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Limited liability, strategic default and bargaining power

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Mirco Balatti, Carolina López-Quiles **Limited liability, strategic default
and bargaining power**

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Abstract

In this paper we examine the effects of limited liability on mortgage dynamics. While the literature has focused on default rates, renegotiation, or loan rates individually, we study them together as equilibrium outcomes of the strategic interaction between lenders and borrowers. We present a simple model of default and renegotiation where the degree of limited liability plays a key role in agents' strategies. We then use Fannie Mae loan performance data to test the predictions of the model. We focus on Metropolitan Statistical Areas that are crossed by a State border in order to exploit the discontinuity in regulation around the borders of States. As predicted by the model, we find that limited liability results in higher default rates and renegotiation rates. Regarding loan pricing, while the model predicts higher interest rates for limited liability loans, we find no such evidence in the Fannie Mae data. We further investigate this by using loan application data, which contains the interest rates on loans sold to private vs public investors. We find that private investors do price in the difference in ex-ante predictable default risk for limited liability loans.

JEL codes: D10, E40, G21, R20, R30

Keywords: lender recourse, mortgage contracts, debt repudiation, renegotiation, discontinuity.

Non-technical summary

The rise of household debt before the financial crisis combined with high default rates was a root cause of the Great Recession and highlighted the role of consumer finance for the macroeconomy. Mortgage debt, in particular, constitutes two-thirds of US household total debt. Outstanding mortgage amounts declined substantially during the Great Recession, but have since reached new historical highs.

While there are several factors that determine the rate of mortgage default, such as adverse economic shocks that leave households unable to honour their debt, default may also be a voluntary choice, commonly referred to as strategic default. One particular aspect the household may consider before choosing to default is whether there is limited or full liability in place. Under limited liability, the lender is not allowed to seize the household's assets after default.

Limited liability constitutes the legal protection of a stakeholder's liabilities beyond a fixed sum. In the context of loans, and in particular of mortgage contracts, limited liability implies a fixed limit on the borrower's obligations, which amounts to the handover of the mortgaged property. In the absence of limited liability, the borrower is liable for the repayment of the full loan amount, and the lender is entitled to seize the borrower's personal assets.

In contrast to the literature, which has studied several effects of limited liability individually, we analyse default decisions, renegotiation and loan pricing together. These are, in fact, equilibrium outcomes of the strategic interaction between lenders and borrowers. To this end, we first develop a simple model of default and renegotiation where the degree of limited liability plays a key role in agents' strategies. Borrowers who can afford to pay the loan may choose to default if their mortgage is underwater. Limited liability encour-

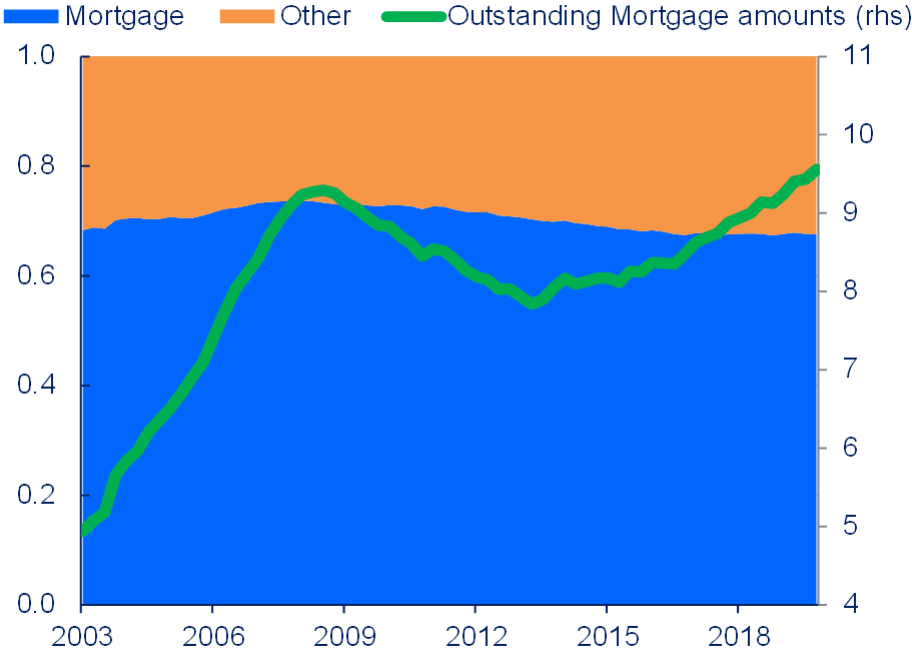
ages this behaviour since borrowers can walk away from their debt more easily. In turn, lenders may be inclined to offer renegotiated loan prices to these borrowers, as they know under limited liability they would not be able to recover more than the foreclosure value of the home. Borrowers thus have greater bargaining power over lenders under limited liability. These interactions also have an effect on loan prices, as the expected value of each loan will depend on the equilibrium of this game. Thus, the model provides three main predictions. First, limited liability leads to higher default rates. Second, lenders renegotiate more under limited liability. Lastly, loan prices are higher for limited liability loans.

We then use Fannie Mae loan performance data to test the predictions of the model. We exploit the difference in regulation in different States. In particular, we limit our analysis to Metropolitan Statistical Areas (MSAs) that are crossed by a State border, where one side has limited liability laws in place and the other does not. This allows us to isolate the effect of limited liability on loan outcomes, as other factors such as economic shocks are expected to be the same within each MSA. As predicted by the model, we find that limited liability results in higher default and renegotiation rates. Regarding loan pricing, while the model predicts higher interest rates for limited liability loans, we find no such evidence in the Fannie Mae data. We further investigate this by using loan application data from the Home Mortgage Disclosure Act (HMDA) database, which contains the interest rates on loans sold to private and public purchasers. We find that private investors do price in the difference in ex-ante predictable default risk for limited liability loans, while their public counterparts, such as Fannie Mae, do not. This has important policy implications, as it imposes price distortions in a multi-trillion dollar market.

1 Introduction

The rise of household indebtedness before the financial crisis combined with high default rates was a root cause of the Great Recession and underlined the importance of consumer finance for the macroeconomy. Mortgage debt, in particular, constitutes two-thirds of US household total debt, as shown in Figure 1. Outstanding mortgage amounts declined substantially during the Great Recession, but have since reached new historical highs.

Figure 1: US households debt



Notes: Share of mortgage and other debt types as a percentage of total household debt. Total US outstanding mortgage amount in trillion US dollars. Source: New York Fed Consumer Credit Panel/Equifax and authors own calculations, 2003-2019.

While there are several factors that determine the rate of mortgage default, such as adverse economic shocks that leave households unable to honour their debt, default may also be a voluntary choice, commonly referred to as strategic default. One particular aspect the household may consider before choosing to default is whether there is limited liability in place. Under limited liability, the lender is not allowed to seize the household’s assets

after default.

Precisely because of the widespread presence of mortgage debt, and in order to prevent strategic default, some jurisdictions allow for lender recourse. Under recourse, lenders are allowed to seize borrowers' assets after default. This aspect of mortgage contracts is predominant in Europe, as noted by Campbell (2012). In the case of the United States, the existence of mortgage recourse is heterogeneous across States, a feature which we will exploit in our analysis.

Strategic default has been widely studied for sovereign debt (e.g. Grossman and Van Huyck (1988); Atkeson (1991)), and other types of unsecured debt (e.g. Jeske (2006)). Mortgage debt is a particular case, and it is interesting to evaluate it in isolation. First, agents making decisions are not sovereign States or investors, but households. Second, debt contracts are highly structured and backed by a real estate property. Third, this type of collateral, in addition to providing an investment opportunity, grants housing services to the borrower. This non-monetary function allows households to derive additional utility from the asset and can thus heavily influence their choices. Fourth, mortgage contracts typically allow borrowers to reach levels of leverage uncommon in other types of debt. Lastly, mortgage contracts are typically longer, the most common contract length being around 30 years. It is worth noting that the decisions made by agents may differ substantially as the loan is amortised.

In order to understand the mechanisms at hand, it is important to review the chain of events after default, and the payoffs from which agents will derive their decisions. When a household defaults on a mortgage, the lender recovers the collateral through foreclosure, short sale, or a deed in lieu. Under limited liability, the borrower is freed from their debt and the lender only recovers the proceedings from the sale of the property. In contrast, under recourse or full liability, the lender can pursue a deficiency judgement.

A deficiency judgement is a ruling through which the lender calculates the difference between the mortgage balance outstanding and the amount recovered through the sale of the collateral. Should the sale of the collateral not be enough to cover the mortgage balance, the lender is entitled to claim the difference from the borrower.

