

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[5]Some examples include Arslan, Guler, and Taskin (2015); Chatterjee and Eyigungor (2015); Chu (2014); Corbae and Quintin (2015); Díaz and Luengo-Prado (2010); Guler (2015); Hatchondo, Martinez, and Sánchez (2014); Iacoviello and Pavan (2013); Li et al. (2016); Mitman (2016); Silos (2007); or Sommer, Sullivan, and Verbrugge (2013). Gete and Reher (2016) solve for the closed-form solutions of a model with aggregate shocks but deterministic heterogeneity.

largest subsidy because they have the largest default risk in GSE-insured loans. This difference is the key driver of our different distributional results. Moreover, this paper complements Jeske, Krueger, and Mitman (2013) by providing another reason why mortgagors hold deposits: they serve as collateral that lower mortgage spreads.

Kim and Wang (2016) study the removal of the FHA credit-risk guarantees in a model with nonrecourse mortgages. They obtain similar distributional results to what we obtain in this paper. A key difference is that their model assumes constant deposit rates, price-to-rent ratios, and homeownership rates. These assumptions eliminate some channels that we show are important for a distributional analysis.

Elenev, Landvoigt, and Van Nieuwerburgh (2016) study a general equilibrium model with aggregate shocks, borrowers, depositors, bankers, and a government that, in addition to subsidizing mortgage credit risk, provides a bailout guarantee to the banks. Their focus is the interaction between the guarantees and bankers' risk-taking, not the distributional aspects. They find that removing the guarantees leads to a more stable financial system with borrowers indifferent on whether to remove the guarantees, while savers are substantially better off. Thus, virtually nobody opposes the removal of the guarantees. Our results are different in this regard because in our setup, the spreads endogenously depend on income, and because we allow for rental markets. Thus, we take account of the groups who would lose with the policy change: renters and low to mid-income mortgagors whose higher spreads prevent them from enjoying the lower house prices while rents increase.

Zhang (2015) uses a partial equilibrium, deterministic assignment model to assess the distributional impact of eliminating the GSEs. He does not model households' default and studies the guarantees as a subsidy to the interest rate. He finds that the guarantees mostly benefit low-income households.

2   Model

There is a continuum of infinitely lived households, a continuum of competitive lenders and a government. It is a closed economy model. The model is described recursively.

2.1 Households

Preferences: Households derive utility from consumption of the numeraire good (c) and from housing services that we call shelter (s). Housing services can be either owned or rented,

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, s_t),$$

where $\beta \in (0,1)$ is the discount factor. The tenure status of a household is denoted by the indicator function I_h ($I_h = 1$ for a homeowner, $I_h = 0$ for a renter).

Endowments: Households supply labor inelastically and receive an idiosyncratic stochastic labor income $y \in Y$ measured in terms of the numeraire. This shock follows a finite state Markov chain with transition probabilities $\pi(y'|y)$ and unique invariant distribution $\Pi(y)$.[6] The income mean is $\bar{y} = \sum_{y \in Y} y\Pi(y)$. Because of the law of large numbers, π and Π describe the fraction of households receiving a particular income shock, and $\bar{y}$ is the aggregate income. We use a progressive tax system that allows for mortgage interest deductions. The function $\tau(y, m, P_m)$ summarizes the total tax payments for a household with an income of y, mortgage loan m and gross mortgage rate $\frac{1}{P_m}$. Thus, $y - \tau(y, m, P_m)$ is the disposable income. Moreover, households receive a lump-sum transfer $T(y)$ from the government which are a function of income.

Markets: There are five markets: owner-occupied housing, rental housing, consumption goods, mortgage credit, and deposits. Households can invest in one-period deposits $P_d d'$ which pay d' next period. Thus, the gross risk-free rate is $\frac{1}{P_d}$. Shelter services can be rented at rental price P_s or obtained from owning a house. The price of a house is P_h. The aggregate stock of housing (H) is in fixed supply. Rental supply is endogenous. One unit of housing stock h equals one unit of shelter services s. A household can be a renter $(h = 0)$, a homeowner who consumes all her housing $(h = s)$, or a landlord who rents part of her housing holdings $(h > s)$. To have well-defined renters and owners, there is a minimum house size for ownership, $h \geq \underline{h}$, but no minimum size for rental.[7] Moreover, to match the relative sizes of owner-occupied and rental housing, there is a minimum housing consumption for landlords, $\underline{s} < \underline{h}$.

To introduce uncertainty about the value of a house, there are idiosyncratic housing depreciation shocks δ' such that if a house of size h is bought today, then next period the size of the house is $(1 - \delta')h$. We denote the associated cumulative distribution function as $F(\delta')$ with support $[\underline{\delta}, 1]$, where $\underline{\delta} \leq 0$. Thus, houses are risky assets.

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[6]A prime denotes the value at the start of the next period.

[7]With perfectly divisible housing, almost everybody would own some housing.

If a household buys a house, she can use it as collateral for one-period mortgage debt. We denote the principal of the loan by $P_m m'$, and the amount to be repaid next period by m'. The gross mortgage rate $\frac{1}{P_m}$ is determined by perfect competition among lenders as we discuss below. The mortgage spread is $s_m = \frac{1}{P_m} - \frac{1}{P_d}$.

A borrower can default on her mortgage after the idiosyncratic shocks (y', δ') are realized at the cost of losing her housing stock, a fraction $\phi_y < 1$ of her disposable income, and a fraction $\phi_d < 1$ of her deposits.[8] Thus, a borrower will default whenever her wealth after repaying the mortgage is smaller than the sum of unseizable disposable income and deposits:

$$y' - \tau(y', m', P_m) + d' + P_h(1 - \delta')h - m' < (1 - \phi_y)(y' - \tau(y', 0, 0)) + (1 - \phi_d)d'. \quad (1)$$

The probability of default is a function of the mortgage m', housing h, deposits d', and current labor income y, which affects the realization of y' through $\pi(y'|y)$.

Households can choose between FHA, GSE, and private (jumbo) mortgage loans. The indicator I_g takes the value of 1 if the household chooses a GSE mortgage, and 0 otherwise (we denote I_f and I_j for FHA and jumbo mortgages). Like in the data, FHA and GSE loans are subject to a common maximum loan size $\bar{l}$, and to loan-to-value caps θ^g and θ^f, respectively.

2.2   Household problem

The household decides her consumption, savings in deposits, tenure choice (renter or owner), and whether to take a FHA, GSE, or jumbo mortgage loan. We denote by a the wealth after the realization of the income and housing depreciation shocks, that is, disposable income plus the value from all assets brought into the period plus transfers. The value function $V(a, y)$ is the value of the optimal tenure and mortgage choice. Households take prices $(P_h, P_s, P_d, P_m^g, P_m^f, P_m^j(m', h, d', y))$ as given. Next, we characterize the problems of a home-buyer who faces GSE, FHA or jumbo mortgages, the problem of a renter, and the household's decision between rental, ownership and type of mortgage.

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[8]Section 4 shows that whether or not mortgages are recourse is not important for the results.

First, the household facing a GSE-insured mortgage solves:

$$V_g(a, y) = \max_{c,d',m' \geq 0, s \geq \underline{s}, h \geq \underline{h}} \left\{ u(c, s) + \beta \sum_{y' \in Y} \pi(y'|y) \int_{\underline{\delta}}^{1} V(a', y') \, dF(\delta') \right\} \text{ subject to} \quad (2)$$

$$c + P_d d' + P_h h = a + P_s (h - s) + P_m^g m', \quad (3)$$

$$s \leq h, \quad (4)$$

$$P_m^g m' \leq \min \left\{ \theta^g P_h h, \bar{l} \right\}, \quad (5)$$

$$a' = \max \left\{ y' - \tau(y', m', P_m^g) + d' + P_h(1 - \delta')h - m', (1 - \phi_y)(y' - \tau(y', 0, 0)) + (1 - \phi_d)d' \right\} + T(y'). \quad (6)$$

The term $P_s(s - h)$ in Equation (3) represents rental income received by landlords (when $h > s$). Equation (4) captures that a homeowner cannot lease more rental space than her housing space. The maximum loan-to-value and loan size on GSE loans are summarized in (5). Equation (6) defines the beginning-of-next period wealth a' following the optimal default rule discussed in (1). The first argument in the max operator of Equation (6) is the disposable income, plus the return on deposits, plus the value of the depreciated house, minus the mortgage payments. The second argument in (6) is the income plus the deposits that the household keeps if she defaults.

Second, the household facing a FHA-insured mortgage solves:

$$V_f(a, y) = \max_{c,d',m' \geq 0, s \geq \underline{s}, h \geq \underline{h}} \left\{ u(c, s) + \beta \sum_{y' \in Y} \pi(y'|y) \int_{\underline{\delta}}^{1} V(a', y') \, dF(\delta') \right\} \text{ subject to} \quad (7)$$

$$c + P_d d' + P_h h = a + P_s (h - s) + P_m^f m', \quad (8)$$

$$s \leq h, \quad (9)$$

$$P_m^f m' \leq \min \left\{ \theta^f P_h h, \bar{l} \right\}, \quad (10)$$

$$a' = \max \left\{ y' - \tau(y', m', P_m^f) + d' + P_h(1 - \delta')h - m', (1 - \phi_y)(y' - \tau(y', 0, 0)) + (1 - \phi_d)d' \right\} + T(y'). \quad (11)$$

Equation (10) summarizes the maximum loan-to-value and loan size of FHA loans. The mortgage rate on FHA loans is higher than the one of GSE loans (that is, $\frac{1}{P_m^f} > \frac{1}{P_m^g}$) but the minimum downpayment requirement of FHA loans is lower (that is, $\theta^f > \theta^g$).

Third, the household borrowing a jumbo mortgage solves:

$$V_j(a, y) = \max_{c, d', m' \geq 0, s \geq \underline{s}, h \geq \underline{h}} \left\{ u(c, s) + \beta \sum_{y' \in Y} \pi(y'|y) \int_{\underline{\delta}}^1 V(a', y') \, dF(\delta') \right\} \quad \text{subject to} \quad (12)$$

$$c + P_d d' + P_h h = a + P_s (h - s) + P_m^j(m', h, d', y) m', \quad (13)$$

$$s \leq h, \quad (14)$$

$$a' = \max \left\{ y' - \tau(y', m', P_m^j) + d' + P_h(1 - \delta')h - m', (1 - \phi_y)(y' - \tau(y', 0, 0)) + (1 - \phi_d)d' \right\} + T(y'). \quad (15)$$

The lending rate of jumbo loans depends on the mortgage m', house size h, deposits d', and current income y. Jumbo loans are not subject to any exogenous limit.

Fourth, households who are renters solve:

$$V_r(a, y) = \max_{c, s, d' \geq 0} \left\{ u(c, s) + \beta \sum_{y' \in Y} \pi(y'|y) V(a', y') \right\} \quad \text{subject to} \quad (16)$$

$$c + P_s s + P_d d' = a, \quad (17)$$

$$a' = y' - \tau(y', 0, 0) + d' + T(y'). \quad (18)$$

Renters cannot borrow from mortgage markets.

Fifth, and finally, the household's value function $V(a, y)$ is the maximum of the previous four options:

$$V(a, y) = \max_{I_g, I_f, I_j, I_r \in \{0,1\}} \left\{ I_g V_g(a, y) + I_f V_f(a, y) + I_j V_j(a, y) + I_r V_r(a, y) \right\} \quad \text{subject to} \quad (19)$$

$$I_g + I_f + I_j + I_r = 1. \quad (20)$$

The homeownership tenure indicator is $I_h = 1 - I_r$.[9]

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[9] To simplify the notation, we denote the overall optimal choice variables as

$$c(a, y) = I_g(a, y)c_g(a, y) + I_f(a, y)c_f(a, y) + I_j(a, y)c_j(a, y) + I_r(a, y)c_r(a, y),$$

where the subscripts g, f, j, and r refer to GSE, FHA, jumbo homeowners, and renters. We use similar notation for s, d', m', h and P_m. We denote the individual state variables as $x = (a, y)$, and $X = A \times Y$ is the state space. We denote the probability measure over X with μ. Since we focus on stationary equilibria in which μ is constant across time, we omit the dependence of prices on μ.

2.3 Lenders

Lenders are risk neutral and compete loan by loan. Lenders are financed through deposits at cost $\frac{1}{P_d}$; they also face origination costs r_w per unit of mortgage issued.[10] Lenders will originate any mortgage that in expectation allows them to cover their cost of funds. Lenders take into account that households may default on their mortgages. If the borrower defaults then the lender receives a fraction $\gamma < 1$ of the house value, a share ϕ_y of borrower's labor income, and a share ϕ_d of her deposits. The loss for the lender in case of borrower's default is the difference between the mortgage payments m' and the amount the lender really recovers:

$$L(m', h, d', y', \delta') = m' - \phi_y(y' - \tau(y', 0, 0)) - \phi_d d' - \gamma P_h (1 - \delta')h. \tag{21}$$

In GSE and FHA loans, the government completely assumes the lender's loss. In contrast, in jumbo loans the lender absorbs all the loss. Lenders pay a guarantee fee (g-fee) to receive the FHA and GSE insurance. The FHA g-fee is larger than the GSEs' g-fee, $g^f > g^g$. This condition implies that FHA mortgages have larger lending rates than GSE mortgages. FHA also allows for lower down payments as discussed before.

A borrower owing mortgage repayments m', with house size h, deposits d', and realized labor income y' will default whenever she suffers depreciation shocks δ' larger than the depreciation threshold function $\delta^*(m', h, d', y')$ implicit in equation (1) ,[11]

$$\delta^*(m', h, d', y') = 1 + \frac{\phi_y y' + (1 - \phi_y)\tau(y', 0, 0) - \tau(y', m', P_m) + \phi_d d' - m'}{P_h h}. \tag{22}$$

Lenders price mortgages insured by the GSEs according to the lender's zero-profit condition:

$$\frac{(1 + r_w + g^g)P_m^g m'}{P_d} = m', \tag{23}$$

where $P_m^g m'$ is the principal of the loan. The left side of (23) is the cost of funds for the lender because the lender has to cover the origination cost, the GSE g-fee (g^g), and the cost of the deposits that fund the loan. The right side of (23) is the revenue from the mortgage loan.

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[10]Positive origination costs $(r_w > 0)$ ensure a positive mortgage spread over the deposit rate for households with zero-default risk. This prevents indeterminacy in their maximization problems.

[11]From here onward, we omit the dependency of the depreciation threshold function δ^* on m', h, d', and y' whenever necessary to save on notation.

Lenders price mortgages insured by the FHA according to the lender's zero-profit condition:

$$\frac{(1 + r_w + g^f)P_m^f m'}{P_d} = m',$$
(24)

where $P_m^f m'$ is the principal of the loan.

Jumbo mortgages are priced according to the lender's expected zero-profit condition:

$$\frac{(1 + r_w)P_m^j(m', h, d', y)m'}{P_d} = \sum_{y' \in Y} \pi(y'|y) \left\{ m'F(\delta^*) + \int_{\delta^*}^1 \left[\left\{ \begin{array}{c} \phi_y(y' - \tau(y', 0, 0)) + \phi_d d' \\ + \gamma P_h(1 - \delta')h \end{array} \right\} \right] dF(\delta') \right\}.$$
(25)

Jumbo lenders are not subject to a g-fee because they do not enjoy any guarantee on their potential losses. Thus, the right side of (25) prices the potential default of the borrower (default happens for shocks δ' above $\delta^*(m', h, d', y')$) and the recovery values.

