Government Loan Guarantees, Market Liquidity, and Lending Standards*

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Abstract

We study third-party loan guarantees in a model in which lenders can screen and sell loans before maturity when in need of liquidity. Loan guarantees improve market liquidity, reduce lending standards, and can have a positive overall welfare effect. Guarantees improve the average quality of *non-guaranteed* loans traded and thus the market liquidity of these loans due to selection. This positive pecuniary externality provides a rationale for guarantee subsidies. Our results contribute to a debate about reforming government-sponsored mortgage guarantees by Fannie Mae and Freddie Mac, suggesting that the excessively high subsidies to these guarantees should be reduced but not completely eliminated.

Keywords: Mortgage guarantees, adverse selection, market liquidity, pecuniary externality, Pigouvian subsidy, Government Sponsored Enterprises.

JEL classifications: G01, G21, G28.

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1 Introduction

Default risk in credit markets is often assumed upon origination by third parties for a fee. Governments are often involved in those contracts by subsidising default guarantees for various types of loans. The most important example are government mortgage guarantees. In 2018, the U.S. government guaranteed 62% of outstanding residential mortgages (equal to 32% of GDP) via institutions such as Fannie Mae and Freddie Mac, which are known as Government Sponsored Enterprises (GSEs).

Mortgage guarantees were traditionally viewed as a way to promote homeownership, but the financial crisis of 2007-09 sparked their criticism and led to calls for reform of GSEs by academics and policymakers.[1] We contribute to this debate by identifying a new economic benefit of third-party loan repayment guarantees—henceforth loan guarantees for short. We show how loan guarantees create a positive externality on the liquidity in secondary markets for *non-guaranteed* loans, resulting in insufficient guarantees. This externality provides an economic rationale for government loan guarantee subsidies. Our results suggest that guarantee subsidies should be reduced from the current excessive level, whereby virtually all new eligible mortgages are sold to the GSEs, but these subsidies should not be completely eliminated.

To illustrate the mechanism, we introduce loan guarantees into a parsimonious model of lending with a two-way feedback between productive and allocative efficiency, as described in Section 2. We start with a benchmark model without loan guarantees. All agents are risk-neutral to highlight the effects of guarantees beyond a well-known risk-sharing motive. At origination each lender has access to a pool of borrowers and can screen at a heterogeneous cost. Screening improves the probability of repayment by possibly identifying a borrower with a low default probability, raising lending standards. Lenders who are subject to a liquidity shock want to sell their loans in the secondary market to outside financiers before maturity. But this market is subject to a standard adverse selection problem since the realized idiosyncratic

[1] Congressional Budget Office (2014) states proposals for GSE reform considered by policymakers. See also Section 4.3 for an overview of the current state of GSE reform and the existing proposals through the lens of our model and results.

liquidity shock and the outcome of screening are not publicly observable, resulting in information asymmetry about loan quality.

In competitive equilibrium, only lenders with screening costs below a threshold (labelled low-cost lenders) choose to screen. The screening choice determines productive efficiency—the average quality of loans originated net of screening costs. Adverse selection in the secondary loan market reduces the social gains from trade (allocative efficiency) and results in multiple equilibria. For clarity of exposition, we focus in the main text on the liquid equilibrium, which exists when high-quality loans are sold upon a liquidity shock. This equilibrium features a two-way feedback between the screening threshold and the secondary market price: more lenders choosing to screen increases the price, but a higher price reduces the incentives to screen.

Our main innovation is to introduce loan guarantees upon origination and to study its effects on lending standards and market liquidity as well as its normative implications. Consistent with the practice of GSEs, we model loan guarantees as a loan sale at origination with a guarantee against loan default.[2] Loan guarantees pass default risk to financiers for a competitive fee right after origination.[3] Since guarantees are backed by the government, we abstract from default risk of the guarantor. Consistent with our application to government-backed mortgage guarantees, whether a loan is guaranteed is observable and the loan trades together with its guarantee in a market for guaranteed loans.[4] This implies a segmentation of secondary markets into guaranteed and non-guaranteed loans, consistent with the existence of separate markets for government-backed securities and private-label securities, such as agency mortgage-backed securities (agency MBS) and private-label MBS.

In equilibrium studied in Section 3, lenders with high-quality loans (who have successfully screened) never sell loans with guarantees. Intuitively, a guarantee pre-

[2] One potential interpretation of the choice to sell loans with a guarantee is that lenders select into different parts of the market where third-party guarantees are available or required. In the United States, eligibility for GSE guarantees requires a maximum size of the mortgage (the conforming limit). See also Appendix A.3 for details.

[3] Consistent with this timing, a popular business model is to specialize in origination of conforming loans, followed by the immediate sale to GSEs, which provide a non-default guarantee for further trading in secondary markets (Hurst et al., 2016; Buchak et al., 2018).

[4] This feature is a key difference to CDS contracts that lack the positive externality we identify.

vents the lender from reaping the benefits of costly unobserved screening. Without subsidies to loan guarantees, loans are not sold with guarantees. For a sufficiently large guarantee subsidy, some lenders with non-screened loans (who have not screened or screened but not successfully) sell loans with guarantees. The guarantee subsidy compensates lenders with non-screened loans for not benefiting from adverse selection in the secondary market for non-guaranteed loans. For very high subsidies, all non-screened loans are sold with guarantees and no lender chooses to screen.

Guarantee usage improves allocative efficiency in two dimensions. First, guarantees create a safe, information-insensitive and thus always liquid asset. Second, guarantees also improve the quality of *non-guaranteed* loans traded. This result—the main positive contribution of the paper—arises from self-selection of lenders with non-screened loans into guarantees. The resulting higher average quality of loans traded in the non-guaranteed market raises its price and allocative efficiency. Intuitively, asymmetric information implies a transfer of resources from lenders with real liquidity needs to lenders who trade on private information (lender without such needs who want to sell non-screened loans). Loan guarantee subsidies reduce this transfer. A higher price of non-guaranteed loans in turn reduces screening incentives and thus guarantee subsidies reduce productive efficiency. In Section 3.1 we review indirect evidence for the spillover of guarantees on the market for non-guaranteed loans and empirical results consistent with key features of our mechanism.

Turning to normative implications in Section 4, we consider a planner who chooses loan guarantees for all lenders. When choosing loan guarantees, the planner faces a trade-off between higher allocative and lower productive efficiency. The planner internalizes the positive externality of guarantees on the price of non-guaranteed loans and when the increases in the gains from trade outweigh the loss due to lower lending standards, the planner chooses to use (more) guarantees at both the intensive and the extensive margin. A regulator subject to a balanced budget constraint and with no information advantage over financiers can achieve the planner's allocation via a subsidy on loan guarantees. We interpret this loan guarantee subsidy as government backing and subsidized guarantees in credit markets. In the case of GSEs, this subsidy takes the form of implicit government guarantee of debt issued by GSEs. This benefit is then partially passed on to lower guarantee fees than what would be charged by a private guarantor (see, for instance, Passmore 2005).

Our results contribute to a debate about the design of government-backed mortgage guarantees after the Great Financial Crisis. They suggest that the current level of subsidies, whereby virtually all eligible mortgages are guaranteed by the GSEs, is excessively high. But our channel provides an economic rationale for a subsidy to mortgage guarantees in some circumstances, so these subsidies should not be eliminated altogether. In particular, subsidies on mortgage guarantees should occur for loans with low observable default risk (e.g. borrowers with sufficiently high credit scores—consistent with the practices of GSEs—or in regions with lower mortgage default risk, which is inconsistent with GSE practices as highlighted by recent critique e.g. Hurst et al. 2016), when screening costs are higher, and for loans with lower payoffs. When lower payoffs are interpreted as more competitive lending markets, then subsidies should occur in countries with a less concentrated lending market, e.g. more in the U.S. than in Canada, or more after recent increase of competition from specialized online lenders (e.g., by FinTechs). We discuss further implications of the model in Section 4.3.

How widely applicable is the mechanism examined in this paper? We have focused so far on our main application: mortgage guarantees. Governments are also involved in subsidies to guarantees of other loan types, such as student loans, small business loans, and export loans—for various economic or political reasons that are outside of our model. For the positive externality emphasized in this paper to arise, there needs to be a liquid secondary market for guaranteed and non-guaranteed loans. From the above other examples, only student loans would fit the bill, where a substantial share of outstanding student loans have been securitized. Compared to residential mortgages, student loans are more likely to default, are not collateralized, and represent a smaller share of the balance sheets of lenders. As a result, student loans are riskier and their liquidity is less crucial for lenders. Our results therefore suggest that there is less scope for welfare-improving government subsidies in this case.

Finally, we probe the robustness of our results in Section 5. First, our main results extend when we introduce collateral. Guarantee subsidies should be provided for loans with high enough collateral. While GSEs have a minimum collateral requirement, it is largely irresponsive to observable risk and thus too static. Second, we study the illiquid equilibrium and our mechanism naturally extends to the condition for the existence of the liquid equilibrium. An additional role for the planner emerges: it liquifies the secondary market via more loan guarantees, which strengthens the normative case for guarantee subsidies. Third, this normative case becomes even stronger in the presence of adverse selection in the loan guarantee market. A new equilibrium with an illiquid guarantee market exists and planner can improve welfare by eliminating it with appropriate guarantee subsidies. Fourth, we study cases where guarantors require a recourse to originating lenders or other credit enhancement that may reduce adverse selection in guarantees and describe under which conditions our results extend. Fifth, we allow for partial loan sales and our main results remain valid, including in the possible separating equilibrium in which loan retention signals loan quality. In Appendix A, we also consider competition between lenders, microfound the screening technology used in the main text, show that the pecuniary externality can extend to markets for loans not eligible for guarantees, and study an alternative timing of the payment of the guarantee fee. All proofs are in Appendix B.

Literature. Our paper is related to three strands of literature. First, it is closely related to a literature on the interaction between productive efficiency and allocative efficiency, where the market liquidity of a loan affects a lender's incentive to screen or monitor borrowers (e.g., Pennacchi 1988; Gorton and Pennacchi 1995; Parlour and Plantin 2008; Parlour and Winton 2013; Chemla and Hennessy 2014; Vanasco 2017; Daley et al. 2020). Our contribution is to examine the implications of loan guarantees for productive and allocative efficiency.