This paper relates to two bodies of literature. The first one exploits different legislative discontinuities around State borders to study several aspects of limited liability and its effect on different market outcomes. Some papers have focused on the effect of limited liability on loan origination. Pence (2006) studies loan origination volumes through the difference in the size of loans on recourse and non-recourse States and finds that non-recourse loans are smaller on average. Curtis (2014) finds that lender-friendly foreclosure is associated with an increase in subprime originations, but has less effect on the prime market. Li and Oswald (2017) leverage on the abolition of deficiency judgements in the State of Nevada in 2009 and find that it led to a decline in equilibrium loan sizes and approval rates. Some other papers have studied the effect of limited liability on loan rates and housing prices. Meador (1982) finds that States with judicial foreclosure exhibit lower interest rates on loans. Pennington-Cross and Ho (2008) inquire whether laws intending to reduce predatory lending behaviour have an effect on loan rates. Their results suggest that these laws have only a modest effect on loan prices. Mian et al. (2015) use judicial requirements for foreclosures across States as an instrument for foreclosures and find that higher foreclosure rates lead to a decline in house prices, residential investments and consumer demand. Another set of papers is concerned with forbearance and loan modifications. Gerardi et al. (2013) find that laws designed to protect borrowers delay but do not prevent foreclosure. Conditional on a loan being underwater, these laws do not increase the probability of cure. Collins et al. (2011) test the extent to which distressed mortgage borrowers benefit from different types of State foreclosure policies. They find that judicial foreclosure proceedings and foreclosure prevention initiatives are associated

with modest increases in loan modification rates. Finally, another group of papers focus on the effect of different legislation on default rates. Ghent and Kudlyak (2011) compare recourse and non-recourse States and find higher mortgage default rates in the latter. Chan et al. (2016) examine how factors affecting mortgage default spill over to other credit markets. They find that, while non-recourse mortgage laws increase mortgage default, they are associated with lower credit card default. Gianinazzi et al. (2019) investigate default behaviour in Europe, where all mortgages have lender recourse and conclude that many households default when the value of the house is greater than the outstanding mortgage balance. They find this result puzzling because it is suboptimal. The authors rationalise it by arguing that, under recourse, the fear of a decline in house prices pushes these households to anticipate their default decision, thereby ‘leaving money on the table’. While these papers focus on individual aspects on limited liability, one contribution of this paper is to encompass default, renegotiation and loan pricing in an integrated setting. We consider this an important aspect, as these elements are all equilibrium outcomes of the strategic interaction between borrowers and lenders, which we show in our model.

The second strand of the literature this paper relates to deals with discrepancies between Government-Sponsored Enterprises (GSEs) and the private market. Most notably, Hurst et al. (2016) find that despite large regional variation in predictable default risk, GSE mortgage rates for otherwise identical loans do not vary spatially. In contrast, they find that the private market does set interest rates which vary with local risk. In this regard, Dagher and Sun (2016) find similar results for credit supply by exploiting an exogenous cutoff in loan eligibility to GSE guarantees. They find that judicial requirements reduce the supply of credit only for jumbo loans, which are ineligible for GSE guarantees.

In this paper we connect these two strands of the literature by analysing default and renegotiation choices by borrowers and lenders, as well as loan pricing, and to highlight the difference in pricing between private and public investors.

In addition, this paper is related to the theoretical literature that studies debt and renegotiation, of which the closest papers are Hart and Moore (1998) and Bester (1994). Some other papers have studied mortgage contracts and default decisions through the lens of a dynamic heterogeneous agents model in general equilibrium. Some examples of such models are Kaplan et al. (2017) and Guren et al. (2018). Guren et al. (2018) investigate the interaction of adjustable and fixed-rate mortgage contracts with monetary policy. Kaplan et al. (2017) propose a life-cycle model of housing decisions with both idiosyncratic and aggregate shocks. Their goal is to replicate the macroeconomic dynamics observed in the data during the Great Recession. These papers focus exclusively on non-recourse mortgages.

In what follows, we present a model of debt renegotiation where the strategic choices of lenders and borrowers depend on the extent to which recourse is enforced. In the model, both house prices and the income of the borrower are stochastic. In some states of the world, the household has enough income to pay their mortgage, whereas in other states of the world it does not. Likewise, in some states of the world, the house value is higher than the mortgage amount, i.e. the household has positive equity, whereas in other states of the world the house value is lower, i.e. the mortgage is underwater. Households who can afford to meet their payments, but whose mortgage is underwater, may find it optimal to default, in particular on instances where it is unlikely that they will be liable with their personal assets after default. Lenders who know this may find it optimal to offer these households a renegotiated mortgage price in order to prevent them from walking away from their obligations. At the same time, the price of these loans will reflect these mechanisms.

We test the predictions of this model exploiting the difference in mortgage laws in different US States. We focus on Metropolitan Statistical Areas that are crossed by a State border, where one State has limited liability laws in place while the other does

not. Using Fannie Mae loan performance data we find, as predicted by the model, that default rates are higher for lower levels of lender recourse, and so are renegotiation rates. However, one result is at odds with our model: there appears to be no significant difference in the interest rate charged on loans across State borders. Importantly, this finding adds to the notion that GSEs do not appropriately price regional differences in the likelihood of default, as pointed out by Hurst et al. (2016). We further investigate this by using loan application data from loans that were sold to private and public buyers. We find a statistically and economically significant difference in loan rates in the private market, as opposed to the findings on GSE pricing. We hence advance to the debate on the differences in pricing between private and public entities by including its interaction with limited liability.

These results have non-negligible economic and policy implications. Since observable differences in local mortgage regulation yield different ex-ante predictable default risk, the lack of price discrimination implies mispricing by GSEs. This is an important distortion in a multi-trillion dollar market. The GSE's single rate policy across jurisdictions generates inefficiencies, which is a cost to taxpayers. On the contrary, private investors of securitised loans are less subject to such costs. In addition, friendly borrowing conditions can increase demand for homes in limited liability jurisdictions, which could generate divergence in house prices across States.

In sum, this paper contributes to the literature along several dimensions. First, we add to the theoretical literature by modelling limited liability explicitly. Furthermore, we incorporate it as a key parameter defined on a continuum, which allows us to identify the different equilibria of the game for different degrees of enforcement of limited liability law. Other features of the model, such as stochastic income and house prices enhance its richness and permit a better characterisation of the equilibria in different states of the world. This is needed to formalise pricing of mortgages theoretically, taking into

account the propensity of default and renegotiation observed in equilibrium, as well as the expected values of household income and house prices. We thus also contribute to the empirical literature, which has studied default and renegotiation individually in partial equilibrium by using this model as a guide for the empirical testing of its implications.

The conclusions of the model are non-trivial. Ex-post, i.e. once a mortgage contract is sealed, the bargaining power given to borrowers by limited liability intuitively points to higher default and renegotiation. Yet, ex-ante lenders know the limited liability law and could be expected to adjust their strategies accordingly, via higher prices or ex-ante commitment to a lower renegotiation propensity in order to disincentivise strategic default. The model suggests that equilibrium pricing should be different but does not point to less renegotiation offering, as in this setting it would represent a non-credible threat.

While the data confirms model predictions regarding default and renegotiation, we find mispricing of ex-ante known strategic default risk in GSEs. This represents an additional dimension of inefficiencies in GSEs, previously unknown in the literature. We therefore also contribute to the literature that has studied loan pricing by GSEs by highlighting the lack of differential pricing along a regulatory dimension.

The rest of the paper is organised as follows. Section 2 proposes a simple model of the strategic interactions between lenders and borrowers and outlines the optimal rates of default, renegotiation, and loan prices. Section 3 describes the data and explains the identification strategy. Section 4 lays out the results for the empirical tests of the model predictions and elaborates on the loan pricing difference between private and public investors. Finally, Section 5 concludes.

2 The Model

This model draws from Bester (1994) model of debt renegotiation with collateral, where we incorporate lender recourse. There are two time periods $t = \{0, 1\}$. Consider a household who wants to buy a house. The house has a purchase price R in period 0. In period 1, the house changes value stochastically to $R(s)$, where $s \in \{s^H, s^L\}$ denotes the state of the world. We assume s^H realises with probability n , and s^L with probability $1 - n$. The household has no initial wealth so it borrows an amount $M = R$ to purchase the property. In $t = 1$, the household will have to pay an amount P equal to the principal plus some non-negative interest, so $P \geq M$. In period $t = 1$ the household receives an exogenous income, which can be either high, Y_H , with probability p , or low, Y_L with probability $1 - p$.

There is asymmetric information about the realisation of income, but the market value of the house in $t = 1$ is public information. All distributions are public information, so the bank knows the probability that Y_H or Y_L realise, that is, it knows p . Asymmetric information implies that the lender cannot write a contract contingent on income.

In the event of default, the bank can choose to foreclose the property, which yields a return of $\Phi R(s)$ (where $\Phi < 1$ represents the recovery rate considering foreclosure costs), or to renegotiate the payment price, offering an alternative payment P' .