2.4 Government

The government collects the g-fees and raises taxes to finance transfers, government spending, and the credit risk guarantees. This is consistent with how the Congressional Budget Office (CBO) computes the government's budget. The CBO inputs the cost of the credit risk subsidies as a spending of the federal government (CBO 2014).

We denote by Ψ_g the credit losses absorbed by the government from GSE loans:

$$\Psi_g = \int_X \sum_{y' \in Y} \pi(y'|y) \int_{\delta^*}^1 I_g(x) L(m'(x), h(x), d'(x), y', \delta') \, dF(\delta') \, d\mu,$$
(26)

and by Ψ_f the credit losses from FHA loans.

The tax receipts Ω are

$$\Omega = \int_X \sum_{y' \in Y} \pi(y'|y) \left[\int_{\underline{\delta}}^{\delta^*} \tau(y', m'(x), P_m(x)) \, dF(\delta') + \int_{\delta^*}^1 \tau(y', 0, 0) \, dF(\delta') \right] d\mu,$$
(27)

where households' total tax liability is a function $\tau(y', m', P_m)$ of households' income and mortgage payments because mortgage interests are tax deductible up to a maximum deductible ζ. We use a tax function calibrated to match the U.S. tax system:

$$\tau(y', m', P_m) = \kappa y' + \iota(y', m', P_m).$$
(28)

The government budget constraint equals the revenue of the government (tax receipts plus mortgage guarantee-fee income) to the government's expenditures: mortgage losses plus lump-sum transfers and exogenous government spending:

$$\Omega + g^g \int_X I_g(x) P_m^g m'(x) \, d\mu + g^f \int_X I_f(x) P_m^f m'(x) \, d\mu = \Psi_g + \Psi_f + \sum_{y \in Y} \Pi(y) T(y) + G. \quad (29)$$

2.5 Market clearing and equilibrium

Since one unit of housing provides one unit of shelter services, the market for shelter services clears when the demand for shelter equals the aggregate housing stock H, which is in fixed supply:

$$\int_X s(x) \, d\mu = H. \quad (30)$$

Moreover, every house needs to have an owner:

$$\int_X h(x) \, d\mu = H. \quad (31)$$

Equations (30) and (31), together with the homeownership indicator I_h, allow us to write the equilibrium in rental markets as

$$\int_X (1 - I_h(x)) s(x) \, d\mu = H - \int_X I_h(x) s(x) \, d\mu. \quad (32)$$

The left side of (32) is the demand for rental housing services. The right side of (32) is the supply of rental housing, that is, the total flow of housing services minus those consumed by homeowners.

The credit market clears if the supply of deposits equals the funds requested by the banks to lend:

$$\int_X P_d d'(x) \, d\mu = (1 + r_w + g^g) \int_X I_g(x) P_m^g m'(x) \, d\mu + (1 + r_w + g^f) \int_X I_f(x) P_m^f m'(x) \, d\mu$$
$$+ (1 + r_w) \int_X I_j(x) P_m^j(m'(x), h(x), d'(x), y) m'(x) \, d\mu. \quad (33)$$

The goods market clears when the aggregate endowment of consumption goods ($\bar{y}$) equals the consumption by households, plus the gross investment in housing (i_h) that ensures a constant

housing stock, plus the costs of mortgage origination and other government spending:

$$\int_X c(x)\, d\mu + i_h + r_w \int_X I_g(x) P_m^g m'(x)\, d\mu + r_w \int_X I_f(x) P_m^f m'(x)\, d\mu$$

$$+ r_w \int_X I_j(x) P_m^j(m'(x), h(x), d'(x), y) m'(x)\, d\mu + G = \bar{y}. \quad (34)$$

The investment (i_h) to cover both the housing net depreciation and the foreclosure costs is

$$i_h = P_h \int_X \sum_{y' \in Y} \pi(y'|y) \left[\int_{\underline{\delta}}^{\delta^*} \delta'\, dF(\delta') + \int_{\delta^*}^1 (1 - \gamma(1 - \delta'))\, dF(\delta') \right] h(x)\, d\mu, \quad (35)$$

where i_h is multiplied by house prices to convert it into units of numeraire.

We define a stationary equilibrium as follows:

Definition A *stationary recursive competitive equilibrium* is a set of value and policy functions for FHA, GSE, jumbo mortgagors, and renters: $V_f(x)$, $V_g(x)$, $V_j(x)$, $V_r(x)$, $c_f(x)$, $s_f(x)$, $d'_f(x)$, $h_f(x)$, $m'_f(x)$, $c_g(x)$, $s_g(x)$, $d'_g(x)$, $h_g(x)$, $m'_g(x)$, $c_j(x)$, $s_j(x)$, $d'_j(x)$, $h_j(x)$, $m'_j(x)$, $c_r(x)$, $s_r(x)$, $d'_r(x)$, household tenure and mortgage choices $I_f(x)$, $I_g(x)$, $I_j(x)$, $I_r(x)$, house price P_h, shelter price P_s, deposit interest rate $\frac{1}{P_d}$, mortgage prices for FHA and GSE loans P_m^f, P_m^g, jumbo mortgage price function $P_m^j(m', h, d', y)$, a tax function $\tau(y, m, P_m)$, lump-sum transfers $T(y)$, and a probability measure μ over X such that:

1. Given prices, tax function, and transfers, the value and policy functions solve the household problems (2), (7), (12), (16), and (19).

2. Given prices and tax function, the FHA, GSE, and jumbo mortgage pricing satisfy (23)-(25) for any household's choice.

3. The government budget constraint (29) is satisfied.

4. The market-clearing conditions (30)-(34) are satisfied.

5. The measure μ is stationary with respect to the Markov process induced by $\pi(y'|y)$, $F(\delta')$ and the policy functions.

3 Calibration

We divide the parameters into two groups. First, those that we assign exogenously following micro-evidence and standard values in the literature. Second, those parameters endogenously selected to match some targets. Table 1 summarizes the parameters. A period in the model corresponds to a year. The Online Appendix contains all the details of this section.

3.1 Exogenous parameters

We assume a CRRA utility function over a CES aggregator for nonhousing consumption and shelter:

$$u(c, s) = \frac{\left[\eta c^{\frac{\epsilon-1}{\epsilon}} + (1-\eta)s^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon(1-\sigma)}{\epsilon-1}}}{1-\sigma}. \tag{36}$$

Several papers have argued that the elasticity of intratemporal substitution ϵ is below one. We set $\epsilon = 0.5$, a value within the accepted range.[12]

To calibrate the earnings process, we follow the literature and assume

$$\ln y' = \bar{w} + \rho \ln y + \varepsilon, \tag{37}$$
$$\varepsilon \sim N(0, \sigma_\varepsilon^2).$$

We set the standard deviation of the innovations σ_ε to 0.129 like Storesletten, Telmer, and Yaron (2004), and the persistence parameter ρ to match a Gini index for earnings of 0.43, like the 2004 Survey of Consumer Finances (SCF) for prime age households with positive wage income. We approximate equation (37) with a seven-state Markov chain using the method of Rouwenhorst (1995).

Regarding the maximum loan-to-value for FHA and GSE mortgages, we assume the usual 3.5% and 20% minimum down payments, $\theta^g = 0.8$ and $\theta^f = 0.965$. We set the GSE g-fee (g^g) to 20 basis points, which according to Elenev, Landvoigt, and Van Nieuwerburgh (2016) was the average rate from 2000 to 2012. In Section 6 we explore the implications of increasing the GSE g-fee to 60 basis points. Following Pennington-Cross (2006), we set the residual value of a foreclosed house (γ) to 0.78. We set $\phi_y = 0.25$ because Title III of the Federal Wage Garnishment Law, Consumer Credit Protection Act stipulates that in case of default the amount

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[12]Davidoff and Yoshida (2008) obtain estimates ranging from 0.4 to 0.9. Kahn (2008) provides evidence based on both aggregate and microeconomic data that is less than one. Li et al. (2016) reports an elasticity of 0.487.

to be garnished by the creditor may not exceed 25% of the disposable wage earnings. According to Table 20 of the FHFA Monthly Interest Rate Survey, the average mortgage origination cost during 2002-2006 was 0.43%. Thus, we set the cost of mortgage origination (r_w) at 40 basis points.

We design the tax function $\tau(y', m', P_m)$ to match the U.S. tax system as we discuss in the Online Appendix. We construct the transfer function $T(y)$ to match the government transfers reported by the CBO (2016), which include cash payments and in-kind benefits from social insurance and government assistance programs.

3.2   Endogenous parameters

Following Jeske, Krueger, and Mitman (2013), we assume a generalized Pareto distribution for the housing depreciation shock δ'.[13] The distribution is truncated to the interval $[\underline{\delta}, 1]$, where $\underline{\delta} \leq 0$. The cumulative density function is

$$F(\delta') = \frac{1 - \left(1 + \xi \frac{(\delta' - \underline{\delta})}{\sigma_\delta}\right)^{-\frac{1}{\xi}}}{1 - \left(1 + \xi \frac{(1 - \underline{\delta})}{\sigma_\delta}\right)^{-\frac{1}{\xi}}}. \tag{38}$$

The location ($\underline{\delta}$), scale (σ_δ), and shape (ξ) parameters, together with the remaining 8 parameters of the model, are calibrated to match the following 11 targets:[14] (1) An equilibrium risk-free rate of 1%. (2) An aggregate share of shelter services over total consumption expenditures of 14.1%. This is the average value over the last 40 years from NIPA data reported by Jeske, Krueger, and Mitman (2013). (3) A homeownership rate of 66%, which was the U.S. average during the period 1970-2014. (4) A share of homeowners with mortgage debt of 70.7%, which matches the value reported by Varasini (2013) for 2012. (5) A share of GSE loans of 65% of the total volume. (6) 56.1% of mortgagors with DTV $\geq$ 60%, which comes from the 2004 SCF. (7) A median deposit-to-asset ratio ($\frac{d'}{P_h h + d'}$) for mortgagors of 8.48%, like in the SCF 2004.[15] (8) A median size of owner-occupied-to-rental housing of 1.85. According to the 2013 American Housing Survey, the median size of owner-occupied housing is 1,800 sqft, while the median size of renter-occupied housing is 974 sqft. (9) A foreclosure rate for mortgagors

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[13]A thick right-tail distribution is needed to match the empirical foreclosure rates. Moreover, the Pareto distribution allows for a closed-form expression for the jumbo pricing function as shown in the Online Appendix.

[14]The housing stock (H) and government spending (G) are the residuals of the housing market-clearing condition (31) and government budget constraint (29).

[15]We proxy deposits by liquid assets, measured in the SCF as financial wealth minus the sum of quasi-liquid retirement, life insurance, certificates of deposit, and savings bonds.

of 1.2%, which is consistent with U.S. mortgage foreclosures between pre-2006 and post-2015. (10) An average house depreciation rate of 1.48%, which matches the 1960-2002 average reported by Jeske, Krueger, and Mitman (2013). (11) A standard deviation of the cross-sectional housing depreciation shocks of 8%. This value is consistent with the range of 6%–10% standard deviation of annual house price growth across U.S. states reported by the FHFA since 1991.

Table 2 compares the empirical targets with the model-generated moments. The model fits the data well. Moreover, concerning other moments not directly targeted, we obtain reasonable values. For example, (1) the share of jumbo loans is 25.1% of the total volume. According to the Urban Institute, nearly 25% of the mortgages originated in 2014 were jumbo loans. (2) An average implicit interest rate subsidy of 44.7 basis points.[16] According to CBO (2010), the spread between interest rates on jumbo and conforming loans suggests that the GSEs lowered mortgage interest rates from less than 25 basis points in normal times to more than 100 basis points at the end of September 2010. (3) A median deposit-to-asset ratio across households of 25.7%. The corresponding value in the 2004 SCF is 21.1%. (4) In the model, government spending is the sum of credit losses, transfers and government outlays. We compute GDP as the sum of aggregate endowment of nonhousing goods plus the value of the shelter services. The model generates a ratio of government expenditures to GDP of 22.1%. In the data, this ratio is, on average, 22.7% for the period of 2006-2016.[17] (5) The shares of mortgagors with debt payments-to-income (DTI) exceeding 31% and 43% are 10.4% and 8.4%, respectively. This is consistent with the guidelines for conventional mortgages. (6) The calibrated model implies a cost differential between FHA and GSE loans of 1.86%. This value is very close to the data once we sum the interest rate differential and the FHA mortgage insurance premiums.[18] (7) The distribution of rental supply along the wealth distribution (Table A1 in the Online Appendix) is consistent with the data reported by Chambers, Garriga, and Schlagenhauf (2009). Using the 1996 Property Owners and Managers Survey, they document that although the majority of rental housing is supplied by middle or wealthy households, 25% of the supply is owned by low-income households. This compares with 30% for the high-income households.

Finally, to comment on the parameter that controls the garnishment of deposits (ϕ_d), this parameter plays two roles. On one side, it controls the insurance that deposits provide in case of default. On the other side, it affects mortgage spreads since it controls the probability of

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[16]The GSE interest rate subsidy (Θ) is the difference between the jumbo rate of a GSE borrower and the GSE rate. Formally, $\Theta(m', h, d', y) = \frac{1}{P_m^j(m',h,d',y)} - \frac{1}{P_m^g}$. The *average* implicit GSE interest rate subsidy is the average of Θ computed over the group of GSE mortgagors.

[17]NIPA series for current expenditures of the Federal Government-to-GDP.

[18]According to USBank.com, the average long-term rates of 30-year fixed FHA and conventional mortgages are 4.0% and 4.125%, respectively. In addition, FHA requires an upfront premium of 1.75% plus an annual premium of around 0.8% of the loan amount.

default and the assets seized upon default. If $\phi_d = 0$, only the insurance role operates. If $\phi_d = 1$ only the collateral role operates. We obtain $\phi_d = 47.2\%$ which suggests a balance between both roles. This parameter is key to match the median deposit-to-asset ratio for mortgagors.

4 Credit Supply

In this section, we analyze the reaction of the lenders, in partial equilibrium, to removing the GSEs. This exercise helps to understand the drivers of the new distributional results that we will present in the following section.

There are two ways to model the GSEs. One way is to model them as a "funding subsidy." That is, the GSEs are able to finance themselves at cheaper rates because they enjoy the support of the U.S. government. They pass their lower cost of funds on to the lenders, who then pass this subsidy to the mortgagors through lower rates. Jeske, Krueger, and Mitman (2013) model the GSEs as a "funding subsidy." The second way to model the GSEs is as a "credit risk subsidy." That is, the g-fees that the GSEs charge do not capture all the credit risk that the GSEs are absorbing. Thus, the GSEs provide a subsidy to credit risk. Elenev, Landvoigt, and Van Nieuwerburgh (2016) model the GSEs as a "credit risk subsidy." Lucas (2011) and CBO (2014) provide strong evidence that GSEs are under-pricing credit risk. In fact, in 2008 the credit risk turned into losses and the U.S. government had to place the GSEs under conservatorship.