Second, our paper is related to a literature on the role of government in the residential mortgage market, GSEs, and the debate about GSE reform. On the supporting side of this debate, Frame and White (2005) suggest that government subsidy to GSEs could be motivated by positive externalities of homeownership (Green and White, 1997; DiPasquale and Glaeser, 1999),[5] willingness to redistribute income to lower income households, make fixed-rate mortgages with long-maturities more available (Fuster and Vickery, 2015), or maintaining the flow of new mortgage credit during periods of financial stress (Rappaport, 2020). Additionally, the subsidy can be motivated by positive information externalities of GSEs lending in areas with low property transaction volume on future (non-guaranteed) lending (Lang and Nakamura, 1990, 1993; Ling and Wachter, 1998; Harrison et al., 2002). On the critical side of this debate, recent work suggested that GSE subsidies reduce welfare because they may lead to more frequent financial crises (Elenev et al., 2016), are regressive (Jeske et al., 2013), and redistribute across regions (Hurst et al., 2016). We find a complementary and novel effect of loan guarantees via higher secondary market liquidity.

Third, our paper relates to a literature on guarantees in lending under asymmetric information. A part of this literature suggest that government loan guarantees can be welfare improving in the setup of Stiglitz and Weiss (1981) with underinvestment due to adverse selection (e.g. Mankiw 1986) and suggest that guarantees lower non-guaranteed loan issuance (e.g. Gale 1990, 1991).[6] These studies focus on lending in primary markets subject to credit rationing and redlining where government subsidies crowd in subsidised borrowers but crowd out borrowers that do not receive subsidies (a negative externality). Our focus is instead on how loan guarantees affect the liquidity in secondary markets and we highlight a positive externality of guarantees on the liquidity of non-guaranteed loans.

Related is also a more recent literature on government intervention in frozen markets (e.g. Tirole 2012, Chiu and Koeppl 2016, or Camargo et al. 2016). These papers consider government intervention usually in the form of direct purchases of bad assets when asymmetric information about legacy assets leads to frozen mar-

[5]Despite the focus on homeownership accentuated by an requirements for minimum GSE activity in disadvantaged areas, the evidence suggests that GSE activities had no or little impact on homeownership and on access to credit in disadvantaged areas (Bostic and Gabriel, 2006; Grundl and Kim, 2021; Painter and Redfearn, 2002). This is because eligibility for GSE guarantee is very broad-based (Frame and White, 2005) and minimum borrower requirements are in general enforced.

[6]Evidence on the guarantee externality to non-guaranteed lending is mixed (e.g., a negative effect on non-guaranteed lending in Ono et al. 2013 and positive effect in Wilcox and Yasuda 2019).

kets (and thus unrealized gains from trade). Our findings also have implications for preventing illiquid markets but we differ in three key aspects. First, our application is government mortgage guarantees and liquidity in secondary markets, while these papers are typically applied to primary lending markets. Second, the quality of assets is endogenous in our model, which captures an important costs of government guarantees. Third, the benefits in our analysis extend beyond the extensive margin of creating a liquid market, as we also consider the intensive margin of improving the liquidity in an already liquid market. Perhaps the closest paper from this strand of literature to ours is Philippon and Skreta (2012), who study interventions in the form of direct lending or debt-guarantee program and show that such intervention can liquify the private primary lending market. Since the quality of assets is exogenous in their model, the costs of government intervention is the same even when the government shuts down the private market. In contrast, providing guarantees for all loans is inefficient in our model due to its negative effects on productive efficiency.[7]

Some other literature focuses on ways how to reduce the information asymmetry that undermines market liquidity in the form of guarantee provision by the informed party: in the primary market (via collateral by borrower, e.g. Bester 1985, Besanko and Thakor 1987) or in the secondary market (via credit enhancement by loan sellers, e.g. Pennacchi 1988, DeMarzo 2005). These guarantees represent risk retention by the informed party, can signal high quality, and lead to a separating equilibrium or make loans information insensitive and thus liquid.[8] The guarantee externality mostly takes the form of credit rationing, higher costs for borrowers without guarantees or lower liquidity of loans without guarantees. In contrast, we study loan guarantees by an uninformed third party. A key force in our model is that the selection into third-party guarantees reveals that a lender has lower portfolio quality. Specifically, agents want to signal that they have successfully screened because this improves the liquidity of their assets and they can do so by refraining from selling loans with guarantees.[9]

[7]While Philippon and Skreta (2012) derive the minimium-cost intervention to implement a given level of investment, we also derive optimal level of guarantees and relate it to our main application of U.S. mortgage guarantees.

[8]The notion of information insensitivity goes back to Gorton and Pennacchi (1990). A recent paper includes Dang et al. (2017), where keeping loan information secret supports market liquidity.

[9]This feature is not always true even in models where screening improves lending standards, as

2 Model

There are three dates $t = 0, 1, 2$ and one good for consumption and investment. Two groups of risk-neutral agents, financiers and lenders, are protected by limited liability. Outside financiers are competitive, deep-pocketed, require a gross return normalized to one, but cannot originate loans. Each lender has one unit of funds at $t = 0$ to originate a loan (a mortgage) and has access to an individual pool of borrowers.

Without screening, $s_i = 0$, lender $i \in [0, 1]$ finds an average borrower at $t = 0$ and receives A (repayment) with probability $\mu \in (0, 1)$ or 0 (default) at $t = 2$. The loan payoff $A_i \in \{0, A\}$ is independently and identically distributed across lenders and publicly observable at $t = 2$. A higher payoff A reflects more profitable lending opportunities, a less competitive lending market, or a lower bargaining power of borrowers. This approach to lending market competition is in reduced-form throughout the main text but we revisit this issue in Section A.1. The repayment probability μ reflects any publicly available information about the quality of non-screened loans, such as a borrower credit score or regional labor and housing market characteristics.

Screening, $s_i = 1$, implies that lender i, with probability ψ, finds a borrower that never defaults. Otherwise, lender i faces an average borrower, with success probability μ. We provide a micro-foundation of these lender payoffs from screening in Appendix A.2. As a result, screening improves the repayment probability from μ to $\psi + (1 - \psi)\mu > \mu$, as shown in Figure 1.[10] A heterogeneous non-pecuniary cost of screening η_i reflects differences in lender types (e.g., traditional versus online lenders) or in screening ability (e.g., because of pre-existing relationships with a borrower).

in e.g. Vanasco (2017). Her analysis focuses on separating equilibria where lenders who successfully screen retain larger share of their loans on balance sheets to separate which undermines loan liquidity. In contrast, our analysis focuses on the pooling equilibrium where screening increases loan liquidity.

[10]A similar screening technology is studied in Vanasco (2017) and could reflect lenders' comparative advantage in loan origination. Evidence consistent with this assumption includes Berger and Udell (2004), who show a positive association between screening and loan quality in a sample of US banks, and Pierri and Timmer (2020) who find that US banks that had invested more in screening, measured by IT adoption, originated mortgages that performed better in a crisis. Moreover, Loutskina and Strahan (2011) find that geographically concentrated mortgage lenders invest more in information collection (screening technology), which reduces loan losses and improves bank profits.

Its density $f > 0$ has support $[0, \overline{\eta}]$, and F is the cumulative distribution.[11]

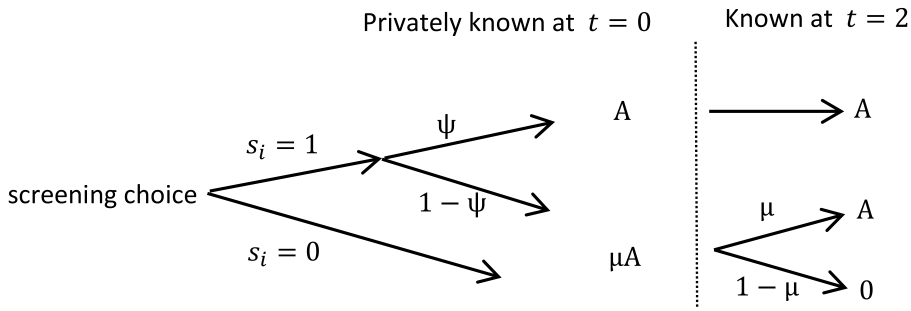

Figure 1: Screening improves the probability of repayment.

At $t = 1$, each lender privately learns the realization of an idiosyncratic liquidity shock λ_i, whereby the preference for interim consumption is $\lambda_i \in \{1, \lambda\}$ with $\lambda > 1$. Our reduced-form modelling of the gains from a loan sale before maturity captures consumption needs or superior non-contractible investment opportunities (see, e.g. Aghion et al., 2004; Holmstrom and Tirole, 2011; Vanasco, 2017). The liquidity shock λ_i is i.i.d. across lenders, independent of the loan payoff, and arises with probability $Pr\{\lambda_i = \lambda\} \equiv \nu \in (0, 1)$. Taken together, the utility of lender i can be written as

$$u_i = \lambda_i c_{i1} + c_{i2} - \eta_i s_i,$$

where c_{it} is her consumption at date t. The average interim utility of consumption is thus $\kappa \equiv \nu\lambda + 1 - \nu < \lambda$.

After the screening choice and origination at $t = 0$, each lender chooses whether to sell a fraction of the loan q_{iG} with the assistance of a guarantor—an outside financier who provides a guarantee against loan default, and stores the proceed of the loan sale until $t = 1$. This guarantee ensures the payoff A to the owner of the loan for a fee k.[12] Both the guarantee payoff and the fee are charged at $t = 2$.[13]

[11]If screening costs were homogeneous, all lenders would be indifferent about screening in equilibrium. All of our results qualitatively carry over to this alternative setup as long as lenders share a common pool of borrowers and the screening cost increases (or the probability of finding a good loan decreases) in the aggregate share of lenders who screen (known as the thinning effect of screening).

[12]We focus on full guarantees without loss of generality, because partial and full guarantees result in the same equilibrium outcome. In a modified setup in which private learning about guaranteed loans could result in adverse selection in secondary market for guaranteed loans, full guarantees are privately and socially optimal, as shown in the Working Paper version (see Ahnert and Kuncl 2019).