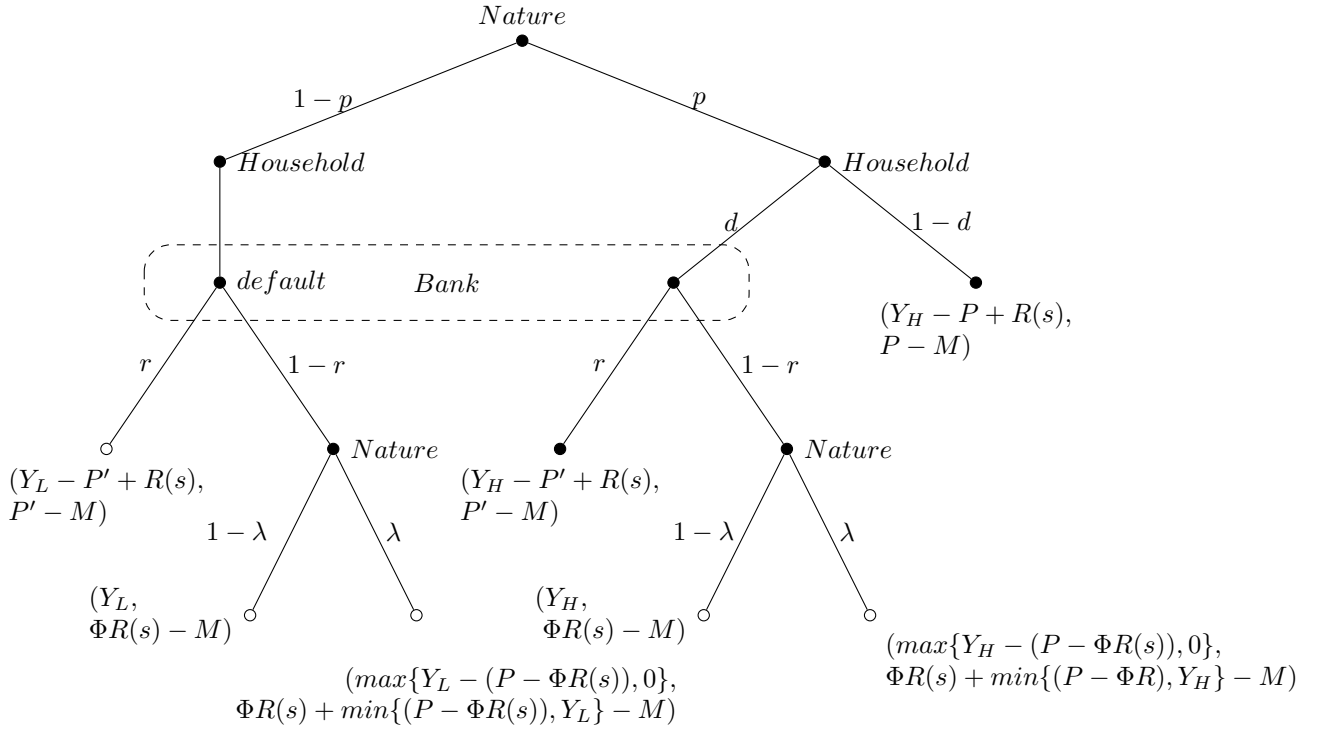
If the bank chooses to foreclose the property, and in order to model the mortgage recourse laws outlined in the previous section, we assume that after foreclosure, there is a judge ruling about the deficiency judgement, which can entitle the bank to seize the household's income for the difference between the amount owed, P , and the amount recovered in foreclosure, $\Phi R(s)$. We assume the judge rules for a deficiency judgement with probability λ . The limited liability case, or non-recourse, is the nested case where the

parameter $\lambda = 0$, i.e. the law rules out deficiency judgements.

It is clear that in the event of a low income realisation, the household is forced to default. With a high income realisation, however, the household may default strategically. Then, the right to foreclose, together with the extent of lender recourse play an important role in incentivising payment by the high income household.

To sum up, a debt contract specifies a payment amount P , and entitles the lender to seize the borrower's personal assets (income) with exogenous probability λ . Lender recourse is a threat that may induce the high income household to pay. At the same time, the extent of lender recourse will affect the incentives for the lender to renegotiate and offer a lower payment price. This is because, under limited liability, i.e. non-recourse, by not renegotiating the bank may be committing to an ex post inefficient outcome. This happens when the foreclosure value of the property is lower than the potential renegotiated payment P' . It is therefore interesting to consider the following game in $t = 1$:

Figure 2: Game in $t = 1$



where p denotes the probability of high income, d denotes the probability with which the household chooses to default, r denotes the probability with which the bank chooses to renegotiate the payment amount, and λ indicates the probability of a deficiency judgement. The dotted area indicates the information set of the bank in the second stage. It observes that the household has defaulted, but it doesn't know whether this default was strategic, i.e. whether the household has high income. The payoffs of the household and the bank are reported below the ending nodes, respectively.

In order to simplify the game and to focus on the most interesting parts of the mechanism, we make the following assumptions about the relative values of the parameters:

Assumption 1. $Y_H > P > Y_L$. The household can only afford the mortgage payment amount if it receives a high realisation of income.

This assumption places the model in the interesting case where some households are financially unable to meet their obligations.

Assumption 2. $\Phi R(s) < Y_L$. *The foreclosure value of the house is lower than the low realisation of income in all states of the world s .*

This assumption yields the interesting case where the bank would be able to recover more by renegotiating than by foreclosing the property.

Assumption 3. $P - \Phi R(s) > Y_L$. *The low income household cannot afford the deficiency judgement for all s .*

From the assumption that $Y_H > P$ it is clear that $Y_H > P - \Phi R(s)$, i.e. the high income household can always afford the deficiency judgement. If the low income household could also pay the deficiency judgement, i.e. if $Y_L > P - \Phi R(s)$, then the asymmetry of information around the realisation of income would be irrelevant to the bank's decision to renegotiate because it would get the same expected return whether the household has high or low income. We impose $P - \Phi R(s) > Y_L$ in order to focus on the more interesting case where asymmetric information about the borrower's realisation of income, together with the fact that the low income household cannot pay the deficiency judgement, introduces an interesting mechanism for the renegotiation of the price.

Corollary 1. $P' = Y_L$. *The renegotiated price is equal to the low realisation of income.*

It is clear that if $P' > Y_L$, the low income household cannot afford the renegotiated price, and will pay at most Y_L , so the renegotiation price must be equal to the low realization of income.

In order to characterise the equilibria of the game, it is important to note two cases:

whether $P < R(s)$, i.e. the household has positive equity on the mortgage, or $P > R(s)$, i.e. the mortgage is underwater.

Assumption 4. $R(s^L) < P < R(s^H)$. *The values of the house in different states of the world are such that the repayment price of the mortgage falls between them. That is, the low value of the house is lower than the price of the mortgage, while the high value of the house is higher, i.e. the mortgage is underwater when s^L realises.*

In the case of positive equity, i.e. state s^H , the equilibria of this game imply no default and no renegotiation. The borrower would not find it optimal to give up the house when they can afford the mortgage, given that the house value is higher than the payment amount unless it gets a renegotiation offer. In turn, the lender would not find it optimal to renegotiate if they know this is the case. In fact, by choosing $r = 0$ the lender can guarantee that the borrower will choose $d = 0$ since for the high income household

$$Y_H - P + R(s^H) > Y_H - \lambda(P - \Phi R(s^H))$$

where the inequality comes from the fact that $\lambda \in [0, 1]$ and $P < R(s^H)$.

In sum, $r = 0$ is a dominant strategy for the lender, independently of λ , in which case only the low income household defaults.

In state s^L , when the mortgage is underwater, one can show that the dominant strategy is not to default if Y_H realises, i.e. $d = 0$ unless

$$\lambda \leq \frac{P - R(s^L)}{P - \Phi R(s^L)} \quad (1)$$

In this case, the lender will choose $r = 1$ if

$$Y_L \geq \Phi R(s^L) + \lambda[(1 - p)Y_L + p(P - \Phi R(s^L))], \text{ i.e.} \quad (2)$$

$$\lambda \leq \frac{Y_L - \Phi R(s^L)}{p(P - \Phi R(s^L)) + (1 - p)Y_L}$$

Alternatively, the lender will choose $r = 0$ if

$$\begin{aligned}
 Y_L &\leq \Phi R(s^L) + \lambda[(1-p)Y_L + p(P - \Phi R(s^L))], \text{ i.e.} \\
 \lambda &\geq \frac{Y_L - \Phi R(s^L)}{p(P - \Phi R(s^L)) + (1-p)Y_L}
 \end{aligned} \tag{3}$$

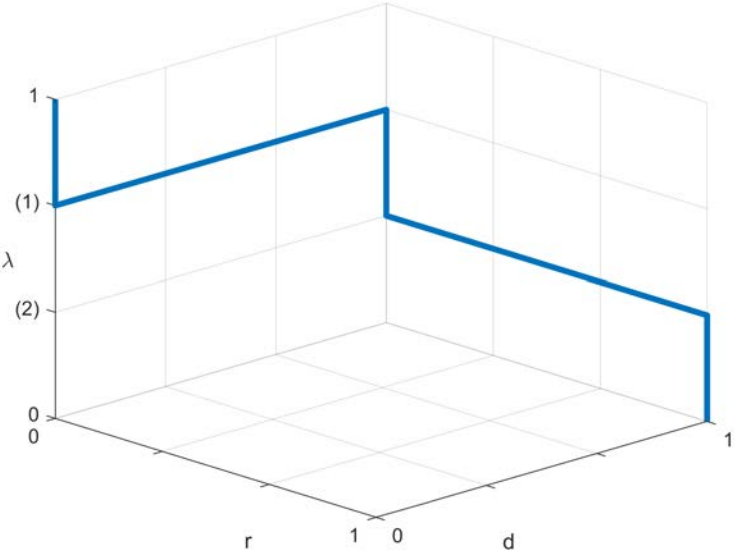
In the case where (2) holds with equality (and therefore (3) as well), the lender will first observe the borrower's strategy, and choose $r = 0$ if $d = 0$, or mix $r \in (0, 1)$ if $d = 1$.