Figure 1 plots mortgage credit supply for three cases.[19] First, the case with no subsidy of any type. Credit supply is the spread between the jumbo loans price function $P_m^j(m', h, d', y)$ from Equation (25) and the risk-free rate. As any credit supply curve, it is increasing in default risk proxied by the debt-to-house-value $\frac{m'}{P_h h}$ (DTV). Second, Figure 1 plots mortgage credit supply when there is only a "funding subsidy" like in Jeske, Krueger, and Mitman (2013). That is, the GSEs lower lenders' cost of funds and competitive lenders pass along the subsidy as lower mortgage rates. It is important to remark from Figure 1 that a funding subsidy implies the same reduction in spreads regardless of the risk of the mortgage. That is, funding subsidies do not change the dispersion of the cross-sectional distribution of mortgage spreads. Removing the funding subsidy will increase mortgage spreads almost equally across households, regardless of their default risk. Thus, a funding subsidy is basically a "level effect."

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[19]All curves assume that the borrower has the minimum house size, median income, and deposits of the benchmark calibration.

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Figure 1 also plots mortgage supply with a "credit risk subsidy" as we do in this paper.[20] The credit risk subsidy is a "shape effect" relative to the jumbo credit supply. That is, the GSEs absorb credit risk from the lenders and thus lenders charge the same spread regardless of the default risk. Interestingly, the difference between the spread of a GSE-guaranteed mortgage and a jumbo mortgage is increasing in DTV. Thus, the GSEs reduce the dispersion in the cross-sectional distribution of mortgage spreads because they reduce the spreads more for the high-risk households. That is, the GSEs provide a larger subsidy to riskier loans. This is consistent with the evidence in Lucas (2011) and CBO (2014).

Figure 1 illustrates the mechanism that drives the distributional results of the next section. Since we model the GSEs as a credit risk subsidy, their removal will increase mortgage spreads the most for the households with highest default risk (that both in the data and in the model are the low and mid-income mortgagors).[21] These are the households who receive the largest subsidy from the GSEs and oppose their removal the most.

Figure 2 shows that whether mortgages are recourse is not an essential element for the distributional implications of the GSEs. Figure 2 compares the spreads between jumbo mortgages with partial recourse, like in our calibration, and mortgages with no recourse (i.e., $\phi_y = \phi_d = 0$). Recourse is similar to a "level shifter," like the funding subsidy. The reason is that both with and without recourse, the spread depends on the DTV, and DTVs are decreasing in wealth. Thus, modeling the mortgage contract with or without recourse does not significantly change the cross-sectional distribution of the spreads, and thus it does not significantly affect who wins and loses from removing the GSEs. Confirming this insight, Kim and Wang (2016) analyze the removal of the FHA guarantees in a nonrecourse model with credit risk subsidies and find similar distributional results to what we present in the next section.

5   Implications of Removing the GSEs

In this section we study the removal of the GSEs. First, we characterize households' portfolio and borrowing choices. This helps to understand why households borrow and buy houses in the model. Then, we study the aggregate and the cross-sectional effects across households. Finally, we simulate an election in which households vote on whether or not to eliminate the GSEs. Section 7 studies the robustness of these results to different modeling choices.

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[20]To focus on the role of the subsidy, Figure 1 plots the case when the g-fee g^g is zero.

[21]With strategic default, the model would imply that households' default risk decreases even more with wealth because the punishment for default is usually larger for wealthier households.

5.1 Households

In this model, buying a house instead of renting is potentially appealing because of the following reasons: (1) It is an asset with collateral properties. This can be seen because housing holdings are nonmonotonic in wealth for low-wealth homeowners.[22] To smooth consumption, these households buy extra housing to borrow against it. As their wealth increases and their consumption smoothing needs are smaller, these households decrease their housing and mortgage holdings. (2) Because markets are incomplete, a house is an asset that helps households to save and smooth consumption. However, because of depreciation shocks, it is a risky asset. On the other hand, it generates rental income with positive excess return over the deposit rate. This explains that when households become wealthy enough, they increase their housing holdings to be landlords. (3) Mortgage interest payments are tax deductible. Figure A1 in the Online Appendix plots the households' choices of housing (h), deposits (d'), and mortgage borrowings (m') as a function of wealth (a) for households with the median income (y_4). The figure illustrates the drivers of the homeownership decision.

It is useful to classify households into four groups. As income and wealth increase, households move from one group to the next one:

(1) *Renters:* households who neither own a house nor have a mortgage ($h = m' = 0$) but usually have some deposits ($d' \geq 0$). Most households with low incomes are renters. Their income and wealth are so low that they cannot get enough credit to buy the minimum house.

(2) *High leveraged homeowners:* these are homeowners with mortgage credit ($h \geq \underline{h}, m' > 0$) and high debt-to-income and debt-to-assets. Low-income homeowners borrow through FHA mortgages because the FHA requires lower down payments, although FHA spreads are larger than GSE spreads. As soon as the household can afford a 20% down payment, she switches to a GSE-insured mortgage. Because deposits can be partially kept in case of default, they provide valuable insurance to homeowners. Even high-leverage households have deposits. This insurance mechanism is characterized in Jeske, Krueger, and Mitman (2013). Moreover, our model has a new argument to hold deposits: since lenders can partially seize them in case of default, larger deposit holdings serve as collateral and lower jumbo mortgage spreads.

(3) *Low-leveraged homeowners:* high-income households usually borrow through jumbo mortgages to avoid the GSEs limits on mortgage size. Their default risk is low because their DTV and DTI are small. Mortgage debt is appealing because its interest payments are tax-deductible.

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[22]For details, see Figure A1 in the Online Appendix.

(4) *Homeowners without debt:* these are households with large housing and deposit holdings that do not require mortgage debt. These households are landlords who rent some of their housing holdings.

5.2   Aggregate effects of removing the GSEs

Table 3 summarizes the aggregate effects of removing the GSE-insured mortgages. Removing the GSEs implies that the government does not have to cover the credit losses Ψ_g in the government budget constraint (29). Table 3 considers two ways in which the government can rebate the unspent credit losses Ψ_g to households: (1) through lower taxes (without altering the progressive nature of the tax system) and (2) through higher transfers (without altering the progressive nature of the transfer system).[23]

Eliminating the GSEs increases the cost of mortgage credit for households previously borrowing through GSE-insured mortgages (both FHA and jumbo loans have higher rates for those households). Average mortgage spreads increase. The contraction in the demand for credit leads to lower deposit rates to discourage households from supplying deposits.[24] Some households either buy less housing or decide not to buy and instead rent. Housing prices decrease while housing rents increase. Housing price-to-rent ratios decrease. Lower return on deposits, cheaper housing prices, and higher housing rents encourage the high-wealth households to rebalance their portfolios from deposits toward housing. Homeownership rates decrease and housing holdings become more concentrated.

5.3   Distributional effects of removing the GSEs

To analyze who wins and who loses from eliminating the GSEs, it is useful to start with the correlation between default risk and the credit subsidy. In our model, DTV and DTI are decreasing in wealth while holdings of deposits are increasing, like in the Survey of Consumer Finances. Thus, GSE borrowers with lower wealth have higher default risk and enjoy higher credit risk subsidies. High-wealth households do not receive much subsidy because either their default risk is small, or they do not use GSE loans. FHA borrowers may suffer from the GSE

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[23]Specifically, when the government budget is balanced via an increase in transfers, we adjust ς, where $T(y) = (\varsigma + \alpha(y))y$. In the benchmark economy, $\varsigma = 0$. The Online Appendix contains the details on the construction of the coefficients of transfers as a share of labor income $\alpha(y)$.

[24]Our model abstracts from the corporate, government, and foreign sectors that also play a role in credit markets. Adding these sectors may cushion the drop in deposit rates since those sectors would increase their credit demands as rates fall. In Section 7, we explore the case in which the deposit rate remains constant.

removal because they may be planning to switch to a GSE mortgage once they can afford the 20% down payment. Thus, the benefits from the GSEs are asymmetrically distributed across households. For instance, the average subsidy is 45 basis points but its standard deviation is 32 basis points. To further illustrate this point, Figure A2 in the Online Appendix plots the GSE credit subsidy as a function of wealth (a) for the households with median income level (y_4).

To formally evaluate the welfare changes after the policy change, we compute the Consumption Equivalent Variation (CEV), $\omega(a, y)$, as the change in per-period composite consumption such that a household is indifferent when moving from a stationary economy with GSEs to another without GSEs.[25] Let $\tilde{u}(\tilde{c}) = u(c, s)$ be the utility of a household in terms of composite consumption.[26] Formally, for each state (a, y) we solve for $\omega(a, y)$ such that

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty} \beta^t \tilde{u}\big((1 + \omega(a, y))\tilde{c}_t\big) \,\Big|\, (a, y)\right] = \mathbb{E}_0\left[\sum_{t=0}^{\infty} \beta^t \tilde{u}(\tilde{c}_t^N) \,\Big|\, (a, y)\right], \tag{39}$$

where the superscript N refers to the economy with no GSEs. If $\omega(a, y) > 0$ the household has higher utility when the GSEs are removed, that is, she must be compensated to live in the economy with GSEs.

Figure 3 plots the CEV as a function of wealth for different levels of income. Table A2 reports the average CEV for different groups of households. There is significant heterogeneity on the welfare assessment across the wealth and income distributions. Renters, high-leverage homeowners, and households with very large deposit holdings lose with the removal of the GSEs. Low-leverage and wealthy households win.

To illustrate the channels that drive the previous results, Figure 4 plots, along the wealth dimension, a decomposition of the CEV for the very low-income households (y_1) and for the

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[25]Given that, in our model, physical capital is nonexistent and the supply of housing is fixed, the transition toward the new steady state happens in a few periods. Thus, the welfare gains of the transition path should be very similar to the steady state welfare gains.

[26]That is, $\tilde{c} = \left[\eta c^{\frac{\epsilon-1}{\epsilon}} + (1 - \eta)s^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}$.

median income households (y_4) into five channels:[27]

$$\omega(a,y) \approx \underbrace{\omega_{\text{GSE}}(a,y)}_{\text{Credit risk subsidy channel}} + \underbrace{\omega_{P_h}(a,y)}_{\text{House price channel}} + \underbrace{\omega_{P_s}(a,y)}_{\text{Rental price channel}} + \underbrace{\omega_{P_d}(a,y)}_{\text{Interest rate channel}} + \underbrace{\omega_\kappa(a,y)}_{\text{Tax channel}}.$$

(40)

First, there is the credit risk subsidy that we discussed in Section 4 and showed in Figure A2. Removing the GSEs implies that the riskier households with GSE guarantees lose their credit-risk subsidies. The bottom panel of Figure 4 shows that this effect is very strong for mid-income and low- and mid-wealth households. Their mortgage spreads increase the most once the GSEs are removed. This channel is basically nonexistent for low-income renters because they had a low probability of becoming GSE mortgagors in the future. It has some relevance for those renters and FHA borrowers who perhaps would have switched to GSE-insured mortgages in the future if the GSEs were not eliminated. As a household gets wealthier and becomes a low-leverage mortgagor or a homeowner with no debt, the probability that the household becomes a GSE mortgagor in the future decreases. Thus, it also decreases the value of the GSE credit risk subsidy.

Second, there is a house price channel. Removing the GSEs lowers demand to buy houses by the households whose cost of mortgage credit is larger. House prices fall, as Table 3 shows. This is beneficial for those households whose mortgage spreads are not affected (FHA borrowers and wealthier households). Renters have a small house price channel because, although cheaper prices help them to buy a house, their utility from owning a house decreases when lower house prices reduce the collateral value of a house (the ability to borrow against it).

Third, there is a rent channel because removing the GSEs leads to higher rents as some households cannot get credit, or find it too expensive and prefer to become renters. This rent channel is negative for the low-income households that are renters. It is beneficial for the wealthy households that are landlords.

Fourth, the fall in deposit rates hurts the deposit holders, which are the richest households who hold most of the deposits, and also for those renters in the margin of homeownership with relatively large savings in deposits.[28] As deposit savings lose value, the wealthy households can

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[27]The Online Appendix contains the exact decomposition. $\omega_{\text{GSE}}(a,y)$ is the CEV between the benchmark equilibrium and the partial equilibrium response of the households when the GSEs are removed but the house price, rental price, interest rate, and taxes remain constant at the benchmark equilibrium values. Similarly, $\omega_{P_h}(a,y)$ is the CEV between the former partial equilibrium and the partial equilibrium response of the households when the house price P_h changes to the value in the no GSE equilibrium (P_h^N) but the other prices and taxes are kept at the benchmark equilibrium values. The other components are computed in a similar way. Different orderings of the decomposition yield similar results.

[28]In Section 7, we explore the case with constant risk-free rates (small-open economy model) and find that

shift their portfolios toward housing (the return from being a landlord is higher), whereas the low- and mid-income households cannot do so because access and cost of mortgage credit act as an entry barrier. Lower deposit rates imply lower mortgage rates for those mortgagors whose spreads are not affected by the credit-risk channel discussed above.

Fifth, the government, once it saves in credit risk subsidies, can lower taxes. Every household benefits from paying lower taxes.

The addition of the five channels make the welfare consequences for mid-income households ($y \in \{y_4, y_5\}$) highly nonmonotone in wealth as Figure 3 plots. The largest welfare losses are in the mid-income, low and mid-wealth households who borrow from the GSEs with 20% down payments. The winners from the reform are some FHA borrowers that benefit from the housing price channel, the wealthier households also benefit, especially those with jumbo mortgages or no debt, that can expand their housing holdings, pay less in taxes, and enjoy the higher housing rents as landlords.[29]

5.4   Voting for the removal of the GSEs

Following the previous discussion, Table 4 simulates a referendum among the households on whether or not to eliminate the GSEs. Reforming the housing finance system has been in the policy agenda for several years but all proposals so far have failed. Table 4 suggests an explanation. The majority of households (around 60%) opposes eliminating the GSEs.

Table 4 also reports the percentage of households in favor of removing the GSEs with households classified by housing tenure, leverage, and wealth. The table illustrates the disagreement between households: the majority of renters are against the removal; some FHA homeowners support the removal; GSE high-leverage mortgagors are opposed; low-leverage, jumbo mortgagors, and homeowners with no debt are in favor of eliminating the GSEs.

Interestingly, our results seem consistent with the political economy of the GSE reform in the United States. For example, political groups associated with low and mid-income households, such as The Leadership Conference on Civil and Human Rights and the National Council of La Raza, have been among the major defenders of the GSEs together with Democratic Senators (The Hill 2015, Open Letter to the FHFA from the Leadership Conference 2014).

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the welfare assessment of the wealthiest households is reversed.

[29]To better assess the importance of the rent and interest rate channels, Table A3 in the Online Appendix reports the CEV excluding those two channels from the sum in (40). Once these two channels are removed, basically only the high leveraged mortgagors with conforming loans oppose the removal of the GSEs.

6 Policy Analysis

In this section, first, we study the benefits and drawbacks of the GSEs. Second, we show that fiscal policy, or raising the g-fees, are alternatives to the GSEs' removal. Third, we study the interactions between removing the GSEs and eliminating the mortgage interest rates deduction. Interestingly, we find that it is easier to reform the GSEs if the reform is done simultaneously with the elimination of the interest rates deduction.