[13]This timing assumption parallels the non-pecuniary screening cost in the sense that it does not

The lender that sells a loan with guarantee receives a subsidy $b \geq 0$ at $t = 2$. This subsidy is funded by a lump-sum tax $T = b \int_i q_{iG} di$ on lenders at $t = 2$. Our approach therefore abstracts from any net transfers to lenders via the guarantee scheme in order to isolate our novel channel. To ensure that lenders can always pay the tax (and to avoid technical complications associated with limited liability), we introduce an additional non-pledgeable endowment n received when taxes are due. Thus, these resources can be used to pay taxes or for consumption at $t = 2$. In sum, the guarantee effectively swaps a loan's payoff A_i with $\pi = A - k$.[14]

At $t = 1$, a lender can sell the non-guaranteed loan $q_{iN} \in \{0, 1-q_{iG}\}$ in secondary market at a price p_N to financiers who are uninformed about the screening cost η_i and choice s_i, liquidity shock λ_i, and loan quality A_i.[15] Note that this specification limits attention to full sales of loans in the main text for expositional simplicity. However, we allow for partial loan sales and the potential related signalling of loan quality in Section 5.5 and show that our main results can extend to this more general setup.

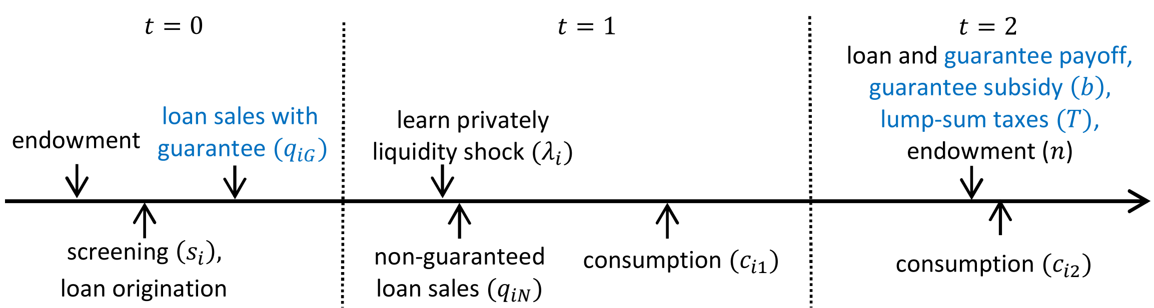

Figure 2: Timeline of events. The actions and payoffs in blue refer to loan guarantees.

affect the lending volume at $t = 0$. In Appendix A.4, we show that our results are qualitatively unchanged in an alternative setup in which a guarantee fee must be paid up front.

[14]Note that the owner of a guaranteed loan gets π and the originating lenders gets the subsidy b at $t = 2$. This split of payoffs and the timing of b and T at $t = 2$ is designed to eliminate any potential welfare gains from direct redistribution among agents with different marginal utilities. Instead, all effects of the subsidy are designed to stem from its impact on the choice to sell loans with guarantees.

[15]It is essential for our results that non-guaranteed loans are sold after lenders learn about the liquidity shock at $t = 1$. This timing ensures that, in equilibrium, some non-guaranteed loan held by lenders who have successfully screened are sold. Only then the adverse selection in this market takes place and thus guarantee subsidy can reduce it. In contrast, the timing of guaranteed loan sales is inessential for our results; it can take place at $t = 0$ or at $t = 1$ without affecting key results (see the alternative version of the model in Ahnert and Kuncl 2019).

2.1 Mapping to U.S. residential mortgage market

The modeling of the guarantee reflects our main application. Loans that are guaranteed are usually sold right after origination when the default risk is passed to a guarantor for a fee. This is consistent with the popular business model specializing in origination of conforming mortgages followed by an immediate sale to GSEs, which provide a non-default guarantee for further trading in secondary markets. Consistently with our application, financiers observe whether a loan is guaranteed and a guaranteed loan is sold together with its guarantee, which is a key difference to contracts like CDS. Thus, segmented markets for guaranteed (G) and non-guaranteed (N) loans exist with respective prices p_G and p_N, which is consistent with separate markets for agency MBS and private-label MBS.

For simplicity we abstract from some of the features of the U.S. mortgage market. We do not explicitly model collateral, but show that our results extend when we introduce collateral in Extension 5.1. Our guarantee specification also abstracts from any potential recourse the guarantor may have on the lender. This is for two reasons. First, the legal requirements for recourse are high. For mortgage guarantees, the GSEs would need to prove that the originator violated the guidelines of their programs.[16] Second, while recourse lowers the upper bound on guarantee subsidies above which all lenders sell loans with guarantees in equilibrium, in the interesting case in which only a subset of lenders sell loans with guarantees, recourse does not affect our results. There is no adverse selection in the market for guarantees and, thus, recourse does not affect the market segmentation and the selection into guarantees.[17]

[16] After the Great Financial Crisis, some banks were sued for allegedly defrauding GSEs by originating loans without the required checks and selling them to GSEs. To illustrate the difficulties in exercising the recourse on original lenders, we briefly discuss a high-profile case of Countrywide and Bank of America. In 2012 they were sued for allegedly carrying out a scheme nicknamed "the Hustle" in 2007-08 that consisted in systematically eliminating quality controls, violating GSE guidelines, and misrepresenting the loan quality to GSEs (The U.S. Attorney's Office, 2012). Countrywide and Bank of America were found guilty in 2013, but in 2016 an appeal court reversed the ruling by arguing the the scheme may have represented only "intentional breach of contract" and not a fraud (The New York Times, 2016). For an overview of some other litigations, see Ruddy et al. (2017).

[17] See Section 5.4 for details, including how recourse matters in the presence of adverse selection in the loan guarantee market.

2.2 A benchmark without guarantees

Suppose loan guarantees are unavailable. We focus on key economic forces and relegate details and proofs to Appendix B.1. Asymmetric information between lenders and financiers at $t = 1$ implies a standard adverse selection problem and multiplicity of equilibria. Non-screened loans (loans originated by lenders who have not screened or screened but not successfully) are always sold and a defining feature of equilibrium is whether lenders sell high-quality loans (which are always repayed) upon a liquidity shock, $\lambda p_N \geq A$. If so, high-quality loans are liquid (so we call this the *liquid equilibrium*). To illustrate our main mechanism, we focus on the liquid equilibrium throughout the main text. That is, we focus on parameters, $\lambda > \underline{\lambda}_L$, for which the liquid equilibrium exists. For an analysis of the illiquid equilibrium, see Section 5.2.

Lenders use a threshold strategy for their screening choice: each lender with a screening cost below threshold η screens. This threshold affects *productive efficiency*—defined as the average quality of loans originated net of screening costs. We refer to lenders with screening costs below (above) the threshold as low-cost (high-cost) lenders. A marginal lender, $\eta_i = \eta$, is indifferent about screening, which yields the threshold:[18]

$$\eta = \psi(1 - \nu)(A - p_N). \tag{1}$$

The right-hand side of Equation 1 captures the benefits of screening. These arise when screening is successful (with probability ψ) and thus results in a high-quality loan that is kept until maturity (in the absence of liquidity shock with probability $1 - \nu$). The net payoff increase from keeping a high-quality loan until maturity rather than selling a non-screened loan is $A - p_N$. As is standard, a higher secondary-market price lowers screening, $\frac{d\eta}{dp_N} < 0$, due to the option to sell non-screened loans at p_N.

The equilibrium is pooling and thus the competitive price of loans in the secondary market reflects the average quality of traded loans. It is the value of high-quality and non-screened loans sold divided by total loans sold. High-quality loans

[18] The expected payoff of screening is $\nu\lambda p_N + (1 - \nu)[\psi A + (1 - \psi)p_N] - \eta$ and the payoff of not screening is κp_N, because lenders with non-screened loans always sell, $p_N > \mu A$. Equating these payoffs yields the threshold cost stated.

(a share ψF) are sold only when their holders are hit by a liquidity shock, while non-screened loans (a share $1-\psi F$)[19] are always sold:

$$p_N = \frac{\nu\psi F + \mu(1-\psi F)}{\nu\psi F + (1-\psi F)} A, \tag{2}$$

where $F(\eta)$ is the equilibrium share of low-cost lenders (and we usually drop the dependence on η for brevity). Equation 2 clarifies that screening supports the price, $\frac{dp_N}{d\eta} > 0$. More screening leads to fewer non-screened loans originated at $t = 0$ (and more high-quality loans), which improves the quality of loans traded at $t = 1$.

We define *allocative efficiency* as the social gains from trade, $\nu(\lambda - 1)p_N$, that arise from the redistribution of funds across financiers and lenders at $t = 1$. These gains are proportional to the difference in interim utilities between lenders with and without liquidity shock, $\lambda - 1$, and the market value p_N of loans sold by liquidity-shocked lenders of quantity ν. Thus, allocative efficiency increases in the price p_N.

The price is affected by the pooling of loans of different qualities. Thus, liquidity-shocked lenders sell loans below the fundamental value and lenders without liquidity shock sell loans for a price above the fundamental value. Pooling effectively redistributes resources from liquidity-shocked lenders with high interim utility λ to lenders without a shock with lower utility, reducing the gains form trade.

In sum, the equilibrium without guarantees (η^*, p_N^*) is given by Equations (1) and (2). There is a two-way feedback between the screening threshold and the secondary market price. We next describe how loan guarantees affect outcomes.

3 Equilibrium

We turn to the equilibrium when loan guarantees are available. The formal definition of equilibrium is in Appendix B.2. Our first result describes under which conditions guarantees upon loan origination are used and by which type of lenders. Let the share

[19]Non-screened loans are originated by high-cost lenders, which have mass $1 - F$, and low-cost lenders who did not screen successfully, with mass $(1 - \psi)F$.

of lenders with non-screened loans who sell loans with guarantees be m.

Proposition 1. ***Equilibrium.*** *Lenders with high-quality loans do not sell loans with guarantees $q^*_{iG} = 0$. Thus, the guarantee fee is $k^* = (1-\mu)A$, resulting in a safe payoff and a secondary market price of guaranteed loans of $\pi^* = \mu A = p^*_G$. There exists a unique bounds $\underline{b}$ and $\bar{b} \equiv \kappa(1-\mu)A$ with $\bar{b} > \underline{b} > 0$ such that:*

1. *For $b \leq \underline{b}$, no loans are sold with a guarantee, $m^* = 0$.*
2. *For $\bar{b} > b > \underline{b}$, some lenders with non-screened loans sell loans with a guarantee, $0 < m^* < 1$.*
3. *For $b \geq \bar{b}$, all lenders sell loans with a guarantee, $m^* = 1$, and choose not to screen, $\eta^* = 0$.*

Proof. See Appendix B.2 (which also defines the equilibrium and the bound $\underline{b}$). ■

Guarantees convert the risky loan payoff A_i into a safe payoff π independent of the private information about loan quality. Thus, when lenders privately learn they have issued a high-quality loan upon screening successfully, they choose not to sell loans with guarantees. If screening lenders were to sell loans with guarantees irrespective of the quality of loans issued, then their payoff would be $\kappa p_G - \eta_i$, which is lower than the payoff of selling loans with guarantees without screening, κp_G. This contradicts the condition that lenders choose to screen and then sell loans with guarantees irrespective of loan quality issued.