Proposition 1. *If $P < R(s)$ there is a unique pure strategy equilibrium with $d = 0$ and $r=0$ independently of λ . If $P > R(s)$ there is a pure strategy equilibrium when condition (1) and (2) are satisfied with strict inequality with $d = 1$ and $r = 0$, while if (1) and (3) are satisfied with strict inequality, the equilibrium is given by $d = 1$ and $r = 1$; therefore, when (1) is satisfied with strict inequality and (3) is satisfied with equality, any $r \in (0, 1)$ and $d = 1$ is an equilibrium, and when (1) is satisfied with equality and (3) is satisfied with strict inequality, any $d \in (0, 1)$ and $r = 1$ is an equilibrium.*

The equilibria of this game will therefore depend on the value of λ and the relative position of thresholds (1) and (2) when they hold with equality. Figure 3 provides a graphical representation of the equilibria as a function of λ when when (1) $>$ (2). As can be seen, for high values of λ , there is no default or renegotiation in equilibrium. This is because high lender recourse imposes too high a cost for the high income household to default, as it may risk a deficiency judgement. Knowing this, the lender chooses to not renegotiate. As lender recourse decreases, the borrower starts facing higher incentives to default, as the risk of a deficiency judgement is lower. When (1) holds with equality, there is no renegotiation and the borrower mixes between default and repayment. For values of lambda between (1) and (2), it is optimal for the household to default, as the risk of a deficiency judgement is below the threshold, but it is still not optimal for the lender

to renegotiate, as the expected payoff from doing so continues to be lower than that of renegotiating. This is because, for the lender, the probability of a deficiency judgement is still high enough such that in expectation they would recover more from the judgement than from the low renegotiated price Y_L . For λ below (2), the incentive for renegotiation kicks in for the lender, as the probability of a deficiency judgement is too low and hence the renegotiated price is higher than the expected recovery value from a foreclosed property. Equilibria for the cases where (1) < (2) and (1) = (2) can be found in Appendix A. In all cases, the equilibria with default and renegotiation appear as λ decreases. Hence, the testable implication is that default and renegotiation are higher in non-recourse States. We will test this in the next Section.

Figure 3: Equilibria when (1) > (2) as a function of λ



We now turn to the pricing decision by the bank. With bank competition, a risk-neutral bank will set a repayment price P in $t = 0$ so as to set the expected value of the game in $t = 1$ equal to zero. The bank knows the value of λ , and it anticipates the equilibrium of the game for each state of the world. Hence, there are three cases:

First, when $\lambda > (1)$, the bank knows that under any realisation of the house value, it is always optimal for the high income household not to default. It therefore anticipates the equilibrium where $d = 0$ and $r = 0$. The expected value of the game is then

$$(1 - p) \left[\Phi(nR_H + (1 - n)R_L) + \lambda Y_L - M \right] + p(P - M) = 0 \quad (4)$$

so

$$P_{\lambda > (1)} = \frac{(1 - p)}{p} \left[M - \Phi(nR_H + (1 - n)R_L) - \lambda Y_L \right] + M \quad (5)$$

Second, when $(1) > \lambda > (2)$, the bank anticipates that the household will default if the low house value realises. Therefore the expected value of the game is

$$\begin{aligned} & n \left[(1 - p) [\Phi R_H + \lambda Y_L - M] + p(P - M) \right] \\ & + (1 - n) \left[(1 - p) [\Phi R_L + \lambda Y_L - M] + p[\Phi R_L + \lambda P - M] \right] = 0 \end{aligned} \quad (6)$$

so

$$\begin{aligned} P_{(1) > \lambda > (2)} = \frac{(1 - p)}{p} \frac{[M - \lambda Y_L - n\Phi R_H - (1 - n)\Phi R_L]}{n + (1 - n)\lambda} \\ + \frac{M - \phi R_L}{n + (1 - n)\lambda} \end{aligned} \quad (7)$$

Third, when $\lambda < (2)$, the bank anticipates that under the low realisation of the house value the household will default, and it also finds it optimal to renegotiate, that is, $d = 1$ and $r = 1$. The expected value of the game is then

$$\begin{aligned} & n \left[(1 - p) [\Phi R_H + \lambda Y_L - M] + p(P - M) \right] \\ & + (1 - n) [Y_L - M] = 0 \end{aligned} \quad (8)$$

so

$$P_{\lambda < (2)} = \frac{(1 - p)}{p} [M - \Phi R_H - \lambda Y_L] + \frac{M}{n} + \frac{(1 - n)}{np} [M - Y_L] \quad (9)$$

It can be shown that P is decreasing in λ in all cases, that is, that for higher lender recourse, mortgage rates are lower.

This model outlines the mechanism we want to highlight and provides testable implications. Namely, that for higher levels of lender recourse, underwater borrowers default at a higher rate even when they have the means to pay for their mortgage. Lenders are incentivised to renegotiate the price of the mortgage in cases where lender recourse is low, as is the case in limited liability States. Loan prices therefore should reflect this. However, as we will see in the next Section, Government Sponsored Enterprises such as Fannie Mae, do not set loan prices differently across jurisdictions with different levels of lender recourse. The fact that in the US most mortgages are bought by GSEs, which are government-guaranteed, implies that in the end this deadweight loss is borne by the taxpayer. We now turn to empirically verify the relationship between recourse laws and mortgage prices, default probabilities, and renegotiation.

3 Data and Methodology

3.1 Fannie Mae Single Family Loan Database

This database contains acquisition data from all the mortgage loans acquired by Fannie Mae, together with monthly performance data of said loans. Acquisition data includes variables such as the seller name, original unpaid balance, original loan term, origination date, original loan-to-value (LTV) ratio, original debt-to-income (DTI) ratio, borrower credit score (FICO score), loan purpose, property type and mortgage insurance percent and type. Performance data includes variables such as current interest rate, current unpaid balance, loan age, remaining months to maturity, delinquency status, last paid instalment date, foreclosure date, foreclosure costs, asset recovery costs and other costs, taxes, net sale proceeds and other proceeds and principal forgiveness amount. Location data of the property is also available. In particular, the State, the Metropolitan Statistical Area (MSA) and the 3-digit Zip code are reported. Data is available on a monthly basis

from 2004 to 2016.

We focus exclusively on purchase loans for principal home, to abstract from the difference in default incentives that may be present for mortgage loans used for investment purposes. We consider a loan to have defaulted once it is over 90 days delinquent, as is standard in the literature. However, we note that our results are robust to other definitions of default.¹

3.2 Home Mortgage Disclosure Act Database

The Home Mortgage Disclosure Act (HMDA) Database contains the universe of all mortgage loan applications filed by reporting banks in the United States. Banks are obliged to report if their balance sheet size is above a certain threshold. The information on each application includes loan characteristics such as the loan amount and the purpose of the loan (purchase, refinance or home improvement); borrower and co-borrower characteristics such as income, race and gender; and characteristics of the property such as its geographical location (Metropolitan Statistical Area, census tract, State, ...), occupancy and type of dwelling (single-family, multifamily, ...).

In addition, the database includes information about whether the loan was granted or not, and the reasons for denial where applicable.

We use this database to explore the differences in the characteristics of the demand for loans, as well as lenders' willingness to lend conditional on loan characteristics between recourse and non-recourse States.

¹For instance, we consider a loan to have defaulted if it has been delinquent for over 90 days at any point in time and has not gone back to current status in the 12 months prior to the end of its reporting life, i.e. no recovery in the 12 months prior to it being sold to a third party, foreclosed or otherwise finalised. Another definition, used by Ghent and Kudlyak (2011), considers a loan to have defaulted when it is terminated by short sale, deed in lieu or REO sale.

This data is available on a yearly basis from 2004 to 2016.

3.3 Federal Housing Finance Agency database

In order to assert the value of the collateral of each mortgage at each point in time, we use House Price Indices from the Federal Housing Finance Agency. They are estimates using all transactions of sold houses in a given period and 3-digit ZIP code. These data are used to estimate the current value of the property and the current equity value of the mortgage owner.

Following the literature, we compute the market price of a house at time t as follows:

$$P_t = P_0 \frac{HPI_t}{HPI_0} \quad (10)$$

where P_0 is the purchase price of the house at the time it was acquired by the borrower, and $\frac{HPI_t}{HPI_0}$ is the growth of the Housing Price Index in the period between the home purchase (time 0) and the present time.

3.4 Identification

Our identification strategy consists of comparing mortgage loans of homes located in recourse and non-recourse States over their life cycle in order to understand the effect of different regulations on different outcomes.

In order to exploit the discontinuity around the border of recourse and non-recourse States, we focus on Metropolitan Statistical Areas that are crossed by a State border. First, let us define what an MSA is:

The United States Office of Management and Budget (OMB) delineates metropolitan and micropolitan statistical areas according to published standards that are applied to Census Bureau data. The general concept of a metropolitan or micropolitan statistical area is that of a core area containing a substantial population nucleus, together with adjacent communities having a high degree of

economic and social integration with that core.

United States Census Bureau.

Mortgages in the same MSA are arguably exposed to the same economic shocks since MSAs are delineated by definition to encompass geographical areas that are ‘economically and socially integrated’. Households on either side of such borders are expected to be exposed to the same economic shocks, so a difference in our variables of interest can be interpreted as stemming from the difference in borrower liability.

We define recourse and non-recourse States following Ghent and Kudlyak (2011). The resulting dataset, in which we select MSAs that are crossed by a State border where one side of the border enforces recourse and the other does not, spans 6 Metropolitan Statistical Areas and 9 States, as shown in Table 1. For the Fannie Mae monthly loan performance data, this implies over 100,000 individual loans over and 4 million observations, while for the Home Mortgage Disclosure Act loan application data we have almost 3.5 million individual loan applications.

Table 1: Metropolitan Statistical Areas

MSA Name	Recourse side	Non-recourse side
Charlotte-Concord-Gastonia	SC	NC
Davenport-Moline-Rock Island	IL	IA
Lewiston	ID	WA
Omaha-Council Bluffs	NE	IA
Sioux City	SD, NE	IA
Virginia Beach-Norfolk-Newport	VA	NC

Notes: Names of the Metropolitan Statistical Areas that are crossed by a State border where one State enforces lender recourse and the other does not. The second and third columns present the abbreviations of the States on either side. Recourse and non-recourse are defined following Ghent and Kudlyak (2011).