6.1 Benefits and drawbacks of the GSEs

Table 5 summarizes the benefits and drawbacks of the GSEs. In terms of drawbacks, the GSEs lead to a larger amount of foreclosures because they provide a subsidy to credit risk. Foreclosures lower welfare in the model because they lead to deadweight losses. Moreover, Elenev, Landvoigt, and Van Nieuwerburgh (2016), in a model with aggregate shocks, show that the GSEs lead to financial fragility.

Figure A3 has an extra result on financial fragility that complements Elenev, Landvoigt, and Van Nieuwerburgh (2016). Eliminating the GSEs will reduce the aggregate debt-to-output ratio of the economy (on average, DTV and DTI are lower). But it will change the cross-sectional composition of leverage. Low- and mid-income households (who are now enjoying the GSE subsidies) would reduce their leverage, while high-income households would increase their leverage. This result happens because for low- and mid-income households the increase in spreads dominates the reduction in deposit rates and housing prices. However, for high-income households, the reduction in deposit rates and housing prices dominate and these households increase leverage when the GSEs are removed.

Concerning the benefits from the GSEs, Table 5 reports an ex ante utilitarian CEV computed by a planner who equally weights every agent in the stationary distribution.[30] Removing the GSEs decreases ex ante utilitarian CEV. To understand this result, Table 5 decomposes the ex ante CEV into a level effect (aggregate size of the economy) and a distributional effect.[31] Removing the GSEs leads to positive level effects because there are less deadweight costs associated with foreclosures and less mortgage origination costs. In terms of magnitudes, the level terms are similar to those of Elenev, Landvoigt, and Van Nieuwerburgh (2016).[32] Moreover, the

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[30]The ex ante utilitarian CEV is the CEV of a household under the veil of ignorance about her income and wealth. The Online Appendix has the definition.

[31]See the Online Appendix for details.

[32]Foreclosure costs are 0.38% of GDP in the benchmark economy with GSEs and fall by 55.1%, origination costs are 0.76% of GDP and fall by 54.0%.

housing maintenance costs drop because maintenance expenses are proportional to the value of the house. However, the distributional terms induce a negative ex ante CEV because removing the GSEs generates higher inequality in consumption and the utilitarian CEV has concave preferences.

Regarding wealth inequality, without the GSEs, the distribution of wealth becomes more concentrated, as reflected by an increase in the Gini index and in the ratios of the wealth percentiles reported in Table 5. Wealth inequality increases mainly for two reasons: (1) low-wealth renters have to spend more in housing rents and save less (the number of renters increase without the GSEs), and (2) homeowners who lose the credit-risk subsidy cut their savings. Figure A4 in the Online Appendix plots the stationary distribution of wealth with and without GSEs.

6.2 Alternative policies: Fiscal policy or G-fee increases

In this subsection we analyze two policies that would mitigate the inequality implications of removing the GSEs. First, Figure A5 in the Online Appendix shows that the government could use a system of taxes and transfers conditional on households' income to implement the redistribution now generated by the GSEs. That is, Figure A5 reports the changes in the current system of transfers that imply that the average of each income group is indifferent once the GSEs are removed (zero CEV). The mid-income groups that lose the most should receive the largest increase in transfers. The wealthier households should see their transfer reduced, except for the households with the largest holdings of deposits who see large losses in their savings. The results in Figure A5 suggest that fiscal policy could implement the redistribution now done through the GSEs, without inducing higher mortgage debt and foreclosures that the GSEs do.

Table 5 studies the case in which the GSEs are maintained and their the g-fees are increased from 20 basis points to 60 basis points. That is, lenders need to pay higher fees to receive the GSEs' credit risk insurance. Table 5 highlights that raising the g-fees is an intermediate stage between keeping the GSEs and eliminating them. Higher g-fees lead to less credit and less foreclosures, although wealth inequality increases.

The increase in wealth inequality from raising the g-fees is consistent with the results of Elenev, Landvoigt, and Van Nieuwerburgh (2016), but different in terms of their conclusion that there is an overall welfare gain. This is because our model has more borrower heterogeneity while Elenev, Landvoigt, and Van Nieuwerburgh (2016) has macro-financial stability, which our

model does not.

6.3 GSEs and mortgage interest deductibility

In this subsection we study the interactions between the reforms of the GSEs and of the mortgage interest rate deductibility. The policy debate treats the two reforms as independent but here we show that the cross-sectional distribution of the winners and losers suggests they should be related.

Table 6 shows that repealing the interest rate deductibility leads to lower mortgage credit, housing prices and homeownership.[33] Most of these results are already in Sommer and Sullivan (2016), but the results for homeownership are different. This difference is driven by the behavior of mortgage spreads, that are exogenous in Sommer and Sullivan (2016). Table 6 reflects that when mortgage spreads are endogenous like in this paper, the interest mortgage deductibility is priced in the jumbo spreads. Lenders understand that deducting interest rates from tax payments help mortgagors to repay their debt. Thus, mortgage spreads increase with the removal of the interest rate deduction as default risk increases. And the higher mortgage spreads reduce homeownership.

Table 7 simulates a referendum among the households on whether to eliminate the GSEs and/or the mortgage interest rate deductibility. Most households favor the removal of the mortgage interest rate deduction (Sommer and Sullivan 2016 obtain the same result). However, the middle-class (third quintile in the wealth distribution) is firmly supporting the interest rate deduction. The poorest households are strongly against it.

Table 7 suggests interesting interactions between the reforms. The mid-wealth households are strongly in favor of keeping both the GSEs and the tax deduction in place. However, it is easier to approve a removal of the GSEs if it comes with the removal of the mortgage interests deduction. This result is mainly due to the renters, who oppose the removal of the GSEs because rents would increase, but who favor the removal of the interest rate deductibility because they do not enjoy it.

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[33]The government budget is balanced through adjustment in taxes. As Section 5 shows, balancing the budget with transfers or taxes does not alter the results.

7   Robustness

Given the importance of the housing rents and interest rate channels discussed in Section 5.3, in this section we explore two alternative modeling choices. First, we modify the model to allow landlords to diversify housing risk. This is key to generate a more elastic supply of rental housing that tames both the housing rents and interest rate channels. The consequences are important because it makes the GSE reform much more likely to be approved. Second, we focus on the case when deposit rates are not sensitive to the removal of the GSEs.

7.1   Real estate fund

In the benchmark model of Section 2, landlords are exposed to housing value risk that cannot be diversified. This is consistent with the mom-and-pop investors popular in rental markets and discussed by Chambers, Garriga, and Schlagenhauf (2009). However, there are also corporate landlords with the size and tools to diversify housing value risk. Raymond et al. (2016) discuss how new technologies facilitate the rise of the large corporate landlord even in the single-family rental market.

In this subsection we allow landlords to diversify housing value risk. To model corporate landlords, we assume that there is a real estate fund with a perfectly diversified portfolio of housing assets that it rents every period. That is, the depreciation for the houses owned by the fund is deterministic. Households can be mom-and-pop landlords like in the model of Section 2, but they can also invest in this real estate fund. There is a fixed per-period participation cost of investing in the real estate fund. This investment provides a safe return in excess of the deposit rate.[34] Thus, in equilibrium, wealthy households invest in the real estate fund.

Table A4 contains the aggregate effects in the model with a real estate fund and, for ease of exposition, also in the benchmark model of Section 2 with rebates via taxes. Comparing across columns we see the consequences of diversifying housing risk: following the GSE removal, the fall in house prices and the increase in housing rents are smaller because corporate landlords are more willing to invest than mom-and-pop investors. Thus, corporate landlords generate an elastic supply of rental housing which mitigates the rent channel, as Table A6 confirms. The welfare losses for renters are smaller, and in fact now a slight majority of them favors the removal of the GSEs.

Also interesting, allowing a richer investment set improves the welfare of the wealthy house-

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[34]The Online Appendix has the formal details.

holds who now do not need to suffer the wealth loss associated with the lower deposit rate. In fact, since these households now can diversify better, Table A4 shows a much smaller fall in deposit rates. Table A6 confirms that now the vast majority of the wealthy households favors the removal of the GSEs.

Thus, the real estate fund has tamed both the rent and the deposit rate channels. As a consequence, Table A6 shows that now the removal of the GSEs can obtain the majority of the votes. However, the rise of the corporate landlord is associated with a much larger fall in the homeownership rate. Moreover, since deposit rates fall by a smaller amount, high leveraged, middle-class households suffer more from higher mortgage costs. On the positive side, since less low income households are exposed to housing risk, foreclosures fall by much more in the case with the real estate fund.

7.2   Constant deposit rates

Our model abstracts from the corporate, government, and foreign sectors that also play a role in credit markets. These sectors would increase their credit demands as interest rates fall when the GSEs are removed. Thus, these sectors would cushion the drop in deposit rates. In this subsection we redo the baseline exercise of Section 5 but assume constant deposit rates.

Table A5 contains the aggregate results. It is interesting to remark that with constant deposit rates the wealthier households have less incentives to reallocate their portfolios away from deposits. Thus, house prices need to fall more to encourage those households to buy the houses not bought by the households that are now renters. The larger fall in house prices mitigates the increase in mortgage spreads for some households and homeownership falls by much less. Rents increase more as rental supply expands less.

Table A6 has the cross-sectional implications. Renters are worse-off than in the baseline case with flexible deposit rates since the higher rents dominate that their savings do not suffer a fall in returns. Mid-wealth, highly indebted households are also worse off since constant deposit rates amplify the increase in mortgage spreads. However, the wealthiest households are much better when the deposit rate does not fall. Thus, removing the GSEs becomes much more regressive when interest rates are constant. For this reason, the results of a vote show that most households oppose the removal, like in the benchmark case.

8 Conclusions

In this paper, we have analyzed the distributional and aggregate consequences of removing the GSEs. The model has endogenous mortgage spreads and all the relevant aspects of current U.S. housing policy (taxes, social transfers, FHA, GSE, jumbo loans, and mortgage interest deductibility). Our main result is that if the GSEs are modeled as a credit-risk subsidy, and if household's default risk is decreasing in wealth, then the GSEs benefit the low and mid-income households. That is, the GSEs are progressive, not regressive, institutions.

We have shown that the uneven distribution of welfare gains and losses after removing the GSEs may explain why reforming the housing finance system is such a complicated endeavor. Most households (especially low- and mid-wealth households) oppose the elimination of the GSEs. GSE reform may require a system of transfers to compensate the losers, or to ensure that rental housing supply is elastic enough to mitigate increases in rents, or to link the reform to jointly eliminating the interest rate deduction. In this case, renters are more likely to support both reforms together.

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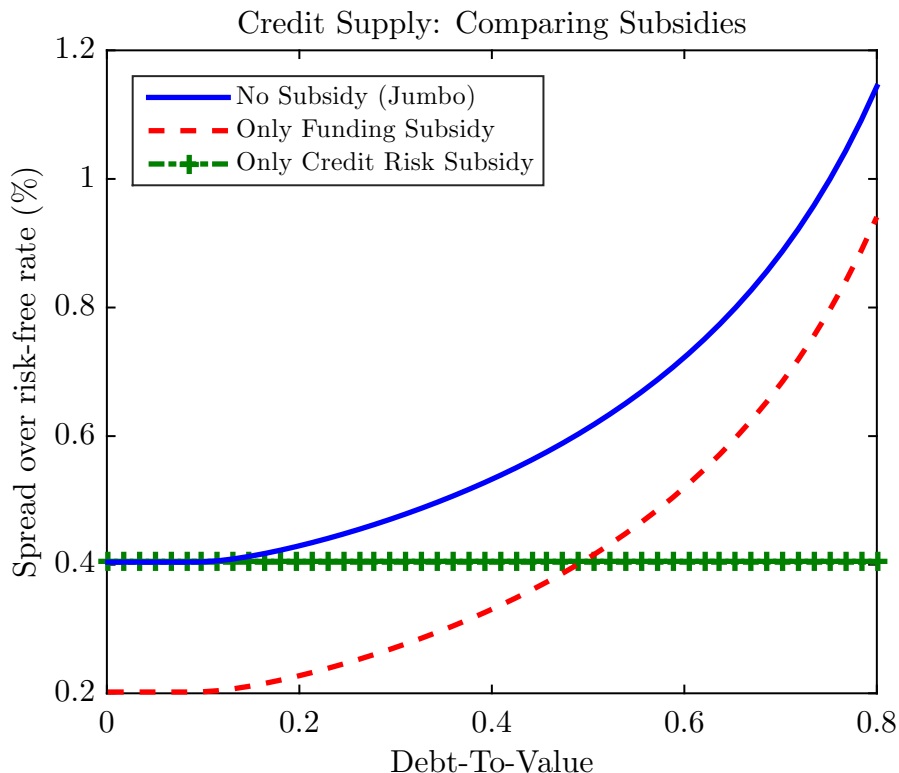
Figures and Tables

Figure 1: Credit supply for different ways of modeling the government guarantee subsidy

This figure plots the mortgage spread $\left(\frac{1}{P_m(m',h,d',y)} - \frac{1}{P_d}\right)$ as a function of the borrower's debt-to-house value $\left(\frac{m'}{P_h h}\right)$ for a household with an income level of y_4 (median income). In one curve government guarantees are nonexistent (i.e., the jumbo market); in another curve the guarantees are modeled as a subsidy to lenders' cost of funds (i.e. a funding subsidy); and in the third curve the guarantees are modeled as a subsidy to lenders' credit risk (in case of borrower's default the government covers lender's losses). All curves assume that the borrower has the minimum house size, median income, and deposits of the benchmark calibration.
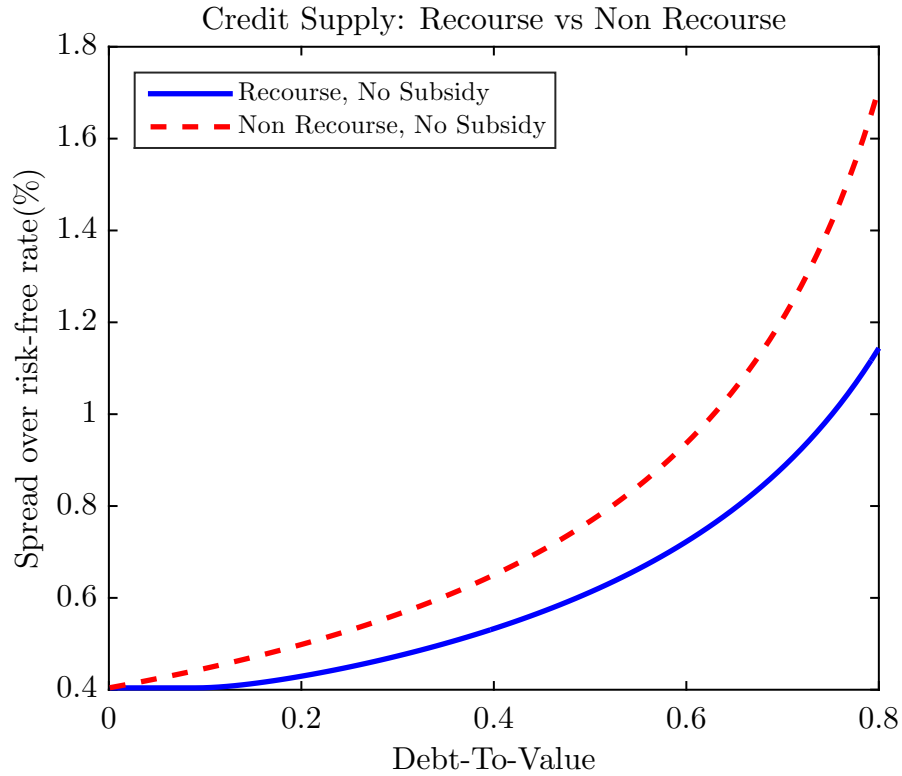
Figure 2: Credit supply under recourse and nonrecourse mortgages if no credit risk guarantees exist

This figure plots the mortgage spread $\left(\frac{1}{P_m(m',h,d',y)} - \frac{1}{P_d} \right)$ as a function of the borrower's debt-to-house value $\left(\frac{m'}{P_h h} \right)$ for a household with an income level of y_4 (median income). One curve is for the case of recourse mortgages and the other curve is for the case of nonrecourse mortgages.