Since financiers update their beliefs about loan quality based on observed q_{iG}, the competitive guarantee fee is the expected cost of guaranteeing the repayment of non-screened loans, $(1-\mu)A$. For such a high fee, though, no lender with high-quality loan chooses to sell loans with a guarantee. Because of this self-selection, selling a loan with guarantee reveals that the lender has a non-screened loan.

When loan guarantees are not subsidised, $b = 0$, they do not take place in equilibrium. This is because risk neutral lenders have no private benefit from guarantees.

Instead they bear the private cost of loosing the option to sell non-screened loans at a premium due to pooling with liquidity-shocked sellers of high-quality loans in the secondary market for non-guaranteed loans. For $\bar{b} > b > \underline{b}$, loans are sold with guarantees, $m^* > 0$, by lenders with non-screened loans who are indifferent about them:[20]

$$p_N^* = p_G^* + \frac{b}{\kappa}. \tag{3}$$

Lenders with non-screened loans choose to sell loans with guarantees for their whole loan or for none, $q_{iG}^* \in \{0, 1\}$. Selling loans with guarantee for a fraction $0 < q_{iG} < 1$ is not optimal. It would signal that lender has not successfully screened, but then would prevent taking advantage of adverse selection in non-guaranteed market for the fraction $1 - q_{iG}$ of the loan.

If the subsidy is so high that even lenders with high-quality loans would sell loans with guarantees, $b > \bar{b}$, then no lender has incentive to perform costly screening. This implies that tax required by any meaningful subsidy are bounded, $T \leq \bar{b}$, and thus additional endowment $n = \bar{b}$ would suffice to cover any relevant subsidy. We henceforth assume that $n \geq \bar{b}$.

Our main positive result in the equilibrium with guarantee usage follows.

Proposition 2. ***Pecuniary externality.*** *Consider $b \in (\underline{b}, \bar{b})$. Loan guarantees increase the price of non-guaranteed loans p_N^* and lower screening η^*.*

Proof. See Appendix B.2 (which also states comparative statics of equilibrium). ■

A key mechanism of our paper is how loan guarantees affect the quality of *non-guaranteed* loans traded. Loan guarantees improve the average quality of non-guaranteed loans traded due to the selection of lenders with non-screened loans into loan guarantees. Guarantees remove these loans from the secondary market for non-guaranteed loans as they are now traded in the market for guaranteed loans. These

[20]With a guarantee, a lender with a non-screened loan expects a payoff $\kappa p_G^* + b$. Without guarantee, a lender with a non-screened loan always sells the non-guaranteed loan with an expected payoff κp_N^*. Equating both payoffs yields the indifference condition for loan guarantees stated.

effects of guarantees and the resulting improvement in the quality of non-guaranteed loans traded is reflected in a modified competitive market price (compared to Equation 2):

$$p_N = \frac{\nu\psi F + \mu(1-\psi F)\,(1-\boldsymbol{m})}{\nu\psi F + (1-\psi F)\,(1-\boldsymbol{m})}A. \tag{2'}$$

The selection into guarantees resulting in a higher price of non-guaranteed loans increases allocative efficiency: it reduces the inefficient redistribution from liquidity-shocked lenders to lenders without shock caused by adverse selection. We can illustrate this by expressing the gains from trade

$$\nu(\lambda-1)\left[p_N(1-(1-\psi F)m) + p_G(1-\psi F)m\right], \tag{4}$$

that increase in the market value of sold loans (depends on the prices in both secondary markets and the respective loan sale shares). We then use (2') to decompose the gains from trade:

$$(\lambda-1)\Big\{\underbrace{\nu\left[\psi F + \mu(1-\psi F)\right]A}_{\substack{\text{Fundamental value of loans}\\ \text{sold by shocked lenders}}} - \underbrace{(p_N - \mu A)(1-\nu)(1-\psi F)\,(1-\boldsymbol{m})}_{\substack{\text{Funds diverted by sellers of non-screened}\\ \text{loans without liquidity shock}}}\Big\},$$

where the benefit of guarantees for the gains from trade is highlighted.

To summarize, for $b \leq \underline{b}$, guarantees are not used, $m^* = 0$, and (p_N^*, η^*) are determined by (1) and (2), as in the benchmark. For $\bar{b} > b > \underline{b}$, some lenders sell loans with guarantees and the equilibrium allocation (η^*, p_N^*, m^*) is defined by Equations (1), (2'), and (3). Condition (3) pins down the price p_N^* at which lenders with non-screened loans are indifferent about guarantees, which is higher than in the benchmark without guarantees. The screening-indifference condition (1) determines the screening threshold η^*, which is lower than in the benchmark. Thus, guarantees lower screening. And the price of non-guaranteed loans (2') determines the share of lenders with non-screened loans who sell loans with guarantees m^*. Since both guarantees and screening increase the price p_N^*, they behave as substitutes in many comparative statics, reviewed in Appendix B.2. Finally, for high guarantee subsidies,

$b \geq \bar{b}$, all lenders sell loans with guarantees, $m^* = 1$, and choose not to screen $\eta^* = 0$.

3.1 Related facts from the U.S. residential mortgage market

We review empirical findings in the U.S. mortgage market consistent with our key positive result—subsidies have a positive externality on the non-guaranteed loans. In our model, this result stems from two endogenous features: a) lenders with lower screening ability are more likely to select into the origination of mortgages for sale to GSEs; and b) subsidies lead to substitution of origination from non-guaranteed loans to guaranteed loans, as opposed to higher origination of guaranteed loans with no impact on non-guaranteed origination. Together they imply that non-screening lenders switch origination from non-guaranteed to guaranteed loans, generating the externality. We review available evidence for the externality and for the two underlying features of the mechanism.

Our key result—a positive impact of loan guarantees on the market of non-guaranteed loans—is consistent with evidence. Naranjo and Toevs (2002) show that GSE activities have a positive spillover on non-conforming loans, i.e. loans that cannot qualify for GSE guarantees. In particular, GSE activities reduce the spread between non-conforming loan rates and Treasury rates. This result is consistent with higher liquidity of non-conforming loans if liquidity gains are passed on to borrowers (this is the case in an extension of the model in Appendix A.1, where we endogenize competition between lenders). Recall that one possible interpretation of the choice to sell loans with guarantees is a lender's self-selection in the parts of the market where government-backed guarantees are available. Then, the externality is on the non-conforming mortgage market—see also the extension in Appendix A.3. Mortgages with size above a conforming limit (jumbo loans) cannot qualify for a guarantee even if they satisfy quality requirements (e.g. a high credit score.)

Key ingredients of our mechanism are also supported by evidence. Our mechanism suggests that lenders with higher screening costs (or lower screening ability) are attracted by GSE subsidies. Several papers find that lenders with better screening technology rely less on GSE guarantees. Loutskina and Strahan (2011) find that more geographically concentrated lenders accept a higher proportion of ex-ante riskier mortgage applications measured by standard observable characteristics but record lower ex-post loan loses. This implies that these lenders have a better screening technology. Concentrated lenders focus on the information-sensitive jumbo market (non-conforming loans without GSE guarantees). Moreover, Buchak et al. (2018) show that, within the set of shadow banks, Fintech lenders rely less on standard hard information when setting interest rates (see Table 9) suggesting information unavailable to other lenders is used. We interpret this as a better screening technology. Buchak et al. (2018) also show that after controlling for various observables including borrower characteristics, Fintech shadow banks are also less likely to sell loans to GSEs compared to other shadow banks (see Table 3, Panel B, Columns 7 and 8).

A second key ingredient of our mechanism is that GSE subsidies induce some substitution of origination from non-guaranteed loans to guaranteed loans. Consistent with this, Gabriel and Rosenthal (2010) show that GSE activity crowds out mortgage purchases in the private secondary market without guarantees.[21] Substitution effects are also consistent with findings that GSE activities had no or little impact on homeownership as "most beneficaries would have bought [a house] anyways" (Frame and White, 2005, p.172).[22]

The two ingredients above directly generate the main results in our model. The fact that subsidies induce lenders with high screening costs to switch from issuing non-guaranteed loans to issuing guaranteed loans imply the externality. Indeed, because high-cost lenders originate fewer non-guaranteed loans, the average quality of non-guaranteed loans traded increases, which makes its secondary market more liquid.

[21] More generally, our assumption that the volume of lending and origination is constrained is consistent with evidence of GSE activities that crowds out the issuance of commercial mortgages (Fieldhouse, 2019), mortgage refinancing crowding out purchase mortgages (Sharpe and Sherlund, 2016), and housing booms crowding out non-mortgage lending (Chakraborty et al., 2018).

[22] Indeed, despite the political goal of promoting homeownership in disadvantaged neighborhoods (an effect not considered in this paper) and the resulting binding minimum requirement for GSE activity in these neighborhoods, many studies found no effect of GSE activities on overall mortgage credit (Ambrose and Thibodeau, 2004) or homeownership in these neighborhoods (Bostic and Gabriel, 2006; Grundl and Kim, 2021; Painter and Redfearn, 2002).

4 Welfare and regulation

We turn to normative implications of loan guarantees. We first characterize a welfare benchmark in which a constrained planner internalizes the pecuniary externality of loan guarantees. We then show that an uninformed regulator subject to a balanced budget can achieve this benchmark via a Pigouvian subsidy on loan guarantees. Finally, we describe implications for government-sponsored mortgage guarantees and relate our findings to several recent proposals for the reform of GSEs.