4 Empirical Analysis

4.1 Testing the Model predictions: the pricing puzzle

In this section we use the Fannie Mae Single Family Loan Performance database to test the predictions from the model. Table 2 shows the mean values for some key variables, separated by recourse and non-recourse, together with the p-values for the two-sided t-test of whether they are statistically different from each other.

Table 2: Descriptive Statistics

	Non-recourse	Recourse	p-value
Variables at origination			
Rate of default (%)	3.24	2.15	<.001
Loan Amount (\$)	196,477	181,003	<.001
Credit Score	750.9	755.6	<.001
Interest Rate (%)	4.85	4.84	.06
Debt-to-income (%)	33.46	33.83	<.001
Loan-to-value (%)	80.32	80.01	<.001
Current variables			
Current Balance (\$)	170,202	157,804	<.001
Current Interest Rate (%)	4.98	4.97	<.001
Market Price (\$)	250,118	227,611	<.001
Months to Maturity	311	310	<.001
N. of loans	48,406	51,892	.
N. of observations	2,044,322	2,174,763	.

Notes: Loan amount, current balance and market price are in US dollar amounts, interest rate, current interest rate, debt-to-income (DTI) and loan-to-value (LTV) are reported as percentages. DTI is calculated as the ratio between the borrower's total monthly obligations and their stable monthly income. Credit score is the FICO score. Source: Fannie Mae Single Family Loan Database, Federal Housing Finance Agency and authors own calculations, 2004-2016.

We consider a loan to have defaulted, as is standard in the literature, when it has delinquency status for longer than 3 months. Default rates are higher in non-recourse States, as predicted by the model, while interest rates at origination are not statistically different across jurisdictions. This is puzzling, as one would expect the higher risk of default to be reflected on prices. We will explore this more formally in the course of

this section. Credit scores are lower on average on the non-recourse side of the border. While this difference is statistically significant, it is not economically significant as the magnitude of the difference is only 5 points in the FICO score. One may worry that there is self-selection into purchasing a house on either side of the border. Lower quality borrowers may choose to live on the non-recourse side of the border since they expect they may need to default with higher probability. This would bias our results. However, this small difference in the credit score is reassuring that borrower quality is similar on either side of the border.

In addition, Debt-to-income ratios are also very similar. Debt-to-income ratios are a good way to measure the likelihood of default of a household, as it measures the strain that their debt places on their finances. The fact that these ratios are similar across jurisdictions, together with our use of the discontinuity around the border which ensures similar exposure to economic shocks, indicates that households can be expected to be able to meet their financial obligations with similar probability. This relates to the model along parameter p , that is, the probability that the household will receive a low income realisation and not be able to meet their payments. Furthermore, Loan-to-value ratios seem to also be similar across jurisdictions, and very close to the regulatory soft limit of 80%. We call this a soft limit because banks are allowed to issue loans for more than 80% of the value of the property, but in order to do so, they must meet additional requirements, which makes 80% the effective limit for a wide majority of loans. Overall, it appears that most variables are similar in recourse and non-recourse States, which allows us to compare these loans and draw conclusions on the relevant variables of interest.

Next, we formally test the model predictions using different regressions. First, the model predicts that default rates should be higher in non-recourse States. We test this using the following Logit regression:

$$L_D = \beta_0 + \beta_1 D_{NR} + \beta_3 X_{i,t} + \epsilon_{i,t} \quad (11)$$

where L_D denotes the log odds of default, D_{NR} is a dummy variable that takes value 1 if the house is located in a non-recourse State and 0 otherwise, and $X_{i,t}$ is the set of control variables. Control variables include the credit score of the borrower, the remaining loan term, the debt-to-income ratio of the borrower, the loan's current outstanding balance and the market price of the property.

Second, the model shows that, when faced with a delinquent borrower, the bank must choose whether to renegotiate the loan payment or let the household default. The model predicts that the bank chooses to renegotiate with lower probability as λ decreases. That implies that we should expect lower levels of renegotiation, conditional on the borrower being delinquent, in non-recourse States. We test the difference in renegotiation rates between recourse and non-recourse States, conditional on the loan being more than 3 months delinquent, which is consistent with the standard definition of default used in the literature. The Logit regression in this case reads:

$$L_M = \beta_0 + \beta_1 D_{NR} + \beta_3 X_{i,t} + \epsilon_{i,t} \quad (12)$$

where L_M denotes the log odds of loan modification and the rest of the variables are defined as in the previous regression.

Finally, the model prediction is that prices should be higher on non-recourse States, owing to the higher level of ex-ante predictable risk. We run an OLS regression to test for the difference in loan prices at origination:

$$rate_{i,t} = \beta_0 + \beta_1 D_{NR} + \beta_3 X_{i,t} + \epsilon_{i,t} \quad (13)$$

where $rate_{i,t}$ is the interest rate agreed in the initial terms, and $X_{i,t}$ are a set of con-

trol variables. The control variables, in this case, are the credit score of the borrower, the initial loan term and the debt to income ratio of the borrower at origination.

Table 3 shows the results from these regressions. Columns 1-4 report Logit coefficient estimates in odds ratios to facilitate the comparison and interpretation of the relative probability of default and renegotiation between recourse and non-recourse States. Values above (below) unity indicate a positive (negative) relation between the independent variable and the likelihood of default or renegotiation. As shown in Column 2, default rates are higher in non-recourse States, as predicted by the model. In terms of magnitude, borrowers in non-recourse States are around 42% more likely to default on their mortgage.² Column 4 shows that the probability of loan renegotiation is 28% higher in non-recourse States. This result is also in line with the model's predictions.

Moving on to pricing, Column 8 shows a puzzling result: the difference in the interest rate between recourse and non-recourse loans is economically negligible at less than 1bp. In addition, the sign of this difference is the opposite of what is predicted in the model. In a regression specification with no time or MSA fixed effects, we find that this difference is not statistically significant. Recalling that these results come from Fannie Mae's loan performance data, they provide evidence of an additional dimension of mispricing by GSEs. In addition to Hurst et al. (2016), who find that GSEs do not correctly price regional risk, we show that such enterprises do not take into account ex-ante predictable non-recourse risk. In order to shed light on this issue, in the next section we take a step

²These results are qualitatively robust if we only use the cross-section of loans rather than the full panel. In the baseline, we opt to use a period by period approach to account for time spent in delinquency and possibility of cure. This also allows including running variables as controls, such as house price, in line with the model.

back and use the HMDA dataset to evaluate loan prices at the loan application stage, where data is available also for the private sector.

Table 3: Regression Results

VARIABLES	Logit - odds ratios				OLS	
	(1) Default	(2) Default	(3) Renegotiation	(4) Renegotiation	(5) Interest Rate	(6) Interest Rate
D_{NR}	1.474*** (0.084)	1.416*** (0.079)	1.268*** (0.092)	1.282*** (0.095)	0.009** (0.004)	-0.008*** (0.003)
Credit Score		0.982*** ($<.001$)		0.990*** (0.001)		-0.002*** ($<.001$)
Months to Maturity		1.004*** (0.001)		1.037*** (0.001)		0.003*** ($<.001$)
DTI		1.051*** (0.002)		1.030*** (0.003)		0.002*** ($<.001$)
Current Balance		1.000*** ($<.001$)		1.000*** ($<.001$)		
Market Price		0.999*** ($<.001$)		0.999*** ($<.001$)		
Observations	4,052,363	3,436,163	3,650,449	3,124,426	100,298	98,617
R-squared					0.859	0.904
Pseudo R2	0.149	0.250	0.053	0.396		
MSA FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Heteroskedasticity robust standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Columns 1-4 report Logit coefficient estimates in odds ratios to facilitate the comparison and interpretation of the relative probability of default and modification between recourse and non-recourse States. Values above (below) unity indicate a positive (negative) relation between the independent variable and the likelihood of default or modification. The standard errors reported in parentheses for the Logit regressions are computed via Delta method to match the odds ratio coefficients. Columns 5-6 report OLS estimates estimated using observations at origination only. Source: Fannie Mae Single Family Loan Database, Federal Housing Finance Agency and authors own calculations, 2004-2016.

4.2 Understanding loan pricing

In this section we focus on loan applications data in order to examine whether there are differences in loan demand, loan origination, and loan sales that could explain the pricing puzzle outlined in the previous section.

4.2.1 Loan origination and sale

Table 4 shows the mean values for some key variables in the HMDA Dataset, separated by recourse and non-recourse, together with the p-values for the two-sided t-test of whether they are statistically different from each other.

Both origination rates and sales to third parties are higher in recourse States. The average income of the applicant is higher in non-recourse States, whereas the median income is equal across jurisdictions, indicating the presence of outliers. Loan amounts of all received applications, as well as those of accepted loans, are significantly different in statistical terms, but are very similar in economic terms, differing by roughly \$1,500. Importantly though, loan-to-income ratios of all applications as well as of originated loans are significantly higher in recourse States. The loan-to-income ratio is a measure of the burden that the loan repayment poses on the borrowers' payment capacity, hence higher loan-to-income is associated with a higher risk of default. The fact that recourse States display higher loan-to-income ratios of granted loans may indicate that lenders are more willing to take on risk in recourse States because they have a higher recovery ratio given that they can seize the borrowers' personal assets in the event of default.