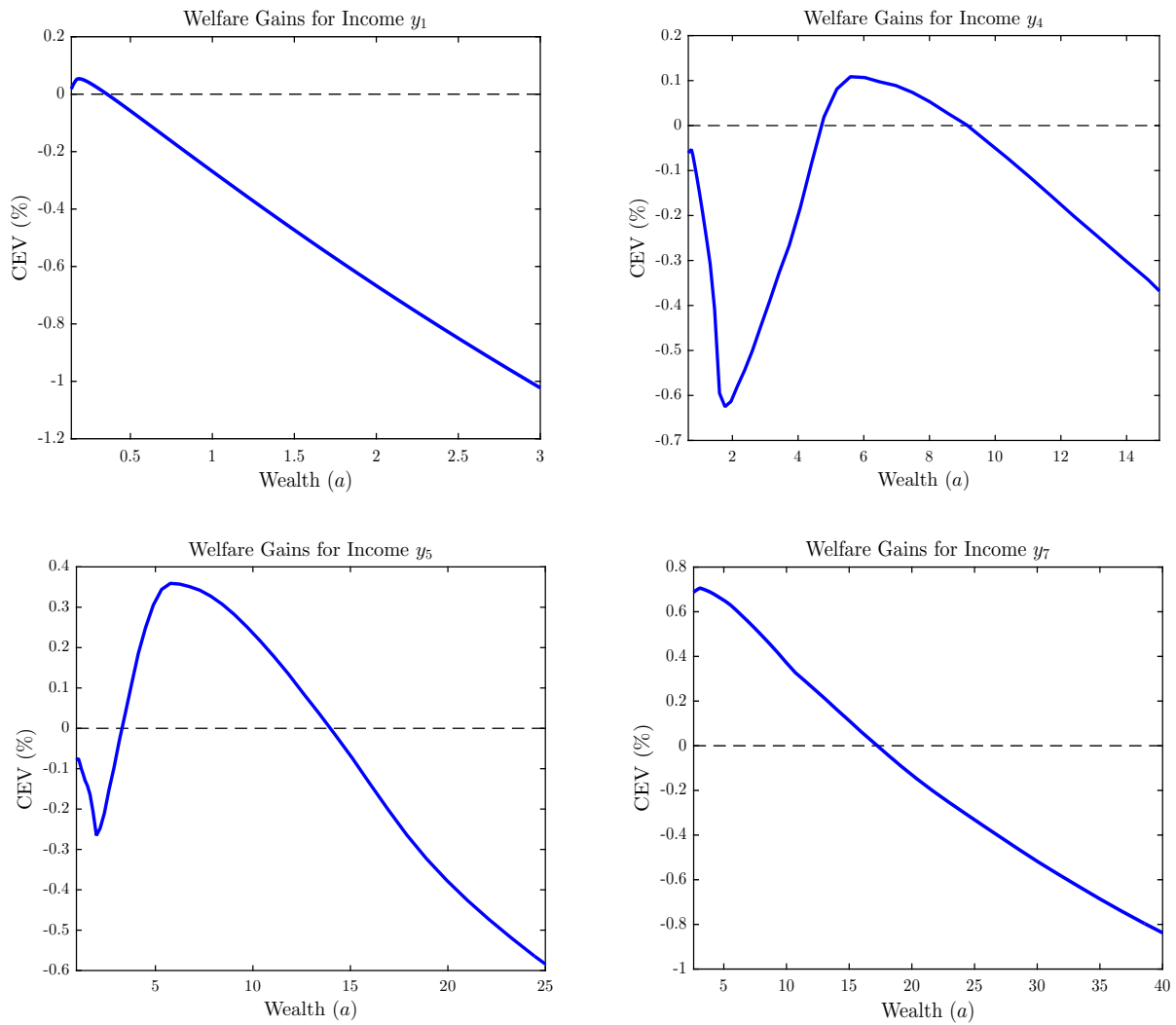**Figure 3: Welfare gains or losses from removing the GSEs**
Each panel plots, for a different income level and as a function of wealth, the percentage change in composite consumption (consumption equivalent variation, CEV) that makes a household in the economy with GSEs indifferent between that economy and an economy with no GSEs. The value is positive if the household has higher utility when the GSEs are removed.
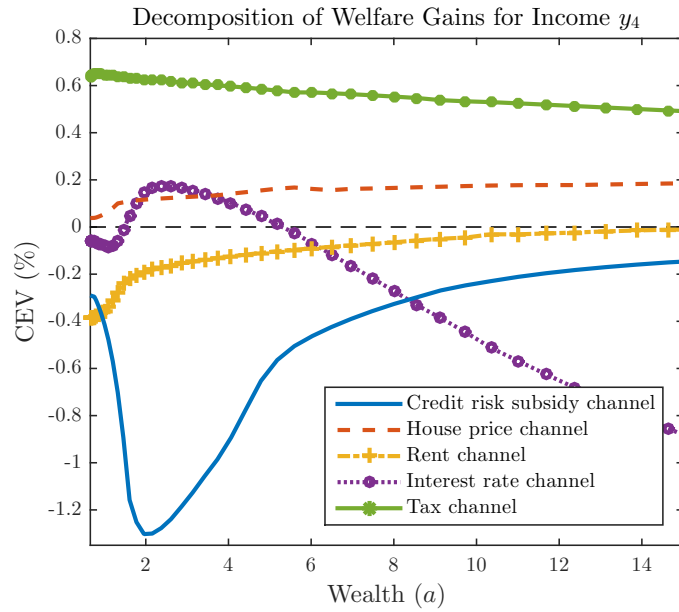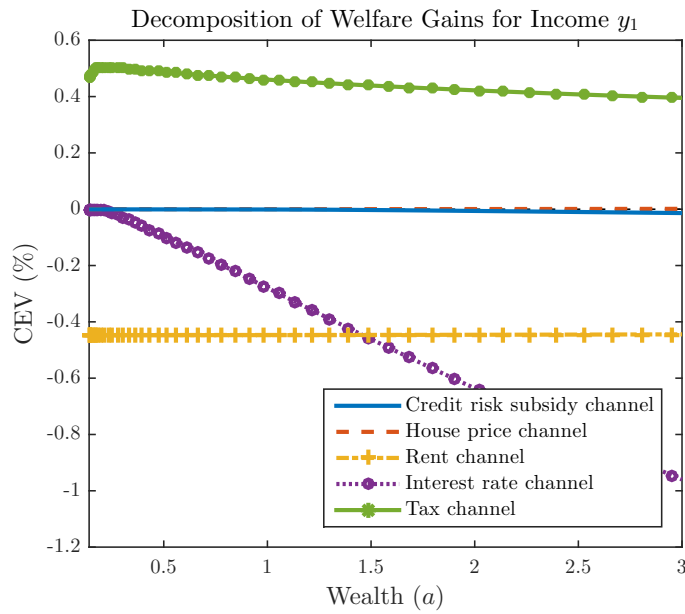
Figure 4: Decomposing welfare gains
This figure plots households' consumption equivalent variation (CEV) for each of the different channels that drive the welfare changes reported in Figure 3. The top panel shows households with an income of y_1 (bottom 2%), whereas the bottom panel plots an income of y_4 (median income). Section 5.3 discusses the details of the decomposition.

Table 1: Parameters, benchmark calibration

Parameter	Value	Description
Exogenous parameters		
ϵ	0.5	Intratemporal elasticity of substitution
ρ	0.986	Labor income persistence
σ_ε	0.129	Labor income volatility
θ^g	0.8	Down payment requirement GSEs
θ^f	0.965	Down payment requirement FHA
g^g	20 basis points	Guarantee fee GSEs
γ	0.78	Foreclosure recovery rate
ϕ_y	0.25	Labor income garnishment
r_w	40 basis points	Mortgage origination cost
$\tau(y, m, P_m)$	See the Online Appendix	Progressive tax function
$T(y)$	See the Online Appendix	Transfer function
Endogenous parameters		
η	0.523	Nonhousing share in consumption
σ	3.97	CRRA parameter
β	0.948	Discount factor
$\underline{h}$	4.98	Minimum house size
$\bar{l}$	5.54	Limit conforming mortgage
g^f	204 basis points	Guarantee fee FHA
$\underline{s}$	3.51	Minimum shelter consumption (owners)
ϕ_d	0.472	Recourse on deposits
ξ	0.684	Pareto shape parameter
σ_δ	0.0179	Pareto scale parameter
$\underline{\delta}$	-0.0273	Pareto location parameter

Table 2: Model moments and targets

Moment	Target	Model
Risk-free rate (%)	1	1
Housing services in total consumption (%)	14.1	14.1
Homeownership rate (%)	66	68.5
% of homeowners with mortgage debt	70.7	72.7
GSE loans as % of total volume	65	66.3
% of mortgagors with debt-to-value $\geq 60\%$	56.1	61.8
Median deposit-to-asset ratio for mortgagors (%)	8.44	9.6
Median size of owner-occupied-to-rental housing	1.85	1.98
Foreclosure rate (%)	1.2	1.14
Average house depreciation (%)	1.48	1.46
House price volatility (%)	8	8.36

Table 3: Aggregate effects of removing the GSEs

Variable	With GSEs	Change to no GSEs	
		If taxes adjust	If transfers adjust
Risk-free rate	1%	-34.2bp	-33.6bp
Average implicit mortgage subsidy	44.7bp	-44.7bp	-44.7bp
Homeownership rate	68.5%	-2.22%	-2.23%
Average debt-to-value mortgagors	58.1%	-19.3%	-19.7%
Average mortgage spread	0.717%	22.1bp	20.1bp
% of homeowners with debt	72.7	-6.87%	-6.02%
Housing stock-to-GDP ratio	4.21	-1.55%	-1.63%
Median deposit-to-asset ratio	25.7%	-13.3%	-13.4%
House price	1	-1.16%	-1.21%
Shelter price	0.0299	3.18%	3.38%
Price-to-rent ratio	33.4	-4.20%	-4.44%

This table compares the benchmark economy with GSEs to the economy with no GSEs (in one case the government savings in subsidies is rebated to households through lower taxes and in the other case through higher transfers). BP, basis points. GDP $= \bar{y} + P_s S$, where S is aggregate shelter.

Table 4: Percentage of households that agree with removing the GSEs

	Wealth quintile group					
	1	2	3	4	5	All
Renter	53.3	0.24	0.01	0	—	33.8
High leveraged homeowner	—	0.15	17.7	—	—	11.6
Low leveraged homeowner	—	—	40.0	93.5	100	78.3
No debt homeowner	—	—	—	85.3	52.7	63.2
All	53.3	0.20	22.2	89.5	54.5	43.9

This table reports the percentage of households of a certain type that agree with removing the GSEs, that is, the percentage with CEV> 0. Low-leverage homeowners are those with debt-to-value below the median debt-to-value in the benchmark economy with GSEs. Wealth quintile group refers to the households in the quintile.

Table 5: Effects of removing the GSEs or increasing the GSEs G-fees

Variable	With GSEs	Change to no GSEs (if taxes adjust)	Change to GSEs g-fee 60bp (if taxes adjust)
Foreclosure rate (%)	1.14	-38.3bp	-8.72bp
Mortgage stock-to-GDP ratio	1.92	-54.0%	-33.9%
Wealth distribution			
Gini index	0.540	2.90%	1.14%
p75/p25 ratio	6.02	20.9%	10.7%
p80/p20 ratio	9.33	15.6%	7.73%
p90/p10 ratio	20.9	4.56%	3.95%
p90/p50 ratio	3.62	9.18%	3.34%
Decomposing welfare gains (CEV in %)			
Aggregate level effect (1)	—	0.636	0.329
Distributional effect (2)	—	-1.149	-0.558
Total (1) + (2)	—	-0.513	-0.229

This table compares the benchmark economy with GSEs g-fee of 20 bp to the economy without them and with the economy with GSEs g-fee of 60 bp. The consumption equivalent variation (CEV) measures the aggregate welfare gains from the removal of the GSEs or increasing the GSEs g-fees using a utilitarian criteria to aggregate. BP, basis points.

Table 6: Aggregate effects of removing the GSEs and/or the mortgage interest deduction

Variable	Change relative to benchmark with GSEs	
	If no deduction	If no GSEs & no deduction
Risk-free rate	-14.5bp	-49.3bp
Average implicit mortgage subsidy	-6.75bp	-44.7bp
Homeownership rate	-0.65%	-2.66%
Average debt-to-value mortgagors	-4.46%	-20.4%
Average mortgage spread	2.14bp	18.1bp
% of homeowners with debt	-13.7%	-10.1%
Housing stock-to-GDP ratio	-0.60%	-1.97%
Median deposit-to-asset ratio	-3.73%	-18.8%
House price	-0.38%	-1.60%
Shelter price	1.74%	3.01%
Price-to-rent ratio	-2.08%	-4.47%

This table compares the benchmark economy with GSEs to two counterfactuals: (1) the economy with no mortgage interest deduction and (2) the economy with no guarantees and no mortgage interest deduction. BP, basis points.

Table 7: Percentage of households that agree with removing the GSEs and/or the mortgage interest deduction

Wealth quintile group	No GSEs	No interest deduction	No GSEs & no interest deduction
Quintile 1	53.3	98.3	96.4
Quintile 2	0.20	57.7	0.20
Quintile 3	22.2	5.55	19.3
Quintile 4	89.5	91.2	90.4
Quintile 5	54.5	63.4	49.7
All	43.9	62.7	51.2

This table reports the percentage of households that agree with removing the GSEs, the mortgage interest deduction, or both policies. Wealth quintile group refers to the households in the quintile.