4.1 A welfare benchmark

We consider a constrained planner P who maximizes utilitarian welfare W. To highlight the effects of loan guarantees, we let the planner directly choose loan sales with guarantees for all lenders, based on observing lender screening costs η_i and the outcome of screening.[23] To keep the focus on the loan guarantee externality, we preserve the friction of asymmetric information and adverse selection in the secondary market for non-guaranteed loans. Thus, the planner is subject to the privately optimal choices of sales of non-guaranteed loans and screening. In sum, the planner who internalizes the benefit of loan guarantees on market liquidity solves[24]

$$\begin{aligned} \max_m W \quad \equiv \quad & \max_m \overbrace{\nu(\lambda-1)\left[p_N\left(1-(1-\psi F(\eta))\, m\right)+p_G\left(1-\psi F(\eta)\right) m\right]}^{\text{Social gains from trade}} \\ & + \underbrace{\left[\psi F(\eta)+\mu(1-\psi F(\eta))\right] A}_{\text{Fundamental value}} + n - \underbrace{\int_0^{\eta} \tilde{\eta}\, dF(\tilde{\eta})}_{\text{Screening costs}} \qquad (5) \\ \text{s.t.} \qquad & (1), \quad (2'), \quad \text{and} \quad p_G=\mu A. \end{aligned}$$

[23]The size of the guarantee subsidy b is irrelevant for the welfare benchmark, because the guarantee choice is controlled by the planner and subsidy costs are fully covered by lump-sum taxes.

[24]Choosing the proportion of lenders with non-screened loans who sell loans with a guarantee, m, is equivalent to choosing loan sales with guarantee for each lender, $\{q_{iG}\}$. Financiers realize that the planner chooses $q_{iG}>0$ only for lenders with non-screened loans. Thus, the mass of lenders with non-screened loans and with $q_{iG}>0$ are separated from the pool with $q_{iG}=0$ and face a fair price $p_N(q_{iG}>0)=\mu A=p_G$ irrespective whether they sell with or without a guarantee. The effect is equivalent to choosing $q_{iG}=1$ for the same mass m of lenders with non-screened loans.

Welfare is the sum of expected payoffs of lenders (up to a constant for the expected payoff of financiers) and is derived in Appendix B.3. It comprises terms associated with productive efficiency and allocative efficiency. Productive efficiency refers to the average quality of loans originated (the fundamental value) net of total screening costs. Allocative efficiency refers to the social gains from trade. As for the market value of loans sold by liquidity-shocked lenders, guaranteed loans (a share $m(1-\psi F)$) are sold for their fundamental value but non-guaranteed loans are sold at a discount due to the adverse selection.

To describe the planner's allocation, let $\Lambda \equiv \frac{\lambda-1}{\kappa}$ be the increase in interim utility due to the liquidity shock, $\lambda - 1$, relative to the average interim utility, κ.

Proposition 3. ***Welfare.*** *There exists a unique bound Λ^P. For $\Lambda > \Lambda^P \equiv \frac{f\psi(1-\mu)A}{F(\nu\psi F+1-\psi F)}$, the planner sells some loan with guarantees, $m^P \in (0,1)$, to improve allocative efficiency, $p_N^P > p_N^*$, at the expense of productive efficiency, $\eta^P < \eta^*$.*

Proof. See Appendix B.3. ■

The planner's choice of loan guarantees balances the marginal social benefits of higher allocative efficiency with the marginal social costs of lower productive efficiency. Guarantees improve allocative efficiency by redistributing resources to liquidity-shocked lenders who experience an increase in interim marginal utility of consumption, $\lambda - 1$. The resources are redistributed from lenders with non-screened loans who are selected to sell loans with guarantees. As a result, they sell their loans at a lower price, as they no longer benefit from pooling with lenders with high-quality loans. The average interim marginal utility of these lenders is κ. Hence, the condition in Proposition 3 measures the gains in allocative efficiency with the ratio $\frac{\lambda-1}{\kappa} = \Lambda$.

The social costs of guarantees in terms of lower productive efficiency are proportional to the marginal effect on the share of screening lenders $f(\eta)$ and the marginal effect of screening on the fundamental value of loans $\psi(1-\mu)A$. Screening is successful with probability ψ and then it increases the expected loan payoff by $(1-\mu)A$.

For low levels of the liquidity shock, $\Lambda \leq \Lambda^P$, the negative effect of guarantees on productive efficiency is so severe that the planner does not guarantee any loans. For high levels of the shock, however, the planner chooses loan sales with guarantees to improve allocative efficiency. While productive efficiency is lowered as higher secondary market price of non-guaranteed loans reduces screening at origination, overall efficiency improves. This tradeoff between allocative and productive efficiency also implies that guarantees for all lenders (effectively ruling out any screening) is socially inefficient.

4.2 Regulation

Consider a regulator R subject to a balanced-budget and with the same information as financiers. A direct implementation of the planner's allocation by choosing guarantees for each lender is thus infeasible. Only lenders with non-screened loans should sell loans with guarantees but the regulator does not observe loan quality or screening.

We show that the regulator can achieve the welfare benchmark with a guarantee subsidy $b \geq 0$ paid at $t = 2$, as introduced in Section 2. The regulator has commitment, announces b at the beginning of $t = 0$, and lenders make their privately optimal choices of loan guarantee and screening at $t = 0$ and of loan sales at $t = 1$. We refer to this arrangement as the regulated economy. At $t = 0$, the regulator chooses the guarantee subsidy b to maximize welfare subject to a balanced budget, $T = b \int q_{iG} di$.

Our main result on regulation and loan guarantee subsidies follows.

Proposition 4. ***Loan guarantee subsidies.*** *For $\Lambda > \Lambda^P$, the regulator implements the welfare benchmark by subsidizing loan guarantees:*

$$b^R = \underbrace{\kappa \left(p_N^P - \mu A\right)}_{\textit{Private cost of guarantee}} < \bar{b}. \tag{6}$$

Proof. See Appendix B.4. ■

The optimal guarantee subsidy implements the social choice of guarantees. The size of the subsidy incentivizes lenders who do not sell loans with guarantees in the unregulated equilibrium due to the private costs of loan guarantees (the loss of the option to pool with sellers of high-quality loans in the secondary market for non-guaranteed loans). Since we already established that guarantee used by all lenders is socially inefficient, the optimal guarantee is below the level $\bar{b}$.

We briefly remark on redistributive effects. We have already mentioned that some lenders benefit from the guarantee subsidy program more than others. All lenders with liquidity shock have a net benefit—after taking into account the lump-sum tax—from the subsidy directly or indirectly through a higher price of non-guaranteed loans p_N. In contrast, lenders who do not sell in the market (lenders with high-quality loans and no liquidity shock) are clear net losers as they only pay the lump-sum tax. Non-screening lenders benefit more from the subsidy program than screening ones, which is reflected in the negative effect of subsidies on screening incentives. At the optimal guarantee level $b = b^R$, the marginal effect of subsidies on welfare is zero, $\frac{dW}{db} = 0$. Thus, marginally, the effect of guarantees is a zero-sum game and we can show that guarantee subsidies redistribute from low-cost to high-cost lenders, also from lenders with high-quality loans to lenders with non-screened loans, and finally redistribute from lenders without liquidity shock to lenders with liquidity shock. For details, see Appendix B.4.

The condition for the provision of guarantee subsidies, $\Lambda > \Lambda^P$, suggest liquidity benefits have to be large to compensate for lower productive efficiency. Proposition 5 below offers comparative statics for this threshold, for the size of the optimal guarantee, b^R, and the costs of the optimal guarantee program, $T^R \equiv b \int q_{iG} di \,|_{b=b^R}$.

Proposition 5. *Suppose that screening costs are uniformly distributed, $F \sim \mathcal{U}[0, \bar{\eta}]$.*

1. *The condition $\Lambda > \Lambda^P$ can be expressed as large and improbable liquidity shock, $\lambda > \lambda^P$ and $\nu < \nu^P$. The threshold λ^P decreases in repayment probability of non-screened loans μ and screening costs $\bar{\eta}$ and increases in loan profitability A and in screening efficiency ψ.*

2. *The optimal guarantee b^R increases in A and λ and decreases in μ.*

3. The cost of the guarantee program T^R increases in λ and $\bar{\eta}$ and decreases in ψ.

Proof. See Appendix B.4. ■

We provide intuition for these results. The benefits of government guarantee subsidies arises when the liquidity shock has a large effect on interim utility, $\lambda > \lambda^P$, but does not occur too often, $\nu < \nu^P$. Then, the ratio of the increase in interim utility by liquidity-shocked lenders to average utility of lenders with guarantees, Λ, is large enough to ensure that guarantee subsidies improve welfare, $\Lambda > \Lambda^P$.

The comparative statics of the threshold λ^P reflect the tradeoff between allocative and productive efficiency. While the parameters μ, ψ, and A affect both allocative and productive efficiency, these effects mostly cancel out and their dominating effect on threshold λ^P is through the social costs of guarantees in terms of less screening. Screening lenders with probability ψ issue a loan to a high-quality borrower (expected payoff A) as opposed to an average borrower (expected payoff μA), resulting in an improvement of the expected loan payoff by $(1-\mu)A$. Therefore, when screening benefits are high (low μ, high ψ and high A) and screening costs low (low $\bar{\eta}$), the social costs of providing guarantees in terms of lower screening have larger negative effect on welfare. In these cases, the minimum threshold for guarantee provision λ_P increases, so the planner intervenes for a smaller range of parameters. Note that higher A affects λ^P because it increases the difference in expected payoff between high-quality and non-screened loans and, thus, increases returns to screening.[25]

The optimal subsidy increases in the difference between the welfare-maximizing price p_N^P and the fundamental value of guaranteed loans μA (see Equation 6). Since both increase in A, the difference $(p_N^P - \mu A)$ also increases in A and decreases in μ. As a result, b^R increases in A and decreases in μ. The optimal subsidy also increases in κ (and thus in λ), because the subsidy is paid at $t = 2$ when lenders have

[25] An equal increase in payoffs for defaulting and repaying loans would increase prices of both guaranteed and non-guaranteed loans, p_G and p_N, but would change neither the difference in payoffs between screening and non-screening, nor the difference between selling and not selling loans with guarantees. Thus, there would be no effect on screening incentives η^*, guarantees m^*, the planner's choice of guarantees on the extensive margin, Λ^P and λ^P, and the intensive margin, m^P. Accordingly, the optimal subsidy b^R and the total cost of the guarantee program T^R would be also unchanged.

unitary marginal utility but has to compensate a loss in loan-sale revenue that can be consumed at $t = 1$ with average marginal utility κ.