Table 4: HMDA

	Non-recourse	Recourse	p-value
All Applications			
Annual income of applicant (\$)	84,723	80,846	<.001
Median annual income (\$)	67,000	67,000	.
Loan amount (\$)	151,716	153,358	<.001
Loan-to-income	2.055	2.155	<.001
Originated Loans			
Annual income of applicant (\$)	89,592	84,430	<.001
Median income (\$)	72,000	71,000	.
Loan amount (\$)	157,237	155,573	<.001
Loan-to-income	2.012	2.101	<.001
Loan acceptance rate (%)	54.04	55.27	<.001
Sold to 3rd party (%)	67.39	68.83	<.001
N. of observations	1,370,430	2,013,317	.

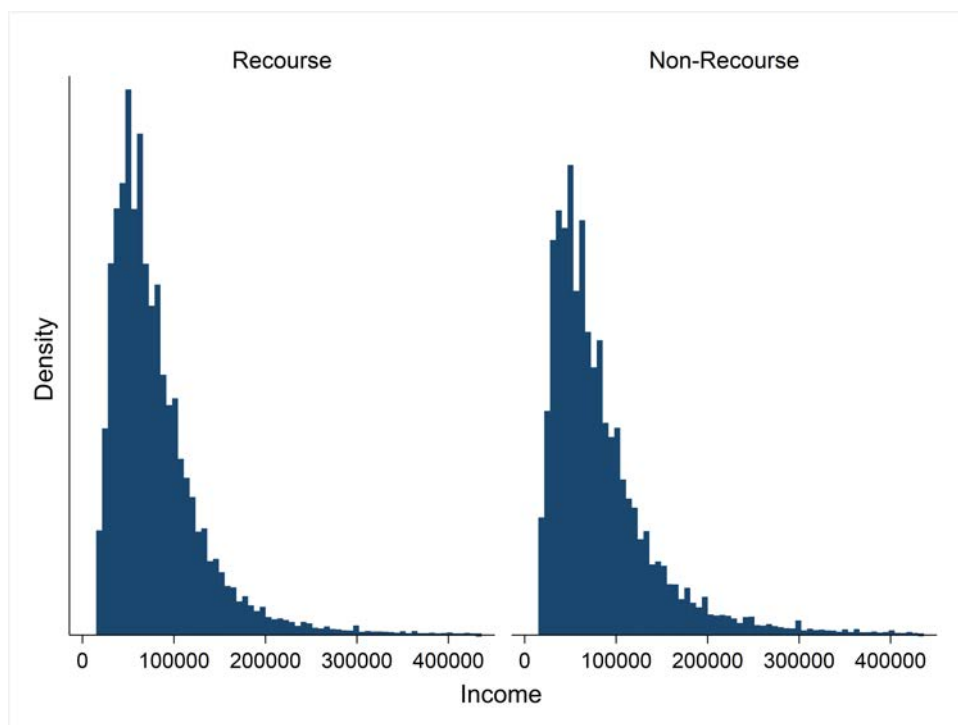
Notes: Income and loan amounts are in US dollars. Loan-to-income is the ratio of the loan amount over the annual income of the applicant. The acceptance rate is the percentage of loan applications that were granted. Loans sold to 3rd parties reflect the percentage of granted loans that were sold to a 3rd party in the natural year in which the loan was originated. Source: Home Mortgage Disclosure Act Database and authors own calculations, 2004-2016.

First, we focus on the characteristics of loan applications, as well as on the lenders' willingness to lend given the applications it receives on either side of the border.

The distribution of income of applications is depicted in Figure 4. There are no significant differences in the distribution of income of applicants on either side of the border. We can therefore conclude that any differences in the probability to originate a loan are due to differences in limited liability.

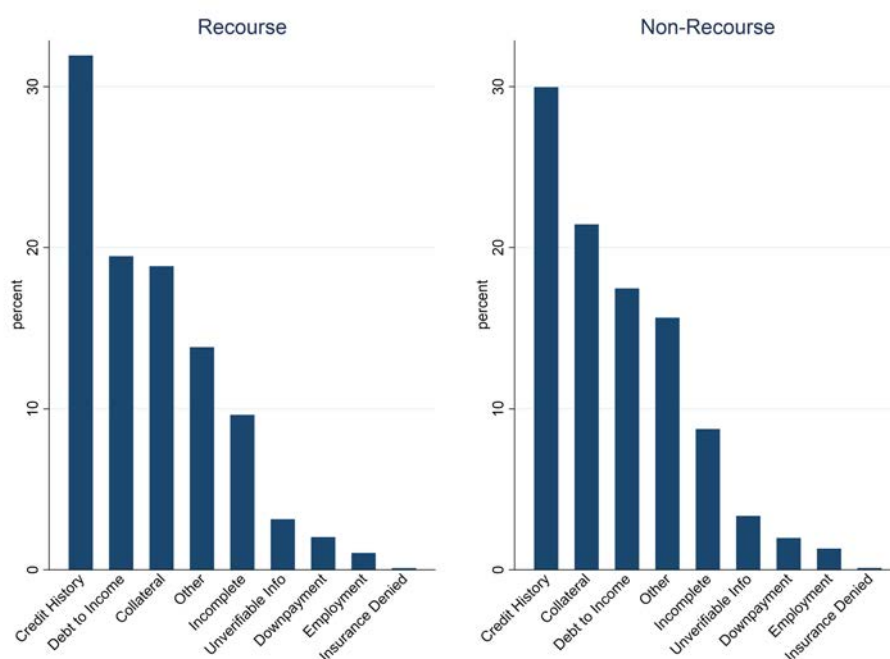
Figure 5 illustrates the differences in reasons for denial. The most common reason for denial is the credit history of the borrower in both types of States. The second most frequent reason in recourse States is the debt-to-income ratio, followed by the value of the collateral (the real estate property). Notably, this order is reversed in non-recourse States, indicating that collateral value is more important to lenders in States with limited liability. This is intuitive since limited liability implies that the lender may be limited in how much they can recover from the borrower in case of default, making the value of

Figure 4: Income distributions



Notes: Distributions of yearly income is US Dollars at the loan application stage split by recourse and non-recourse States. Source: Home Mortgage Disclosure Act Database and authors own calculations, 2004-2016.

Figure 5: Reasons for loan denial



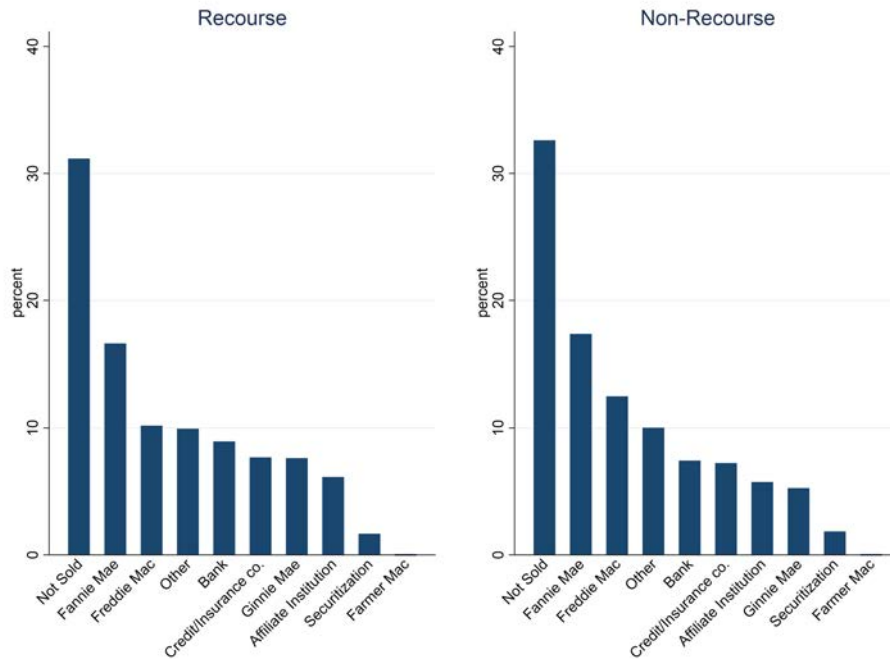
Notes: The height of the bars in the histograms indicate the frequency of different reasons for loan denial split by recourse and non-recourse States. Source: Home Mortgage Disclosure Act Database and authors own calculations, 2004-2016.

collateral an important source of compensation for this risk.

Next, we are also interested in the originate-to-distribute behaviour of banks. Leading up to the Financial Crisis in 2007, and ever since, it has become increasingly evident that the business model of many lenders is to originate mortgages and sell them to third parties, thereby eliminating credit risk from their balance sheets. Figure 6 contains information about the proportion of loans that were sold to a third party in the year of its origination and the identity of the purchaser.

It can be seen from the Figure that lenders sell just under 70% of their loans to third parties. The most common purchasers are State Agencies, Fannie Mae and Freddie Mac. Banks sell slightly more non-recourse loans than recourse loans.

Figure 6: Loan sales



Notes: The height of the bars in the histograms indicate the percentage of loans kept on the issuer’s balance sheet or sold to a range of public and private purchasers split by recourse and non-recourse States. Source: Home Mortgage Disclosure Act Database, 2004-2016.