A   Online Appendix

A.1   Consumption-Shelter Decision

We simplify the household's maximization problem by first solving analytically the static problem of how to allocate resources between consumption (c) and shelter (s). Given a household's state (a, y), housing tenure and mortgage choice (I_g, I_f, I_j, I_r), and a feasible portfolio choice (d', m', h), we denote as g the resources available for current consumption, that is

$$g = a - (P_h - P_s)h + I_g P_m^g m' + I_f P_m^f m' + I_j P_m^j (m', h, d', y)m' - P_d d'.$$

The problem of allocating g resources between consumption c and shelter s is

$$U(g, h, I_h) = \max_{c,s \geq 0} \frac{\left[\eta c^{\frac{\epsilon-1}{\epsilon}} + (1-\eta)s^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon(1-\sigma)}{\epsilon-1}}}{1-\sigma},$$

$$\text{subject to}$$

$$c + P_s s = g,$$

$$\underline{s} \leq s \leq h \text{ if } I_h = 1.$$

The closed-form solution to the maximization problem is $c(g, h, I_h) = g - P_s s(g, h, I_h)$ and

$$s(g, h, I_h) = \begin{cases} \underline{s} & \text{if } \underline{s} > (1-\theta)\dfrac{g}{P_s} \text{ and } I_h = 1, \\ h & \text{if } h < (1-\theta)\dfrac{g}{P_s} \text{ and } I_h = 1, \\ (1-\theta)\dfrac{g}{P_s} & \text{else.} \end{cases}$$

The associated indirect utility is

$$U(g, h, I_h) = \begin{cases} \dfrac{\left[\eta(g - P_s\underline{s})^{\frac{\epsilon-1}{\epsilon}} + (1-\eta)(\underline{s})^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon(1-\sigma)}{\epsilon-1}}}{1-\sigma} & \text{if } \underline{s} > (1-\theta)\dfrac{g}{P_s} \text{ and } I_h = 1, \\[4ex] \dfrac{\left[\eta(g - P_s h)^{\frac{\epsilon-1}{\epsilon}} + (1-\eta)(h)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon(1-\sigma)}{\epsilon-1}}}{1-\sigma} & \text{if } h < (1-\theta)\dfrac{g}{P_s} \text{ and } I_h = 1, \\[4ex] \dfrac{\left[\eta^\epsilon + (1-\eta)^\epsilon P_s^{1-\epsilon} \right]^{\frac{1-\sigma}{\epsilon-1}} g^{1-\sigma}}{1-\sigma} & \text{else,} \end{cases}$$

where θ is the optimal share allocated to consumption absent the constraints on shelter:

$$\theta = \frac{\eta^\epsilon}{\eta^\epsilon + (1-\eta)^\epsilon P_s^{1-\epsilon}}.$$

A.2 Labor Income Process

We discretize the AR(1) labor income process using the method of Rouwenhorst (1995). We choose $\bar{w}$ such that the stationary mean labor income is normalized to one. The set of income shock realizations is

$$Y = \{0.1133,\ 0.2125,\ 0.3984,\ 0.7470,\ 1.4007,\ 2.6266,\ 4.9251\},$$

with transition probability matrix:

$$\pi = \begin{bmatrix} 0.9584 & 0.0408 & 0.0007 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.0068 & 0.9587 & 0.0340 & 0.0005 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0136 & 0.9588 & 0.0272 & 0.0003 & 0.0000 & 0.0000 \\ 0.0000 & 0.0001 & 0.0204 & 0.9589 & 0.0204 & 0.0001 & 0.0000 \\ 0.0000 & 0.0000 & 0.0003 & 0.0272 & 0.9588 & 0.0136 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.0005 & 0.0340 & 0.9587 & 0.0068 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0007 & 0.0408 & 0.9584 \end{bmatrix},$$

which implies the stationary distribution $\Pi = (0.0156, 0.0937, 0.2344, 0.3125, 0.2344, 0.0938, 0.0156)$.

A.3 Transfers

We calibrate the transfers conditional on labor income using Table 7 of the Supplemental Data in The Distribution of Household Income and Federal Taxes 2013 reported by CBO (2016). The transfers include cash payments and in-kind benefits from social insurance and government assistance programs. We set $T(y) = \alpha(y)y$. Then we compute labor income for each group and estimate $\alpha(y)$ from the data on transfers as a share of labor income. We ensure that the units are consistent with our model. For the labor income values in A.2 we obtain:

$$\{\alpha(y_i)\}_{i=1}^7 = \{0.7115, 0.6925, 0.5659, 0.3081, 0.1224, 0.0604, 0.0392\}.$$

A.4 Tax Function

The flat component of the tax function (28) is set to the payroll tax in 2013, $\kappa = 7.65\%$. To construct the $\iota(y', m', P_m)$ term of (28), we follow the tax schedule described in the 2013 IRS Form 1040 Instructions, Schedule Y-2, page 101. We convert all cutoff levels in the units appropriate to our model using the median CPS wage earnings in 2013. Table A7 shows the normalized marginal tax rates, cutoff income levels, and maximum deductible mortgage amount.

We define $\iota(y', m', P_m) = \varphi(z(y', m', P_m))$, where $\varphi(z)$ is a fifth order polynomial,

$$\varphi(z) = \begin{cases} \sum_{i=0}^{5} a_i z^i & \text{if } z \leq 5.58, \\ \sum_{i=0}^{5} a_i 5.58^i + 0.396(z - 5.58) & \text{else.} \end{cases}$$

Where z denotes taxable income, it is labor earnings minus mortgage interest deductions, that is, $z(y', m', P_m) = \max\{y' - (1 - P_m)\min\{m', \zeta\}, 0\}$. Taxable income cannot be negative. For computational tractability, we follow Chatterjee and Eyigungor (2015) and assume that the interest deduction for a jumbo mortgagor is based on the risk-free mortgage rate ($\frac{1}{P_m^{rf}} = \frac{1+r_w}{P_d}$).

To solve for the coefficients $\{a_i\}_{i=0}^{5}$ we minimize $\sum_{z \in Z} (\varphi(z) - \tilde{\varphi}(z))^2$ subject to $\varphi(0) = 0$ and $\varphi'(5.58) = 0.396$. Z is an equally spaced grid of 1000 points over the interval $[0, 5.58]$, and $\tilde{\varphi}(z)$ is the tax function consistent with Table A7,

$$\tilde{\varphi}(z) = \begin{cases} t_n(z - z_1) & \text{if } n^*(z) = 1, \\ \sum_{i=2}^{n^*(z)} t_{i-1}(z_i - z_{i-1}) + t_{n^*(z)}(z - z_{n^*(z)}) & \text{if } n^*(z) > 1, \end{cases}$$

where $n^*(z)$ is the maximum $n \in \{1, 2, ..., 7\}$ such that $z \geq t_n$. The solution is $\{a_i\}_{i=0}^{5} = \{0, 0.1013, 0.0533, 0.0016, -0.0022, 0.0002\}$. Figure A6 compares the marginal tax rates in the data and those implicit in the model tax function $\varphi(z)$.

A.5 Mortgage Pricing Function

Here we derive a closed-form expression for the jumbo mortgage pricing function (25). The expression is useful since allows to avoid numerical integration over the depreciation shock δ'.

Integrating by parts on the last term of the right side of (25) gives

$$\int_{\delta^*}^{1} (1 - \delta') \, dF(\delta') = \begin{cases} \int_{\underline{\delta}}^{1} F(\delta') \, d\delta' & \text{if } \delta^* < \underline{\delta}, \\ -(1 - \delta^*) F(\delta^*) + \int_{\delta^*}^{1} F(\delta') \, d\delta' & \text{if } \underline{\delta} \leq \delta^* \leq 1, \\ 0 & \text{else.} \end{cases}$$

If the depreciation shocks follow (38), using integration by substitution we obtain the following expression for the integral of the cumulative distribution function

$$\int_{\delta^*}^{1} F(\delta') \, d\delta' = \frac{1 - \delta^* + \frac{\sigma_\delta}{1 - \xi} \left[\left(1 + \xi \frac{(1 - \underline{\delta})}{\sigma_\delta} \right)^{1 - \frac{1}{\xi}} - \left(1 + \xi \frac{(\delta^* - \underline{\delta})}{\sigma_\delta} \right)^{1 - \frac{1}{\xi}} \right]}{1 - \left(1 + \xi \frac{(1 - \underline{\delta})}{\sigma_\delta} \right)^{-\frac{1}{\xi}}}.$$

Using these equations in (25) gives a closed-form expression for the mortgage pricing function.

A.6   Household Problem

We solve the household problem using discrete state space methods. The algorithm is:

Step 1. Initialize the value function $V^{(0)}$ at each grid point of the state space.

Step 2. At each grid point of the state space, the ith iteration maximization problem searches for the housing tenure and mortgage type choice that solves

$$V^{(i)}(a, y) = \max_{I_g, I_f, I_j, I_r \in \{0,1\}} \left\{ I_g V_g^{(i)}(a, y) + I_f V_f^{(i)}(a, y) + I_j V_j^{(i)}(a, y) + I_r V_r^{(i)}(a, y) \right\} \text{ subject to}$$

$$I_g + I_f + I_j + I_r = 1.$$

The value function of a homeowner facing a GSE insured mortgage is

$$V_g^{(i)}(a, y) = \max_{h \geq \underline{h}, d' \geq 0, m' \geq 0} \left\{ U(g, h, 1) + \beta \sum_{y' \in Y} \pi(y'|y) \int_{\underline{\delta}}^{1} V^{(i-1)}(a', y') \, dF(\delta') \right\}$$

$$\text{subject to}$$

$$g = a - (P_h - P_s)h + P_m^g m' - P_d d',$$

$$P_m^g m' \leq \min \left\{ \theta^g P_h h, \bar{l} \right\},$$

$$a' = \max \left\{ y' - \tau(y', m', P_m^g) + d' + P_h(1 - \delta')h - m', (1 - \phi_y)(y' - \tau(y', 0, 0)) + (1 - \phi_d)d' \right\} + T(y').$$

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The value function of a homeowner facing a FHA insured mortgage is

$$V_f^{(i)}(a, y) = \max_{h \geq \underline{h}, d' \geq 0, m' \geq 0} \left\{ U(g, h, 1) + \beta \sum_{y' \in Y} \pi(y'|y) \int_{\underline{\delta}}^1 V^{(i-1)}(a', y') \, dF(\delta') \right\}$$

subject to

$$g = a - (P_h - P_s)h + P_m^f m' - P_d d',$$

$$P_m^f m' \leq \min \left\{ \theta^f P_h h, \bar{l} \right\},$$

$$a' = \max \left\{ y' - \tau(y', m', P_m^f) + d' + P_h(1 - \delta')h - m', (1 - \phi_y)(y' - \tau(y', 0, 0)) + (1 - \phi_d)d' \right\} + T(y').$$

The value function of a homeowner facing a jumbo mortgage is

$$V_j^{(i)}(a, y) = \max_{h \geq \underline{h}, d' \geq 0, m' \geq 0} \left\{ U(g, h, 1) + \beta \sum_{y' \in Y} \pi(y'|y) \int_{\underline{\delta}}^1 V^{(i-1)}(a', y') \, dF(\delta') \right\}$$

subject to

$$g = a - (P_h - P_s)h + P_m^j(m', h, d', y)m' - P_d d',$$

$$a' = \max \left\{ y' - \tau(y', m', P_m^{rf}) + d' + P_h(1 - \delta')h - m', (1 - \phi_y)(y' - \tau(y', 0, 0)) + (1 - \phi_d)d' \right\} + T(y').$$

The value function of a renter is

$$V_r^{(i)}(a, y) = \max_{d' \geq 0} \left\{ U(a - P_d d', 0, 0) + \beta \sum_{y' \in Y} \pi(y'|y) V^{(i-1)}(y' - \tau(y', 0, 0) + d' + T(y'), y') \right\}.$$

If the constraint set is empty in any problem conditional on being homeowner (GSE, FHA, jumbo), then the corresponding value function takes value minus infinity.

For (a', y') outside the state space grid, we evaluate the value function $V^{(i-1)}(a', y')$ using piecewise linear interpolation. We break the conditional expectation in two parts

$$\int_{\underline{\delta}}^1 V^{(i-1)}(a', y') \, dF(\delta') = \int_{\underline{\delta}}^{\delta^*} V^{(i-1)}(a', y') \, dF(\delta')$$

$$+ (1 - F(\delta^*))V^{(i-1)}([(1 - \phi_y)(y' - \tau(y', 0, 0)) + (1 - \phi_d)d' + T(y')], y'),$$

where we use a Gauss-Legendre integration method to calculate the integral over the payment interval $[\underline{\delta}, \delta^*]$.

Step 3. Update the value function $V^{(i)}$.

Step 4. Repeat Steps 2 and 3 until the value of the value function at each state space grid point converges, i.e. $\|V^{(i)} - V^{(i-1)}\| \leq \varepsilon$.

Some additional comments:

Step 1: To discretize the state space, we have seven income points (y), and for each one we create a grid $A(y) = \{a(y)_i\}_{i=1}^n$ of $n = 64$ points for the wealth level a. We set the minimum element of each grid $a_1(y)$ equal to $(1 - \phi_y)(y - \tau(y, 0, 0)) + T(y)$, which is the starting wealth next period in case of default in the current period if $d' = 0$. We construct polynomial spaced grids with more density at the lower bound by using a linearly spaced grid z over $[0, 1]$ and then constructing the grid for $a(y)$ as $a_1(y) + (a_n(y) - a_1(y))z^{1/\alpha}$. We set $\alpha = 0.4$.

Step 2: To ensure that we find a global solution, we perform the maximization in two steps. First, we solve the household's problem using grid search. We use an evenly spaced grid of 75 points for h, 75 points for m', and 75 points for d'. Second, we use the solution obtained through grid search to start an optimization algorithm and solve the maximization problem at each grid point. For the computation of the integral in the conditional expectation, we use 16 Gauss-Legendre quadrature nodes.

Step 3: We set $\varepsilon = 10^{-5}$.

A.7 Stationary Distribution

We look for a stationary distribution of the state variables. We approximate the stationary measure $\mu(a, y)$ with a discrete density function. Define $\delta^*(a, y, y')$ and $a'(a, y, y', \delta')$ as the shock default threshold (22) and next-period wealth implied by the optimal decision rules for (a, y) and the next-period shocks (y', δ'). The algorithm to compute a stationary distribution is:

Step 1. Discretize the state space. Denote the income specific grid by $A(y) = \{a_i(y)\}_{i=1}^n$ where $a_1(y) = (1 - \phi_y)(y - \tau(y, 0, 0)) + T(y)$. We define a grid $Q = \{\underline{\delta}, ..., 1\}$ for the depreciation shock δ' and let $p(\delta')$ be a probability mass function defined over Q.

Step 2. Initialize the measure $\mu^{(0)}$ at each grid point of the state space.

Step 3. During the ith iteration, update $\mu^{(i)}(a_j(y'), y')$ and $\mu^{(i)}(a_{j+1}(y'), y')$ as follows:

$$\mu^{(i)}(a_j(y'), y') = \sum_{y\in Y}\sum_{a\in A(y)}\sum_{\delta'\in Q^*}\pi(y'|y)\,F(\delta^*(a,y,y'))\,p^*(\delta')\left[\frac{a_{j+1}(y') - a'(a,y,y',\delta')}{a_{j+1}(y') - a_j(y')}\right]$$

$$\times\,\mathbb{I}\left(a_j(y') \le a'(a,y,y',\delta') \le a_{j+1}(y')\right)\mu^{(i-1)}(a,y)$$

$$+\sum_{y\in Y}\sum_{a\in A(y)}\pi(y'|y)\left[1 - F(\delta^*(a,y,y'))\right]\left[\frac{a_{j+1}(y') - a'(a,y,y',\delta^*(a,y,y'))}{a_{j+1}(y') - a_j(y')}\right]$$

$$\times\,\mathbb{I}\left(a_j(y') \le a'(a,y,y',\delta^*(a,y,y')) \le a_{j+1}(y')\right)\mu^{(i-1)}(a,y),$$

where $\mathbb{I}(x)$ equals 1 if the statement x is true, 0 otherwise, and $Q^*(a,y,y')$ is the set of $\delta' \in Q$ such that $\delta' \le \delta^*(a,y,y')$ with conditional probability mass function $p^*(\delta')$ defined over Q^*.