While there is lump-sum taxation and the regulator runs a balanced budget, we can also characterize the total cost of the optimal guarantee subsidy T^R. The factors influencing this costs also reflect the planner's trade-off when choosing the optimal level of loan guarantee. The benefit of guarantees is higher allocative efficiency and thus T^R increases in the marginal utility under liquidity shock, λ. The social costs of guarantees is lower screening. Therefore, when screening is less efficient (lower probability of identifying high-quality borrowers ψ or the distribution of screening costs shifts towards higher costs—higher $\bar{\eta}$), then T^R is higher. The effect of non-default payoff A and repayment probability of non-screened loans μ on T^R is ambiguous, because they have have the opposite effect on the subsidy size b^R and the share of lenders receiving the subsidy $m^P(1-\psi F)$. Higher A and lower μ increase the optimal subsidy size b^R. But the share of lenders receiving the subsidy decreases in the share of screening lenders F, which itself increases in A and decreases in μ. Thus, higher A and lower μ decrease the share of lenders receiving the subsidy.[26]

4.3 Implications for mortgage guarantees and the role of GSEs in the U.S. mortgage market

We turn to our main application of mortgage guarantees. Loan guarantee subsidies in the model can be mapped to the guarantee fee of GSEs that does not fully reflect the total cost of the guarantee. The subsidy to the GSEs took the form of an implicit government guarantee for the debt of GSEs. This subsidy was then partially passed to lower guarantee fees. For example, Congressional Budget Office (2014) argues Fannie Mae's and Freddie Mac's fees were lower than what competitive firms would charge for the same guarantee. And Passmore (2005) estimates the size of the government implicit subsidy to GSEs and the partial passthrough to lower guarantee fees.

[26] If taxes were distortionary, an additional negative effect of guarantee subsidies would arise. This effect would increase in T and would reduce the optimal guarantee usage m^P.

At least since the GSEs have been put in conservatorship in 2008, their reform has been debated. Various ideas regarding the GSEs replacements have been suggested, ranging from replacement by one government-owned monopoly or competing mini-GSEs to complete wind-down of GSEs and privatization of its functions (Layton, 2022). Some of these ideas took shape in legislative proposals,[27] but due to political differences about the desirable role of government in the housing market, none of these proposals were enacted. Instead, the reform of GSEs has so far taken place through regulatory changes by the Federal Housing Finance Agency (FHFA) that mainly targeted the reduction of credit risk held by the GSEs.[28]

Despite these changes, the GSEs continue to facilitate securitization and provide guarantees for almost all eligible mortgages. In our model, this corresponds to the corner case of $m^* = 1$ and $b \geq \bar{b}$. However, Proposition 3 states that $m^P < 1$, suggesting that the current level of guarantee subsidies is too high. From the perspective of our mechanism, the role of GSEs in secondary markets for MBS should be reduced to allow for a bigger role to competing non-guaranteed private-label securitization of eligible mortgages. Our result suggests that the current reforms are insufficient and more wide-ranging reforms are needed.

Our results also suggest that guarantee subsidies should not be eliminated completely. Indeed, our mechanism motivates subsidies in several economic situations. First, guarantee subsidies should cover loans with a low observable default risk conditional on loans not being screened (high μ). Recall that the repayment probability of non-screened loans μ captures all publicly observable information that determines the repayment probability of a loan that a lender chooses to sell with guarantee in equilibrium. The guarantor understands that such loans are not screened in equilibrium. In contrast, this hard information is less relevant for loans that were screened and thus not sold with guarantees.[29]

[27]See e.g. the Path Act, the Delaney-Carney-Himes Act, the Corker-Warner and the Johnson–Crapo Act, or the HOME Act.

[28]These changes included a reduction in retained portfolios and the creation of a market for credit risk transfer (CRT) (Davidson, 2016). This market reduces the credit risk exposure of GSEs, while keeping MBS safe and creates a market for pricing of mortgage credit risk (Finkelstein et al., 2018).

[29]Hard information being less informative for screened loans is consistent with findings that loans of more concentrated lenders were more risky ex ante based on publicly observable information but

The publicly observable information μ can be specific to the borrower, loan or region. Accordingly, we interpret high values of μ as borrowers with high credit scores or loans in regions with low predictable default risk (regions with strong labor markets, regions with stability or sustainable growth in house prices, or loans with high collateral—see Section 5.1). Conditioning mortgage guarantees on high credit scores is consistent with the practices of GSEs in the US. However, as Hurst et al. (2016) show, government support for mortgage guarantees does not vary across regions despite large regional variation in predictable default risk (see also Ouazad and Kahn (2021) for documented insensitivity of GSEs to increases in regional flood risk).

Second, guarantee subsidies should arise when loans are less profitable, e.g. borrowers have a lot of bargaining power or the lending market is more competitive (low A). This result implies that the benefits of loan guarantees are higher in countries with lower profit margin of lenders (e.g., the United States as opposed to Canada). Third, less guarantees is desirable when screening costs are lower (a shift in F, i.e. lower $\bar{\eta}$). Recent technological advances and extensive data analysis of borrowers, such as big data or machine learning innovations (e.g., Fuster et al., 2019; Buchak et al., 2018), would reduce the benefits of guarantees.

Our model suggests that the recent competition from Fintech (e.g., specialized online lenders) have an ambiguous impact on subsidies to mortgage guarantees. On the one hand, Fintechs increase lending market competition that supports mortgage guarantee subsidies. On the other hand, technological advances introduced by Fintechs reduce the cost of screening that reduces the benefit of mortgage guarantees.

recorded lower losses ex post (Loutskina and Strahan, 2011). The rates of Fintech shadow banks are less explained by standard observables relative to other shadow banks (Buchak et al., 2018), suggesting that FinTechs used information unavailable to other lenders as they may have screened.

5 Extensions and Discussion

5.1 Collateral

So far we have abstracted from collateral. Suppose now that loan owners receive collateral C upon default at $t = 2$. To preserve the model's linearity in A, we define $C \equiv \gamma A$ for $\gamma \in (0, 1)$ without loss of generality. We have the following result.

Proposition 6. ***Collateral.*** *Higher collateral γ raises the secondary market prices of loans, lowers screening, and increases the share of loans guaranteed. For a uniform distribution of screening costs, $F \sim \mathcal{U}[0, \bar{\eta}]$, the planner guarantees more loans, $\frac{dm^P}{d\gamma} > 0$ for $\Lambda > \Lambda^P$, and subsidizes guarantees for a larger range of parameters, $\frac{d\Lambda^P}{d\gamma} < 0$.*

Proof. See Appendix B.5. ■

Collateral provides a lower bound on a loan's return, so prices for both non-guaranteed and guaranteed loans increase and are less sensitive to screening and guarantees. A higher price of non-guaranteed loans lowers screening incentives. Lower screening, in turn, indirectly increases the incentives to sell loan with guarantee. Lower screening in the presence of collateral reduces the social cost of guarantees. As a result, the planner (who internalizes the positive externality of guarantees) chooses to use more guarantees on both the intensive and the extensive margins.

The normative result in Proposition 6 has an interesting implication for mortgage guarantees. In particular, the result suggests that guarantee subsidies should be provided only for loans with sufficiently high collateral. On the parameter subspace $\Lambda > \frac{1}{1-\nu}$, we can rewrite the condition for the optimal provision of guarantee subsidies, $\Lambda > \Lambda^P$, simply as $\gamma > \gamma^P$. Moreover, this bound on collateral increases in observable risk (measured by lower values of μ), that is $\frac{d\gamma^P}{d\mu} < 0$. In practice, the GSEs have a collateral requirement: they provide guarantees only to mortgages with LTV below 80% (or a similar credit enhancement). However, this is a static requirement, which is largely insensitive to observable risk. Leaving aside other potential reasons for the LTV limit, such as limiting the government's credit exposure, our result would suggest that a static collateral requirement of GSEs is not desirable.

5.2 Illiquid equilibrium and liquifying the market

Here we turn to the illiquid equilibrium, in which lenders with liquidity shock do not sell high-quality loans. Thus, only non-screened loans are traded in the non-guaranteed market. The following proposition describes our results.

Proposition 7. ***Illiquid equilibrium and liquifying the market.***

1. *For $\lambda < \bar{\lambda}_{IL} \equiv {}^{1}/_{\mu}$, where $\bar{\lambda}_{IL} > \underline{\lambda}_L$, there exists an illiquid equilibrium with $p_N^* = \mu A$ and $\eta^* = \psi A(1 - \kappa\mu)$.*
2. *Suppose the planner can select the equilibrium type. For $\lambda_L^P < \lambda < \underline{\lambda}_L$, the planner chooses more guarantees, $m^P > 0$, to create the liquid equilibrium.*
3. *A regulator implements the planner's allocation by subsidizing guarantees to keep the equilibrium liquid, and to eliminate the welfare-inferior illiquid equilibrium.*

Proof. See Appendix B.6 for a proof, a formal characterization of the illiquid equilibrium, a definition of the bound λ_L^P and modified definitions of the problems of the planner and the regulator, respectively. ■

For $\lambda < \bar{\lambda}_{IL}$, an illiquid equilibrium exists because a low price, $p_N = \mu A < {}^{A}/_{\lambda}$, and no sales of high-quality loans are mutually consistent. Since the price in the illiquid equilibrium is lower than in the liquid equilibrium, the threshold ranking is $\bar{\lambda}_{IL} > \underline{\lambda}_L$, and thus there are multiple equilibria for $\lambda \in \left(\underline{\lambda}_L, \bar{\lambda}_{IL}\right)$. Since lenders with non-screened loans do not pool in the secondary market with sellers of high-quality loans in the illiquid equilibrium, they sell their loans at a lower price and thus lenders have higher incentives to screen than in the liquid equilibrium, $\eta^* = \psi A(1 - \kappa\mu)$.[30] Without guarantee subsidies, lenders with non-screened loans are indifferent about

[30] Evidence consistent with this implication includes Mian and Sufi (2009) and Keys et al. (2010).

loan guarantees with $m^* < 1$. Guarantee subsidies eliminate the illiquid equilibrium.[31]

Subsidised guarantees increase the parameter space for which the liquid equilibrium exists, $\lambda p_N \geq A$, since guarantees raise the price of non-guaranteed loans (Proposition 2). We refer to this effect of guarantees as an increase in the quantity dimension of allocative efficiency. It complements the guarantee-induced increase in the price dimension of allocative efficiency described in Section 3.