We would like to examine how recourse affects the willingness of banks to grant a loan conditional on application characteristics. Following Dell’Ariccia et al. (2012), we use the loan-to-income ratio at origination as a proxy for the ex-ante risk of a loan.³ A higher loan-to-income is associated with a higher risk of default since the loan obligation weighs heavier on the borrower’s ability to pay. We use a Logit model of the following form:

$$L_O = \beta_1 + \beta_2 D_{NR} + \beta_3 LtI_i + \beta_4 D_{NR} LtI_i + \epsilon_i \quad (14)$$

where L_O are the log odds of a loan being originated; D_{NR} is a dummy variable that

³The only further borrower characteristics included in HMDA are self-reported ethnicity, race and gender. Results are robust to including this set of controls.

takes value 1 if the property is located in a non-recourse State and 0 otherwise, LtI_i is the loan-to-income ratio of application i . β_4 is then the regression coefficient for the interaction term between the non-recourse dummy and the loan-to-income ratio.

We also run a Logit model of the same form to assess the difference in the probability of selling a loan to a third party:

$$L_S = \beta_1 + \beta_2 D_{NR} + \beta_3 LtI_i + \beta_4 D_{NR} LtI_i + \epsilon_{i,t} \quad (15)$$

where L_S are the log odds of a loan being sold.

Table 5 shows the results of these regressions. The interpretation of interaction terms in Logit regression needs careful consideration. First, it is worth noting that the regression results are expressed in terms of log odds. While Logit models are linear in log odds, they are not linear in other metrics such as probabilities. We want to be able to interpret the results of these regressions in terms of the difference in the probability of originating a loan between recourse and non-recourse, conditional on the ex-ante risk of the loan as proxied by the loan-to-income ratio. This probability difference will therefore depend on the different values of the model variables. Furthermore, the interaction term is composed by a categorical variable and a continuous variable, so in order to interpret the results, it will be necessary to evaluate the coefficient at different levels of loan-to-income.⁴

⁴While we follow Dell’Ariccia et al. (2012) in the use of loan-to-income as a key variable to measure the riskiness of a mortgage, results are comparable if we use income instead.

Table 5: Loan Origination and Sale

VARIABLES	(1) Origination	(2) Origination	(3) Loan Sale	(4) Loan Sale
D_{NR}	-0.158*** (0.004)	-0.106*** (0.008)	-0.261*** (0.005)	0.111*** (0.011)
LtI	-0.051*** (0.002)	-0.042*** (0.002)	0.310*** (0.002)	0.394*** (0.003)
$D_{NR}LtI$		-0.022*** (0.003)		-0.179*** (0.005)
Constant	0.677*** (0.004)	0.653*** (0.005)	0.584*** (0.006)	0.408*** (0.008)
Observations	1,286,996	1,286,996	796,090	796,090

Heteroskedasticity robust standard errors in parentheses

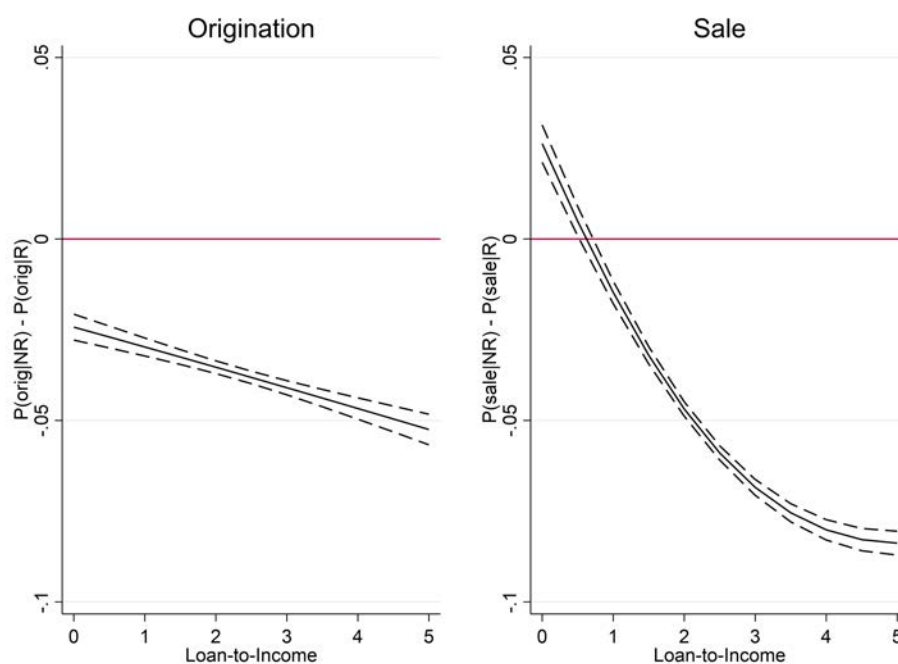
*** p<0.01, ** p<0.05, * p<0.1

Notes: This table shows Logit regression results for loan origination and loan sale. The coefficients are expressed in log odds. The dependent variable in Columns 1-2 are the log odds of a loan being originated, and in Columns 3-4 the log odds of an originated loan being sold. Dependent variables include a dummy variable (D_{NR}) that denotes non-recourse States, the Loan-to-income ratio (LtI) as a proxy for loan riskiness, and the interaction between the two. Source: Home Mortgage Disclosure Act Database and authors own calculations, 2004-2016.

We therefore use the margins of responses to retrieve the estimated probabilities of origination and sale for recourse and non-recourse. We then plot the differences in estimated probabilities for different values of loan-to-income, together with their 95% confidence intervals. Figure 7 presents the results.

As can be seen, banks are less likely to originate loans in non-recourse States, and this probability is decreasing in the loan-to-income ratio. This is an intuitive result since non-recourse loans can be considered ‘riskier’ because of limited liability. For a given level of LtI risk, banks would rather lend in a State where they can seize the borrower’s assets in the event of default. At the same time, banks are less likely to sell non-recourse loans to third parties, and this probability is also decreasing in loan-to-income.

Figure 7: Differences in probability of Origination and Sale



Notes: The solid line plots the difference in the probability of origination and sale between recourse and non-recourse States for different levels of loan-to-income ratios (a proxy of the riskiness of the loan). The dashed lines trace the 95% confidence intervals. Source: Home Mortgage Disclosure Act Database and authors own calculations, 2004-2016.

4.2.2 Interest rate on sold loans

One of the striking results from Table 3 is that for loans bought by Fannie Mae, the interest rate at origination does not differ between recourse and non-recourse loans. Given that non-recourse loans are expected to have a lower recovery rate in the event of default, one could expect the interest rate for these loans to be higher. We ask whether the fact that the interest rate at origination does not differ across jurisdictions for loans that were sold to Fannie Mae is due to the fact that banks anticipated they would sell this loans to a third party and therefore did not have an incentive to price in their risk. To this end, we use the HMDA loan application database to test whether loans that were not sold to a third party were priced differently, conditional on observables.

While the loan application data does not include the interest rate of each loan, banks report the spread between the rate charged for a given loan and the average interest rate that a loan with similar characteristics would have in the market. Banks must report the spread (difference) between the annual percentage rate (APR) and the applicable average prime offer rate if the spread is equal to or greater than 1.5 percentage points for first-lien loans. Due to this, there is a selection issue on the spread variable: we do not observe the spread if it is lower than the reporting threshold. In order to overcome this issue, some papers in the literature, for instance Pennington-Cross and Ho (2008), have applied the Heckman two-stage procedure for selection correction to this dataset. Hence, we run the following Probit regression:

$$Y_i = \delta X_i + u_i \quad (16)$$

where Y_i takes value 1 if the spread of loan application i is observed (i.e. if the spread is greater than 1.5 percentage points), and X_i is a set of variables that influence the probability of the spread being above the reporting threshold. We use all available borrower information in X_i , which includes income and dummy variables for self-reported race and gender.

We then use $\hat{\delta}$ to compute the inverse Mills ratio, $\lambda(X\hat{\delta}) = \frac{\phi(X\hat{\delta})}{\Phi(X\hat{\delta})}$, and it to different second stage regressions in order to answer different questions. First, we examine the difference in the spread between recourse and non-recourse States using the following regression:

$$spread_i = \beta_0 + \beta_1 D_{NR} + \gamma \lambda(X\hat{\delta}) + \epsilon_i \quad (17)$$

where D_{NR} takes value 1 for non-recourse loans and 0 otherwise. Then, we ask whether the spread is higher for loans that are sold to third parties, and whether this differs across jurisdictions. The regression reads:

$$spread_i = \beta_0 + \beta_1 D_{NR} + \beta_2 D_{Sold} + \beta_3 D_{NR} D_{Sold} + \gamma \lambda (X \hat{\delta}) + \epsilon_i \quad (18)$$

where D_{Sold} takes value 1 for loans that were sold to third parties and 0 otherwise and $D_{NR} D_{Sold}$ is an interaction term of both dummy variables.

Hurst et al. (2016) show that public agencies such as Fannie Mae and Freddie Mac are less efficient at pricing mortgage loan risk than the private market. They argue that this price difference leads to cross subsidisation from low risk mortgages to high risk mortgages. We explore whether this issue extends to the difference in risk between recourse and non-recourse loans in the following way:

$$spread_i = \beta_0 + \beta_1 D_{NR} + \beta_2 D_{Private} + \beta_3 D_{NR} D_{Private} + \gamma \lambda (X \hat{\delta}) + \epsilon_i \quad (19)$$

where $D_{Private}$ takes value 1 for loans that were sold to private buyers (securitisation agencies, commercial banks, insurance companies, funds...) and 0 for loans that were sold to public buyers (Fannie Mae, Freddie Mac, Ginnie Mae and Farmer Mac).