$\mu^{(i)}(a_{j+1}(y'), y')$ is updated using the same equation as above after replacing the first and third terms in square brackets by $\left[\frac{a'(a,y,y',\delta') - a_j(y')}{a_{j+1}(y') - a_j(y')}\right]$ and $\left[\frac{a'(a,y,y',\delta^*(a,y,y')) - a_j(y')}{a_{j+1}(y') - a_j(y')}\right]$.

The previous equation says that if next-period wealth falls in one particular wealth interval, then allocate the distribution to the adjacent two grid points of wealth according to (1) the distance to the two adjacent grid points; (2) the transition of y' and δ'; and (3) the share of population that defaults. In practice, we iterate over current states (a,y) and allocate the mass to future states.

The conditional probability mass function is $p^*(\delta_i') = \frac{p(\delta_i')}{\sum_{\delta'\in Q^*}p(\delta')}$.

Step 4. Repeat Step 3 until the value of the measure at each state space grid point converges, that is, $\|\mu^{(i)} - \mu^{(i-1)}\| \le \varepsilon$.

Some additional comments:

Step 1: We discretize the distribution of the shock variable δ' by placing a grid of 1000 evenly spaced points over $[\underline{\delta}, 1]$ with associated probabilities $p(\delta_i') = \frac{f(\delta_i')}{\sum_{\delta'\in Q}f(\delta')}$, where $f(\delta')$ is the probability density function of δ'.

Step 2: The measure $\mu^{(0)}$ is initialized with a uniform distribution over the state space.

Step 3: We set $\varepsilon = 10^{-12}$.

A.8 Equilibrium

With the optimal decision rules and the stationary distribution, we check if the equilibrium conditions (29), (30), (31), and (33) hold within tolerance. If they do not, we update the initial

guesses for P_h, P_s, P_d and κ (if taxes adjust). Then we solve again the household problem in A.6, the stationary distribution in A.7 and check if the conditions hold.

A.9 CEV and Ex Ante Utilitarian CEV

Given the preferences (36), the CEV, $\omega(a, y)$, that solves equation (39) has an analytical solution in terms of the value functions:

$$\omega(a, y) = \left[\frac{V^N(a, y)}{V(a, y)}\right]^{\frac{1}{1-\sigma}} - 1.$$

As discussed in Section 5, the CEV $\omega(a, y)$ can be decomposed into five channels: (1) credit risk subsidy (GSE removal), (2) house price, (3) rental price, (4) interest rate, and (5) tax. Let $V_{\text{GSE}}^N(a, y)$ be the value function of the *partial equilibrium* response of the households when the GSEs are removed but the house price P_h, rental price P_s, interest rate $\frac{1}{P_d}$, and taxes κ remain constant at the benchmark equilibrium values. Similarly, let $V_{P_h}^N(a, y)$ be the value function of the partial equilibrium response of the households when the GSEs are removed, the house price P_h changes to the value in the no GSE equilibrium (P_h^N), but the other prices and taxes are kept at the benchmark equilibrium values. The other value functions are defined in a similar way. By construction, we have

$$\frac{V^N(a, y)}{V(a, y)} = \frac{V_{\text{GSE}}^N(a, y)}{V(a, y)} \frac{V_{P_h}^N(a, y)}{V_{\text{GSE}}^N(a, y)} \frac{V_{P_s}^N(a, y)}{V_{P_h}^N(a, y)} \frac{V_{P_d}^N(a, y)}{V_{P_s}^N(a, y)} \frac{V^N(a, y)}{V_{P_d}^N(a, y)}.$$

Or, using the definitions in footnote 27,

$$(1 + \omega(a, y)) = (1 + \omega_{\text{GSE}}(a, y))(1 + \omega_{P_h}(a, y))(1 + \omega_{P_s}(a, y))(1 + \omega_{P_d}(a, y))(1 + \omega_\kappa(a, y)).$$

Therefore, (40) follows. In practice, different orderings of the decomposition yield similar results.

The ex ante utilitarian CEV (ω) is the CEV of a household under the veil of ignorance about her income and wealth (recall that $\tilde{u}(\tilde{c}) = u(c, s)$ where $\tilde{c}$ is composite consumption):

$$\int_{Y \times A} \mathbb{E}_0 \left[\sum_{t=0}^\infty \beta^t \tilde{u}\big((1 + \omega)\tilde{c}_t\big) \,\Big|\, (a, y)\right] d\mu = \int_{Y \times A} \mathbb{E}_0 \left[\sum_{t=0}^\infty \beta^t \tilde{u}(\tilde{c}_t^N) \,\Big|\, (a, y)\right] d\mu^N.$$

Given the preferences (36) this ex ante CEV becomes:

$$\omega = \left[\frac{\int_{Y \times A} V^N(a, y) \, d\mu^N}{\int_{Y \times A} V(a, y) \, d\mu} \right]^{\frac{1}{1-\sigma}} - 1.$$

Let g^N be the gross growth rate of average composite consumption between the economy with no GSEs and the benchmark with GSEs. The ex ante CEV can be decomposed into terms capturing: (1) the aggregate level effect of composite consumption change (ω_L),

$$\int_{Y \times A} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \tilde{u}\big((1 + \omega_L)\tilde{c}_t\big) \,\Big|\, (a, y) \right] d\mu = \int_{Y \times A} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \tilde{u}\big(g^N \tilde{c}_t\big) \,\Big|\, (a, y) \right] d\mu,$$

and (2) a term capturing the distributional effect across types and states (ω_D),

$$\int_{Y \times A} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \tilde{u}\big(g^N(1 + \omega_D)\tilde{c}_t\big) \,\Big|\, (a, y) \right] d\mu = \int_{Y \times A} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \tilde{u}(\tilde{c}_t^N) \,\Big|\, (a, y) \right] d\mu^N.$$

By construction, $(1 + \omega) = (1 + \omega_L)(1 + \omega_D)$. By taking approximation, $\omega \approx \omega_L + \omega_D$.

A.10   Robustness Analysis

A.10.1   Real estate fund

A household invests $P_v v'$ in the fund and tomorrow gets v'. With the investment, the real estate fund buys houses and rents them out immediately, that is $\int_X P_v v'(x) \, d\mu = P_h K - P_s K$, where K is the housing position of the fund. Tomorrow it sells the nondepreciated part and pays back to investors to earn zero-profits, that is, $\int_X v'(x) \, d\mu = P_h(1 - E(\delta'))K$.

The risk-free gross return of the fund's investment strategy is then

$$\frac{1}{P_v} = \frac{P_h(1 - E(\delta'))}{P_h - P_s},$$

which pins down the price for the fund holdings P_v. There is a fixed per-period participation cost for investing in the real estate fund (f). Hence, the fund has to earn a higher return than the risk-free deposits in order to induce positive holdings in equilibrium (that is, $\frac{1}{P_v} > \frac{1}{P_d}$).

We assume that upon default the fund holdings are seized at the same rate as deposits (ϕ_d). Then, the maximization problem of a GSE borrower in this new scenario is obtained by

replacing $d' = \tilde{d}' + v'$, where $\tilde{d}'$ denotes deposits now, and by replacing the budget constraint (3) with

$$c + P_d\tilde{d}' + P_v v' + \mathbb{I}(v' > 0)f + P_h h = a + P_s(h - s) + P_m^g m'.$$

The same applies for the maximization problem of FHA, jumbo mortgagor, and renter.

The housing market-clearing condition is now given by

$$\int_X h(x)\,d\mu + K = H.$$

All the remaining equilibrium conditions remain the same except that in the left side of the credit market-clearing condition (33) d' is replaced by $\tilde{d}'$.

Regarding calibration, we set the discount factor $\beta = 0.949$ and the fixed participation cost $f = 0.074$ to match an equilibrium risk-free rate of 1% and a ratio of aggregate real estate fund investment-to-financial wealth of 30%.[35] We retain the remaining parameters at the values obtained in the calibration of the benchmark economy (hence the idiosyncratic house shocks follow the same process as before). The model yields a share of GSE loans of 64.4%, similar to the benchmark economy. Table A4 reports the relevant moments.

A.10.2 Constant deposit rate

The equilibrium with GSEs of this model is exactly like that in the benchmark economy with GSEs. It differs with respect to the benchmark experiment in that the credit-market-clearing condition (33) is not enforced and the risk-free rate $\frac{1}{P_d}$ is kept constant.

A.11 Computing DTI

We proxy for mortgage payments in our one-period mortgage debt model as the difference between the existing mortgage amount (m) and the new loan size ($P_m m'$). We abstract from mortgage refinancing transaction costs and therefore we can think of our model as one in which households can freely adjust how fast they amortize their mortgage over time. Consequently, we define mortgage debt payment-to-income (DTI) as $\frac{(m - P_m m')}{y}$. We recover the existing mortgage amount m (that is, the amount at the *beginning* of the period) associated to the current state (a, y) using the equilibrium policy rules and iterating forward.

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[35]This is the ratio of investment in real estate (which is not a part of the primary residence and that is not owned by a business) to financial wealth in the SCF 2004 according to Guiso and Sodini (2013).
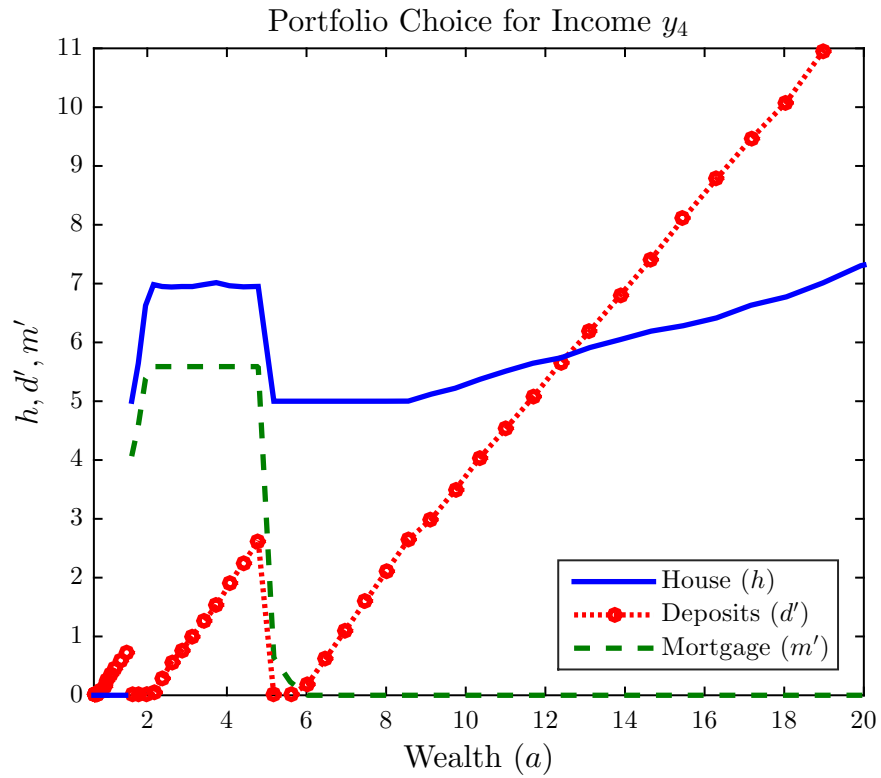
Online Appendix. Figures and Tables.