Next, we consider a planner who not only chooses the loan guarantees as in Section 4 but can also select the equilibrium (liquid or illiquid). A new result is that the planner internalizes the effects of loan guarantees on the quantity dimension of allocative efficiency. The planner liquifies the secondary market for non-guaranteed loans, as shown in Figure 3, while the illiquid equilibrium is unique in the unregulated economy. The planner refrains from liquifying the market, however, when loan guarantees would reduce screening incentives and productive efficiency severely.

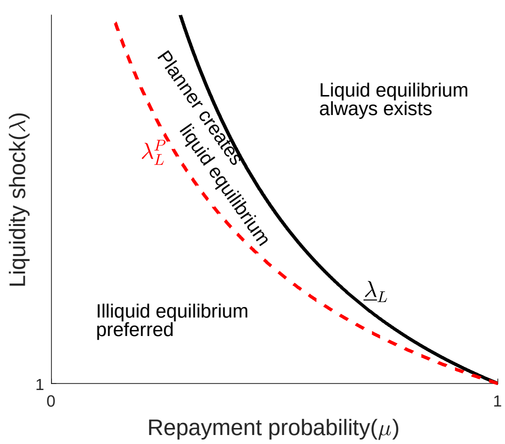

Figure 3: Liquid and illiquid equilibrium. A liquid equilibrium exists for $\lambda > \underline{\lambda}_L$ when loan guarantees are not subsidised. For $\lambda_L^P < \lambda < \underline{\lambda}_L$, the planner liquifies the market for non-guaranteed loans by choosing enough loan sales with guarantees, creating the liquid equilibrium. For $\lambda \leq \lambda_L^P$, the illiquid equilibrium is chosen.

The regulator can implement the modified planner's allocation with the guarantee subsidies b. Positive guarantee subsidies eliminate the illiquid equilibrium when it is inferior. And sufficiently high guarantee subsidies, $b \geq (^1/_\lambda - \mu)\, A$, can sustain a

[31] For $b > 0$, lenders with non-screened loans strictly prefer to sell loans with guarantees, which implies $m = 1$ and thus $p_N = A$ and $\lambda p_N > A$, contradicting the existence of an illiquid equilibrium.

liquid equilibrium when it does not exist in the unregulated economy and is welfare superior whenever $\lambda_L^P < \lambda < \underline{\lambda}_L$.

5.3 Adverse selection induced by screening

In this extension, we study a modified screening technology that increases the adverse selection in the secondary market for non-guaranteed loans and creates adverse selection in the loan guarantee market. Our modification is as follows: low-cost lenders, whose screening does not improve loan quality (which occurs with probability $1-\psi$), privately learn the loan quality A_i at $t = 0$.[32] Thus, a share $(1-\psi)(1-\mu)$ of low-cost lenders privately learn that they financed a lemon and selectively sell lemons in the secondary market for non-guaranteed loans or purchase guarantees for them at $t = 0$. We focus on the liquid equilibrium, where non-guaranteed high-quality loans are sold in the secondary market. We have the following results.

Proposition 8. ***Adverse selection in loan guarantee market.*** *In the modified model where screening identifies lemons at $t = 0$, additional multiple equilibria arise:*

1. *An equilibrium with an illiquid guarantee market, $k = A$ and $p_G = 0$, exists for $b < \tilde{b}^{AS}$.*
2. *For $\lambda \geq \underline{\lambda}_L^{AS}$ and $b > \underline{b}^{AS}$, where $\underline{\lambda}_L^{AS} > \underline{\lambda}_L$ and $\underline{b}^{AS} < \tilde{b}^{AS}$, there exist multiple equilibria in which both markets for guarantees and non-guaranteed loans are liquid and guarantees are used. Compared to the liquid equilibrium in Proposition 1, the prices of both loan types are lower and the screening is higher.*

The regulator subsidizes guarantees to eliminate the equilibrium with an illiquid guarantee market when it is welfare dominated. In the equilibrium with liquid guarantees, the planner subsidises guarantees if $\Lambda > \Lambda^{P,AS}$.

Proof. See Appendix B.7 (in which $\underline{\lambda}_L^{AS}$, $\Lambda^{P,AS}$, $\underline{b}^{AS}$ and $\tilde{b}^{AS}$ are defined). ■

[32] This screening technology can be microfounded in an environment in which lenders learn loan quality, can reject loan applications, and then draw a new application.

Due to private learning of loan quality A_i at $t = 0$, low-cost lenders can selectively sell lemons with guarantees. Thus, the additional defining feature of equilibrium is whether high-cost lenders sell loans with guarantees and make the guarantee market liquid because not only lemons are guaranteed, $k < A$ and $p_G > 0$. The guarantee markets can be illiquid for $b < \tilde{b}^{AS}$ since $p_G = 0$ and low-cost lenders selectively selling lemons with guarantees are mutually consistent. For $\underline{b}^{AS} < b < \tilde{b}^{AS}$, there exists both the equilibrium with illiquid guarantee market and multiplicity of equilibria with liquid guarantee market where some guarantees are bought by high-cost lenders. The latter equilibria with a liquid guarantee market have a higher price for non-guaranteed loans and lower screening. The multiplicity of equilibria with liquid guarantee market is due to indifference of lenders with lemons about guarantees (sell loans with guarantees with probability m^l) and indifference of high-cost lenders about guarantees (sell loans with guarantees with probability m^h).

The regulator can achieve the optimal subsidy program by targeting a price that maximizes planner problem p_N^P and committing enough resources to the subsidy program $T = p_N^P [\nu F(\psi + (1-\psi)\mu) + 1 - F + (1-\psi)(1-\mu)F]$. Various equilibrium combinations of m^l and m^h will imply different b, but always the same costs of subsidy program T, the target price p_N^P and welfare.

Next, we compare an equilibrium with a liquid guarantee market to the main model. Additional asymmetric information at $t = 0$ increases adverse selection in both the guarantee market and the secondary market for non-guaranteed loans. This reduces both the price for guaranteed loans, $p_G^* \leq \mu A$, and the price of non-guaranteed loans. Screening incentives are higher in the modified model for two reasons. First, screening has an additional private benefit of privately identifying lemons at $t = 0$ and selectively selling them with guarantees (at an advantageously low guarantee fee) or selling them in the non-guaranteed secondary market. Second, the lower price of non-guaranteed loans lowers the payoff from not screening. As in the main model, guarantees improve the average quality of non-guaranteed loans traded.

Adverse selection in the loan guarantee market further strengthens the case for loan guarantee subsidies compared to the main model. It creates a new and additional incentive to liquify the guarantee market and improve allocative efficiency, with an independent welfare benefit. Indeed, the regulator can use guarantee subsidies to eliminate the equilibrium with illiquid guarantee market when it is welfare-dominated. In the equilibrium with liquid guarantee market, the planner subsidises guarantees when the improvement in allocative efficiency outweights the deterioration of productive efficiency, i.e. when $\Lambda > \Lambda^{P,AS}$.

5.4 Recourse and credit enhancements

Consider a modified setup in which lenders who sold loans with guarantees are responsible for covering a share α of borrower default costs. This setup could reflect the recourse that GSEs have on loan originators if they can prove loan originators intentionally violated GSE loan requirements (recall the related discussion in the model section). It could also reflect a required credit enhancement or overcollatralization of guaranteed loans that benefit their holder at $t = 2$.

We assume that the share α is not chosen by lenders; rather, it is a requirement of GSEs to qualify for a guarantee. For endogenous choice of risk-retention by lenders who do not sell loans with guarantees that may signal loan quality, see Section 5.5 on partial loan sales. We also assume that this recourse is credible, that is the additional endowment at $t = 2$ is large enough to cover recourse costs. In other words, we abstract from difficulties of enforcing the recourse or lenders defaulting on it at $t = 2$.

We model the recourse as a second guarantee by the lender that complements the first one by the guarantor. As in the main text, the payoffs and fees of guarantees are paid at $t = 2$. Loan owners receive a payoff $p_G = A - k^G - k^l$, where k^G and k^l are guarantee fees for the guarantor and the lender, respectively.[33]

The analysis proceeds in two steps. First, we consider this modification in isolation. Second, we consider its interaction with adverse selection in guarantees

[33] Recourse differs from just varying the coverage of the third-party guarantee. It also provides a guarantee by the originating lender who may be better informed about the loan quality than loan buyers and, therefore, bear different expected costs of recourse.

described in Section 5.3. We have a first result.

Proposition 9. ***Recourse without adverse selection in guarantees.*** *Higher recourse α lowers the threshold of the subsidy $\bar{b}(\alpha)$ above which guarantees are purchased by all lenders. For $b < \bar{b}(\alpha)$, recourse has no effect on the equilibrium outcome and our previous results are unchanged.*

Proof. See Appendix B.8. ■

Higher recourse α increases the guarantee payoff for lenders with high-quality loans. The costs of providing recourse is lower for them compared to lenders with non-screened loans, so they gain from collecting a guarantee fee k^l that reflects the average quality of guaranteed loans. Hence, higher recourse lowers the guarantee subsidy threshold above which lenders with high-quality loans sell loans with guarantees, $\frac{d\bar{b}(\alpha)}{d\alpha} < 0$. As in the main text for $b > \bar{b}(\alpha)$, all lenders sell loans with guarantees but differently from the main text, some lenders still screen to be able to provide recourse at lower costs. (There exists no separating equilibrium with exogenous recourse.)

Similar to the main text, for $b < \bar{b}(\alpha)$ only lenders with non-screened loans sell loans with guarantees. Thus, $p_G = \mu A$ and $k^l = (1-\mu)A\alpha$ and $k^G = (1-\mu)A(1-\alpha)$, so the payoff of lenders with non-screened loans selling loans with guarantees is unaffected by recourse, $\kappa p_G + k^l - (1-\mu)A(1-\alpha) + b = \kappa p_G + b$. The recourse does not affect the choice of guarantees, the equilibrium outcome, and other results.

Next, we explore the implication of recourse in the presence of adverse selection in the market for loan guarantees, as described in Section 5.3.