The results of these regressions are laid out in Table 6. Regression 17 is shown in Column 1. The loan spread is significantly lower in non-recourse States which is a surprising result. We are interested, however, in whether there is a significant difference in loan pricing for loans that were sold to third parties, and among those, whether there is a difference between private and public buyers. Column 2 presents the results of Regression 18. The constant term implies that the average spread of a recourse loan that was kept by the bank is around 6.7%. The coefficient of D_{NR} captures the difference in the interest rate between non-recourse and recourse for unsold loans. The interest rate on unsold loans is 24bp lower for non-recourse loans. The coefficient for D_{Sold} equals the difference between sold and kept loans in recourse States. It implies that, among recourse loans, the spread is around 5bp lower for those that were sold. The coefficient for the interaction term $D_{NR} D_{Sold}$ is equivalent to a difference-in-differences estimator. It represents the

difference in the spread between recourse and non-recourse loans for loans that were sold. The fact that it is positive and statistically significant indicates that in the market for loan sales the spread is higher for non-recourse mortgages. This result is intuitive, since non-recourse implies a higher rate of default as predicted by the theoretical model, and shown empirically in the previous section. We note that there may be an endogeneity issue in interacting D_{NR} and D_{Sold} , as we have shown before that non-recourse loans are less likely to be sold to third parties than their recourse counterparts.

This phenomenon is further investigated in Column 3, where the pool of sold loans is split between private and public buyers, as outlined in regression 19. The coefficient for $D_{Private}$ indicates the difference between loans sold to private and public agents in recourse States. The estimate of this difference is almost 200bp, which is an order of magnitude higher than the D_{Sold} coefficient in Column 1. This implies that most of the variation in the spread of sold loans is driven by pricing behaviour of private investors.

The coefficient for the interaction term $D_{NR}D_{Private}$ is also positive and statistically significant. It means that for non-recourse loans, private purchasers demand a higher spread than public agencies. This suggests that private markets price in the higher risk associated with non-recourse loans (or limited liability) to a greater extent than their public counterparts. We conclude from this analysis that banks do charge significantly higher interest rates on non-recourse loans when selling the loan to a private third party, while loans bought by Fannie Mae seem to have the same interest rate at origination, as was shown in Table 2. These results are in contrast with Hurst et al. (2016), who find that interest rates do not vary across recourse and non-recourse States for both private and public loans.

Table 6: Heckman Regression Results

EQUATION	VARIABLES	(1) spread	(2) spread	(3) spread
Second Stage	D_{NR}	-0.085*** (0.008)	-0.242*** (0.013)	-0.006 (0.025)
	D_{Sold}		-0.052*** (0.011)	
	$D_{NR}D_{Sold}$		0.266*** (0.017)	
	$D_{Private}$			1.978*** (0.021)
	$D_{NR}D_{Private}$			0.222*** (0.032)
	Constant	6.722*** (0.047)	6.731*** (0.048)	4.913*** (0.123)
First Stage	Income	-0.002*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)
	Female	0.051*** (0.002)	0.051*** (0.002)	0.040*** (0.004)
	Native	-0.014 (0.015)	-0.014 (0.015)	-0.082*** (0.030)
	Asian	-0.149*** (0.008)	-0.149*** (0.008)	-0.046*** (0.014)
	Black	0.339*** (0.003)	0.339*** (0.003)	0.314*** (0.005)
	Hawaiian	0.051*** (0.017)	0.051*** (0.017)	0.049 (0.031)
	Constant	-1.363*** (0.002)	-1.363*** (0.002)	-2.112*** (0.004)
	Observations	3,072,488	3,072,488	2,897,723

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: This table shows the first and second stage of the two-step Heckman procedure for selection correction. The first stage is a Probit regression where the probability of being selected depends on borrower observables. We include as selection variables the borrower's income, gender, and race. The inverse Mills ratio is computed from the first stage and is used in the second stage regression as an independent variable together with other explanatory variables. D_{NR} is a dummy variable that takes value 1 for non-recourse States and 0 for recourse States, D_{Sold} is a dummy variable that takes value 1 for loans that were sold and 0 for loans that were kept by the bank, $D_{Private}$ is a dummy variable for loans that were sold to a private entity and 0 for loans that were sold to a public enterprise (GSE). Standard errors are corrected to account for the two-step procedure. Source: Home Mortgage Disclosure Act Database and authors own calculations, 2004-2016.

5 Conclusion

The rise of household indebtedness before the Financial Crisis combined with high default rates was a root cause of the Great Recession and underlined the role of consumer finance for the macroeconomy. Mortgage debt in particular, constitutes two-thirds of US household total debt, and it currently follows an increasing trend.

While there are several factors that determine the rate of mortgage default, such as adverse economic shocks that leave households unable to honour their debt, default may also be a voluntary choice, commonly referred to as strategic default. One particular aspect the household may consider before choosing to default is whether there is limited liability in place. Under limited liability, the lender is not allowed to seize the household's assets after default. On the contrary, under lender recourse, the lender is allowed to claw back the borrower's assets after default.

While the literature has analysed the consequences of limited liability, such as default rates, loan renegotiation or forbearance, and interest rates in isolation, we embody all these features in our analysis as equilibrium outcomes of the strategic interaction between borrowers and lenders.

We use a model of default and renegotiation to highlight the mechanisms at hand, and we test them empirically by exploiting the difference in legislation across US States. We do this by comparing loans for houses situated in Metropolitan Statistical Areas that are crossed by a State border, where one State enforces lender recourse and the other does not. Given that MSAs are defined by the US Census Bureau as *a core area containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration with that core*, we argue that borrowers on either side of the border are exposed to the same economic shocks, and the difference in their

behaviour towards their mortgage loans can be thought to stem exclusively from the presence or absence or limited liability.

In the model, both house prices and the income of the borrower are stochastic. In some states of the world, the household has enough income to pay their mortgage, whereas in other states of the world it does not. Likewise, in some states of the world, the house value is higher than the mortgage amount, i.e. the household has positive equity, whereas in other states of the world the house value is lower, i.e. the mortgage is underwater. Households who can afford to meet their payments, but whose mortgage is underwater, may find it optimal to default, in particular on instances where it is unlikely that they will be liable with their personal assets after default. Lenders who know this may find it optimal to offer these households a renegotiated mortgage price in order to prevent them from walking away from their obligations. At the same time, the price of these loans will reflect these mechanisms. Loan rates are expected to be higher under limited liability, because of the higher ex-ante predictable default and renegotiation risk, and the lower recovery rate for the lender after default.

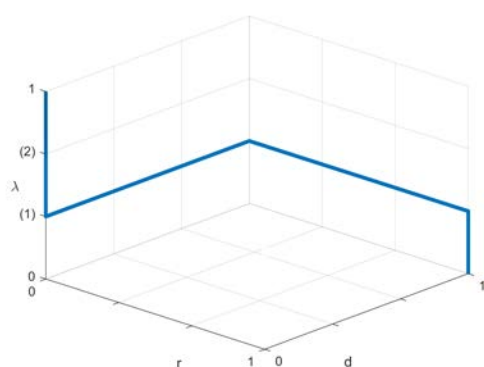
These predictions are confirmed by the data. In fact, non-recourse loans are around 42% more likely to default, and 28% more likely to receive a renegotiation offer. However, while the model predicts that loan rates should be higher for non-recourse loans (as they have a higher expected default rate), loan performance data from Fannie Mae does not confirm this. This lack of price differentiation has been noted in the literature, for instance by Hurst et al. (2016). They note that Government-Sponsored Enterprises (GSEs) fail to appropriately price in regional differences in ex-ante predictable default risk. In this paper, regional risk is expected to be the same within each MSA, as they are by definition integrated economic areas. However, we still find a lack of price differentiation on the side of GSEs, which fail to account for the risk of default and renegotiation brought about by the difference in legislation. We test this by using additional data from the Home

Mortgage Disclosure Act (HMDA) in order to compare the interest rates on loans that were sold to private investors vs GSEs, for recourse and non-recourse States. We find that the difference in default risk implied by different recourse laws is indeed priced into loans that are securitised by private investors. Overall, rates on non-recourse loans sold to private investors are around 22bp higher than their recourse counterparts.

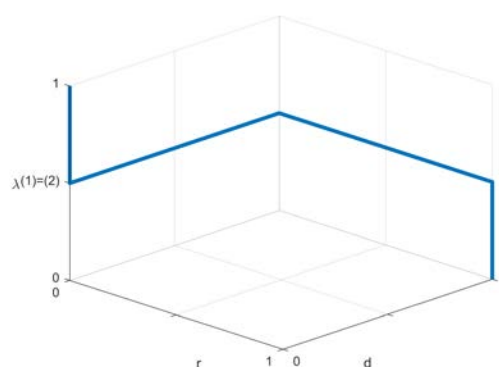
These results overall speak to the distortions imposed by the differences in limited liability across States, together with the heterogeneity of public and private market participants. Given the size of the market and the importance of mortgages in households' balance sheets, our findings have important macroeconomic implications. Further theoretical research should fill the gap in how these mechanisms interact in general equilibrium.

Appendix A: Equilibria under different relative values of thresholds (1) and (2)

Figure 8a shows the same graphic representation for the case when $(1) < (2)$. In this case, for values of λ weakly greater or smaller than the threshold, the above logic still holds. However, for values between (1) and (2) , the household would find it optimal not to default, so the lender would not renegotiate. For $\lambda = (1)$, the borrower would mix between defaulting and repaying. If it defaults, then the lender would mix between renegotiating or not. The same logic holds when $\lambda = (1) = (2)$, which is represented in figure 8b.



(a) $(1) < (2)$



(b) $(1) = (2)$

Figure 8: Equilibria for different relative values of (1) and (2)

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