Figure A1: Households' portfolio choice
This figure plots households' choice of housing, deposits, and mortgage debt as a function of wealth (a) for the households with median income level (y_4).
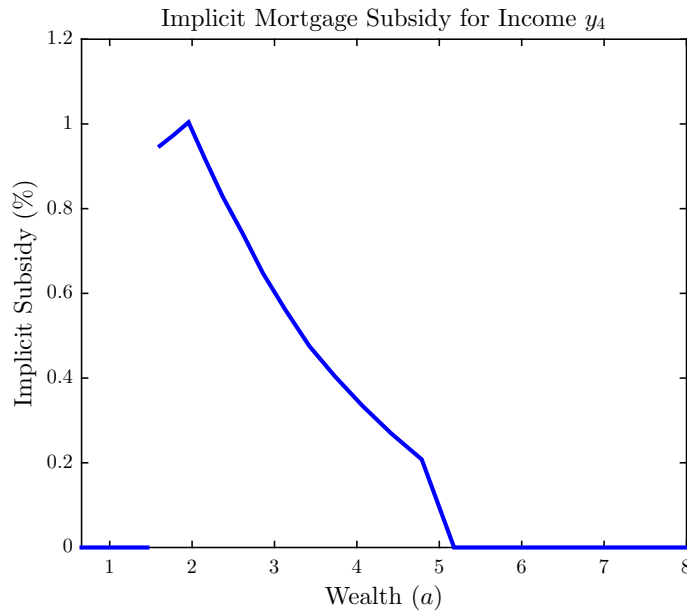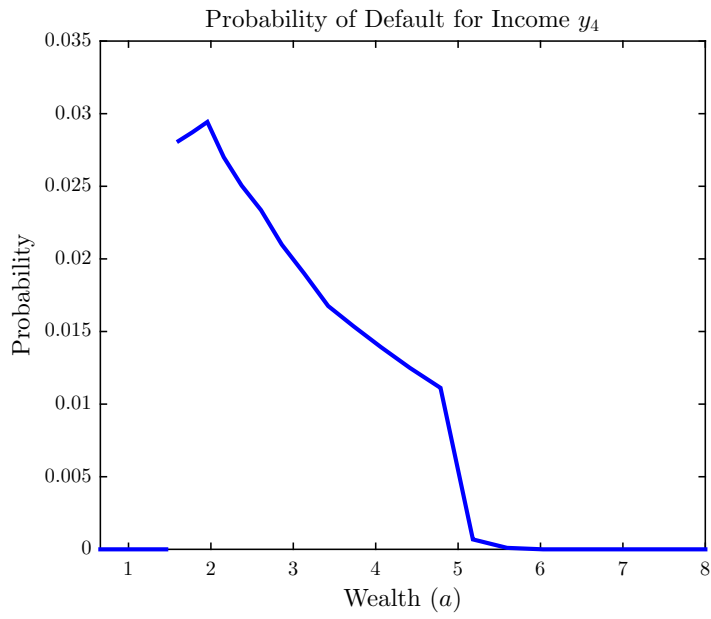
Figure A2: Default probability and implicit subsidy for GSE borrowers
The top panel plots the default probability for the household with median income (y_4) who is a GSE borrower. The bottom panel plots the implicit credit risk subsidy computed relative to the nonconforming mortgage.
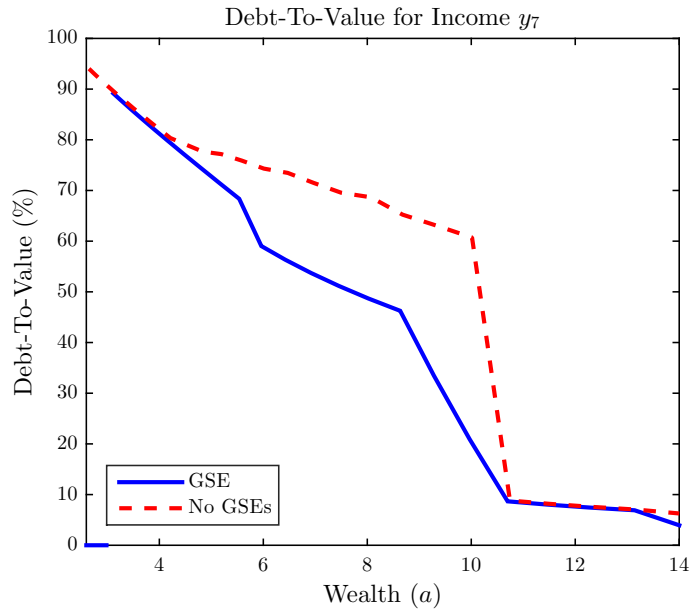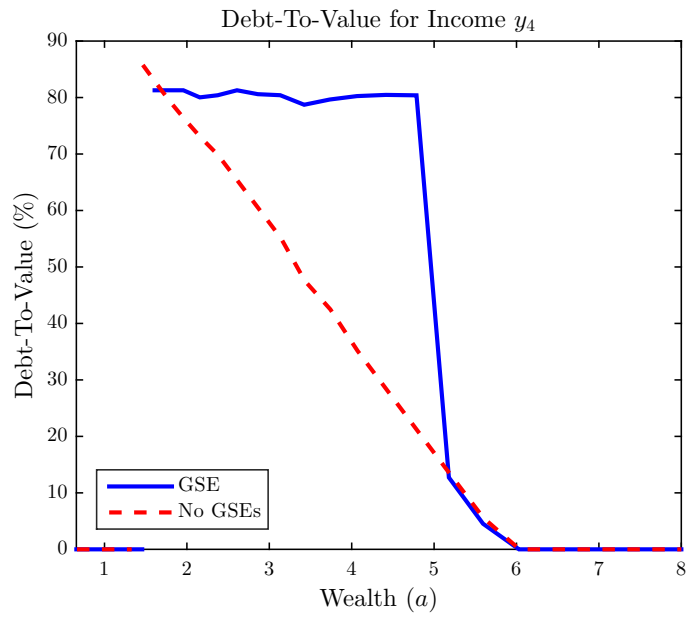
Figure A3: Households' debt-to-value with and without GSEs
Both panels plot debt-to-value before and after removal of the GSEs. The top panel focuses on
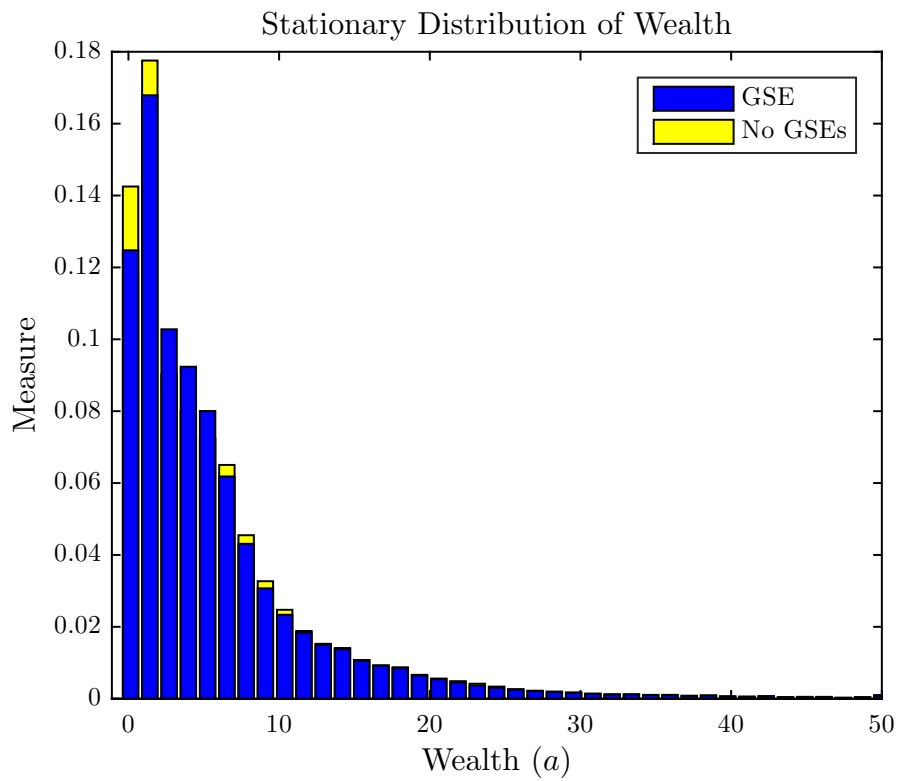GSE-insured mortgagors. The bottom panel studies jumbo mortgagors.

Figure A4: Wealth distribution with and without GSEs
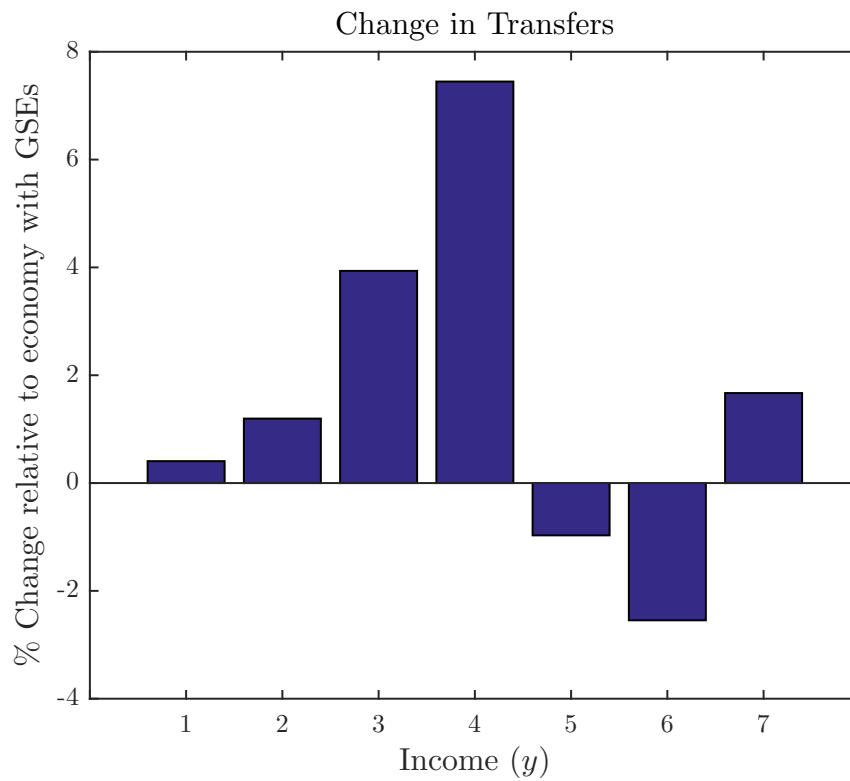This figure plots the stationary wealth distribution with and without GSEs.

Figure A5: Transfer changes needed to undo redistribution induced by the removal of the GSEs

This figure plots the changes in transfers needed to ensure an average zero CEV for each income group when the GSEs are removed.
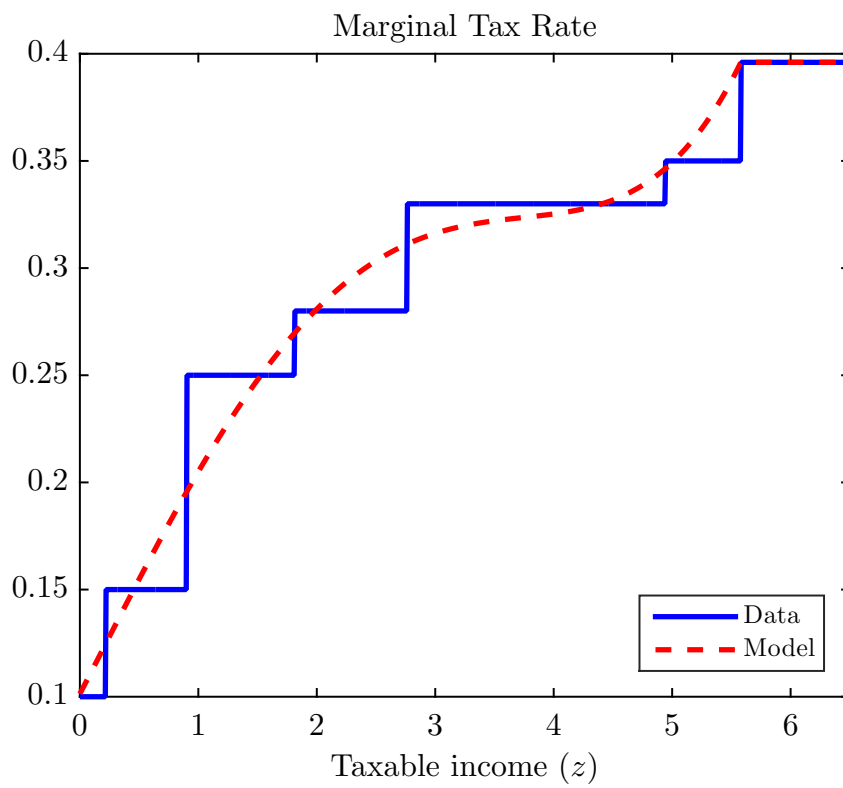
Figure A6: Marginal tax rate in the data and in the model

Table A1: Distribution of rental housing supply

Wealth quintile group	Percentage of total supply
Quintile 1	0
Quintile 2	11.9
Quintile 3	35.5
Quintile 4	20.2
Quintile 5	32.3

This table reports the percentage of total rental housing supply along the wealth distribution in the benchmark economy with GSEs. Wealth quintile group refers to the households in the quintile.

Table A2: Welfare effects by household type of removing the GSEs (when taxes adjust)

Average CEV (%)	Wealth quintile group					
	1	2	3	4	5	All
Renter	0.004	-0.227	-0.852	-0.968	—	-0.094
High leveraged homeowner	—	-0.566	-0.267	—	—	-0.371
Low leveraged homeowner	—	—	-0.001	0.286	0.464	0.211
No debt homeowner	—	—	—	0.163	-0.048	0.020
All	0.004	-0.373	-0.225	0.227	-0.028	-0.078

This table reports the average Consumption Equivalent Variation (CEV) in percentages by household type. It is positive when the household is better off without the GSEs. Low-leverage homeowners are those with debt-to-value below the median debt-to-value in the benchmark economy with GSEs. Wealth quintile group refers to the households in the quintile.

Table A3: Welfare effects of removing the GSEs separating the rent and interest rate channels

	Average CEV (%)	Percentage CEV > 0
By household type		
Renter	0.385	88.1
High leveraged homeowner	-0.328	7.56
Low leveraged homeowner	0.232	85.8
No debt homeowner	0.554	100
All	0.239	72.0
By wealth quintile		
Quintile 1	0.511	100
Quintile 2	-0.122	37.3
Quintile 3	-0.191	23.3
Quintile 4	0.351	100
Quintile 5	0.647	100

This table reports the overall CEV numbers in Table 4 and Table A2 separated out from the rent and interest rate channels. That is, the CEV is computed using only the other three channels (credit risk subsidy, house price, and tax channels) in the decomposition (40). Wealth quintile group refers to the households in the quintile.

Table A4: Robustness analysis: Real estate fund

Variable	Benchmark economy		Real estate fund (recalibrated)	
	With GSEs	Change to no-GSEs	With GSEs	Change to no-GSEs
Risk-free rate	1%	-34.2bp	1%	-14.7bp
Average implicit mortgage subsidy	44.7bp	-44.7bp	47.3bp	-47.3bp
Homeownership rate	68.5%	-2.22%	66.3%	-8.53%
Average debt-to-value mortgagors	58.1%	-19.3%	56.8%	-14.5%
Average mortgage spread	0.717%	22.1bp	0.662%	7.8bp
% of homeowners with debt	72.7	-6.87%	71.4	-11.1%
Housing stock-to-GDP ratio	4.21	-1.55%	4.34	-0.44%
Median deposit-to-asset ratio	25.7%	-13.3%	33.1%	10.7%
House price	1	-1.16%	1	-0.11%
Shelter price	0.0299	3.18%	0.0281	2.64%
Price-to-rent ratio	33.4	-4.20%	35.6	-2.78%
Foreclosure rate (%)	1.14	-38.3bp	1.09	-68.5bp

This table studies the removal of the GSEs in the economy with a real estate fund of Section 7.1. For ease of exposition, the first two columns reproduce Table 3 for the case with rebates via taxes. BP, basis points.

Table A5: Robustness analysis: Constant deposit rates

Variable	Benchmark economy		Constant deposit rate	
	With GSEs	Change to no-GSEs	With GSEs	Change to no-GSEs
Risk-free rate	1%	-34.2bp	1%	0bp
Average implicit mortgage subsidy	44.7bp	-44.7bp	44.7bp	-44.7bp
Homeownership rate	68.5%	-2.22%	68.5%	-0.78%
Average debt-to-value mortgagors	58.1%	-19.3%	58.1%	-19.8%
Average mortgage spread	0.717%	22.1bp	0.717%	13.2bp
% of homeowners with debt	72.7	-6.87%	72.7	-3.89%
Housing stock-to-GDP ratio	4.21	-1.55%	4.21	-3.91%
Median deposit-to-asset ratio	25.7%	-13.3%	25.7%	-4.71%
House price	1	-1.16%	1	-3.20%
Shelter price	0.0299	3.18%	0.0299	5.85%
Price-to-rent ratio	33.4	-4.20%	33.4	-8.55%
Foreclosure rate (%)	1.14	-38.3bp	1.14	-55.4bp

This table studies the removal of the GSEs in the economy with constant deposit rates of Section 7.2. For ease of exposition, the first two columns reproduce Table 3 for the case with rebates via taxes. BP, basis points.

Table A6: Robustness analysis: Percentage of households that agree with removing the GSEs

	Benchmark economy	Real estate fund	Constant deposit rate
By household type			
Renter	33.8	56.9	0.08
High leveraged homeowner	11.6	0.23	0.18
Low leveraged homeowner	78.3	68.6	73.5
No debt homeowner	63.2	80.6	99.6
All	43.9	55.3	40.4
By wealth quintile			
Quintile 1	53.3	97.1	0
Quintile 2	0.20	16.5	0.20
Quintile 3	22.2	5.43	5.55
Quintile 4	89.5	77.5	95.8
Quintile 5	54.5	79.7	100

This table reports the percentage of households of a certain type that agree with removing the GSEs, that is, the percentage with CEV> 0. Low-leverage homeowners are those with debt-to-value below the median debt-to-value in the economy with GSEs. Wealth quintile group refers to the households in the quintile.

Table A7: Tax system parameters

n	Cutoff income level (z_n)	Tax rate (t_n)
1	0	0.10
2	0.22	0.15
3	0.90	0.25
4	1.81	0.28
5	1.81	0.33
6	2.76	0.35
7	5.58	0.396
Maximum deductible (ζ)		12.291

This table shows the normalized marginal tax rates, cutoff income levels, and maximum deductible mortgage amount. These values are obtained from the tax schedule described in the 2013 IRS Form 1040 Instructions, Schedule Y-2, page 101. We converted all cutoff levels in the units appropriate to our model using the median CPS wage earnings in 2013.