Proposition 10. ***Recourse with adverse selection in guarantees.*** *For $\alpha > \underline{\alpha}$ and $\psi < \bar{\psi}$ there exists an equilibrium in which recourse eliminates the adverse selection in guarantees but worsens the adverse selection in the non-guaranteed market, to such an extent that $p_N < \mu A$. As a result, higher subsidies may reduce the price in non-guaranteed market, $\frac{dp_N}{db} < 0$. When the above conditions are not satisfied (i.e. $\alpha < \underline{\alpha}$ or $\psi > \bar{\psi}$), our key results from the main text continue to hold.*

Proof. See Appendix B.8, which also defines the thresholds $\underline{\alpha}$ and $\bar{\psi}$. ■

We focus on the equilibrium in which the markets for both guaranteed and non-guaranteed loans are liquid, $p_N > 0$ and $p_G > 0$. Recourse can reduce adverse selection in loan guarantee market because the costs of lender's guarantee is higher for lenders with lemons than for lenders with non-screened loans. But this implies that lemons are sold in the market for non-guaranteed loans. When recourse is high, $\alpha > \underline{\alpha}$, and the screening efficiency ψ is low, $\psi < \bar{\psi}$, then no lemons are guaranteed and screening lowers the price p_N, $\frac{dp_N}{d\eta} < 0$. The negative screening effect on the price p_N of privately identifying lemons and dumping them in the market for non-guaranteed loans dominates the positive screening effect of a higher quality of loans issued. In this case, the average quality of loans sold in the non-guaranteed market is lower than the loan quality of high-cost lenders, $p_N < \mu A$. Higher guarantee subsidies then remove relatively better loans worth μA from the non-guaranteed loans pool, which lowers the price p_N, $\frac{dp_N}{db} < 0$. In this equilibrium, higher price increases the screening incentives and thus guarantee subsidies also lower screening, $\frac{d\eta}{db} = \frac{d\eta}{dp_N}\frac{dp_N}{db} < 0$.

5.5 Partial loan sales

In this extension we build on a common finding in the adverse selection literature: retaining some exposure to risk can signal a lender's high quality and support market liquidity (e.g., Pennacchi 1988; Gorton and Pennacchi 1995; DeMarzo and Duffie 1999). Thus, we allow for partial sales of non-guaranteed loans by lenders, $q_{iN} \in [0, 1-q_{iG}]$, where retaining default risk $1-q_{iG}-q_{iN}$ may signal loan quality. Financiers use $1 - q_{iG} - q_{iN}$ to update their beliefs about loan quality. First, we consider q_{iN} chosen at $t = 1$ after the realization of the liquidity shock as in the main text. Similar to Winton (2003), under some conditions (which yield a simple parameter constraint) and the D1 refinement of financiers' beliefs, only a pooling equilibrium with full loan sales, $q_N = 1$, exists and all of our results from the main text apply.

Second, we consider the setup where lenders can commit at $t = 0$ to a particular q_N conditional on loan sales taking place. Thus, at $t = 1$ they can either sell no loans

$q_{iN} = 0$ or the pre-committed fraction $q_{iN} = q_N$. This is as a commitment to a particular risk-retention in case of loan sale. We show that under some condition and refinement of financier beliefs, a unique separating equilibrium exists. Importantly, the main insights from the main text also arise in this (separating) equilibrium.

Proposition 11. ***Partial loan sales chosen at*** $t = 1$***.*** *For* $\lambda\mu > 1$*, the pooling equilibrium in which financier beliefs satisfy the D1 refinement and all liquidity shocked lenders who did not sell loans with guarantees sell all non-guaranteed loans,* $q_N = 1$*, exists. A fully separating equilibrium does not exists.*

Proof. See Appendix B.12, which also defines the equilibrium. ■

The pooling equilibrium in the main text (liquidity shocked lenders sell all their non-guaranteed loans) exists if the following conditions are satisfied. First, shocked lenders prefer to sell high-quality loans rather then keep them till maturity, $\lambda p_N > A$. Second, lenders with non-screened loans without liquidity shock want to pool, which is satisfied when the above condition $\lambda p_N > A$ holds as then $p_N > \mu A$. Finally, shocked lenders with high-quality loans do not gain by lowering their loan sales q_{iN} below 1. (Recall that $q_{iG} > 0$ signals that lender has not screened and thus lenders pooling in the secondary market for non-guaranteed loans have chosen $q_{iG} = 0$.) If $\lambda\mu > 1$, then lenders with non-screened loans and without a shock are always more willing to reduce the amount of loan sold than a liquidity shocked lender with high-quality loans. Under D1 beliefs, a lender who does not sell all non-guaranteed loans, $q_{iN} < 1$, is viewed as a lender with non-screened loans and without liquidity shock, implying the price is $p_N \mid_{q_{iN}<1} = \mu A < p_N^*$. Thus the shocked lender with high-quality loans prefers to sell all loans at a pooling price p_N. Since $p_N > \mu A$ in equilibrium, then the condition $\lambda\mu > 1$ is the most constraining.

The pooling equilibrium in the main text is thus more likely for a more severe liquidity shock (higher λ) and when the difference between the value of the high-quality loan and non-screened loan decreases (higher μ). These imply that shocked lenders with liquidity shock have lower incentives to deviate by lowering q_{iN} and lenders with non-screened loans have higher gains from mimicking such deviation.

These comparative statics are reminiscent of Winton (2003), who studies the existence of a pooling equilibrium in a setup where financial intermediaries with better assets cannot signal their type by issuing less equity against projects on their balance sheets.

A fully separating equilibrium does not exist because the lender with non-screened loans without liquidity shock would always want to mimic a seller with high-quality loans: the mimicking payoff $qA + (1-q)\mu A$ exceed its separating payoff μA for any $q > 0$. To achieve full separation, we thus consider a commitment for loan retention made at $t = 0$ conditional on selling any loans at all at $t = 1$.

Proposition 12. ***Partial loan sales with conditional commitment at*** $t = 0$***.*** *For* $\nu > \underline{\nu} \equiv \frac{\mu\lambda-1}{\lambda-1}$*, there exists a unique separating perfect Bayesian equilibrium that satisfies the Intuitive Criterion, where lenders with high-quality loans sell* $q_N^* < 1$ *loans when liquidity shocked. Subsidised guarantees improve welfare as they increase allocative efficiency (by increasing* q_N^**) at the expense of productive efficiency.*

Proof. See Appendix B.12. ■

First, suppose loan guarantees are not available. Risk retention is more costly for lenders with non-screened loans. For $\nu > \bar{\nu}$, there exists a loan retention $1 - q_N^*$ at which lenders with high-quality loans want to separate and lenders with non-screened loans do not mimic and instead sell all loans when liquidity shocked. When multiple separating equilibria exist, we apply the Intutive Criterion (Cho and Kreps, 1987) and only the out-of-equilibrium beliefs in the separating equilibrium with the lowest loan retention satisfies this criterion. In this separating equilibrium, lenders with high-quality loans sell $q_N^* = \frac{\mu\nu(\lambda-1)}{\kappa-\mu}$ of loans when liquidity shocked for a price $p_N \mid_{q_N = q_N^*} = A$ and lenders with non-screened loans sell all loans when liquidity shocked for the price $p_N \mid_{q_N=1} = \mu A$.

Introducing subsidised loan guarantees increase the non-mimicking payoff of lenders with non-screened loans. This lowers screening incentives. But it also lowers the minimum loan retention by lenders with high-quality loans needed for separation, $\frac{q_N^*}{db} > 0$. Hence, guarantee subsidies increase the gains from trade. The welfare-maximizing level of subsidies is positive $b^P > 0$. To conclude, the subsidised guarantee externality and the trade-off faced by the planner choosing optimal guarantee subsidies is similar to those in the pooling equilibrium in the main text.

6 Conclusion

Credit risk is often assumed upon loan origination by third parties for a fee (e.g., mortgage guarantees by GSEs). We study loan sale at origination with third-party repayment guarantees when lenders can screen and can sell loans in secondary markets. Consistent with the practice of GSEs, the guarantee trades with the underlying loan and segmented markets for guaranteed and non-guaranteed loans co-exist.

In equilibrium, no lender sells loans with guarantees in the absence of subsidies. Some lenders with non-screened loans (who have not screened or screened unsuccessfully) only sell loans with guarantees when subsidies are high enough to compensate them for lost private benefit of selling their loans in the secondary market for non-guaranteed loans at an advantageous price due to information asymmetry. Lenders with high-quality loans (who successfully screened) never sell loans with guarantees because guarantee passes the benefit of successful unobserved screening to the guarantor, while its cost remains with the lender. The selection of lenders with non-screened loans into guarantees improve the average quality of non-guaranteed loans traded. This raises both market liquidity and allocative efficiency. Higher liquidity, in turn, lowers screening and thus reduces productive efficiency.

Since lenders do not internalize the full benefit of loan guarantees for allocative efficiency and welfare, guarantees can be insufficient in the unregulated economy. We define a welfare benchmark in which the planner chooses loan sales with guarantees for all lenders to maximize utilitarian welfare. When the improvements in allocative efficiency exceed the losses in the productive efficiency, the planner chooses to use loan sales with guarantees. This benchmark can be achieved with loan guarantee subsidies that align the private and social incentives of selling a loan with guarantees.

Therefore, our results provide an economic rationale for government subsidies to loan guarantees. These results contribute to the debate about the role of government-backed guarantees in lending markets, such as the activities of GSEs in the mortgage market. Our results suggest that current level of mortgage guarantee subsidies where virtually all eligible loans are guaranteed are excessively high. But our results also imply that mortgage guarantee subsidies should not be completely eliminated. We describe under which economic conditions mortgage guarantees should be subsidized.

There are several potential directions for further work. First, we assumed that each lender has access to a separate pool of borrowers. If lenders share a common pool instead, then screening has a thinning effect and a lender's choice of screening reduces the quality of the residual pool, a negative externality. Since lenders who successfully screen never buy guarantees in equilibrium, we expect loan guarantees to mitigate this negative externality and the social incentives to subsidize loan guarantees would even be higher. Second, if a general return required by outside financiers is considered, a lower return (e.g. due to a savings glut or stimulative monetary policy) should boost market liquidity. This would reduce lending standards and raise guarantee benefits.

References

Aghion, P., P. Bolton, and J. Tirole (2004). Exit options in corporate finance: Liquidity versus incentives. *Review of Finance 81*, 327–53.

Ahnert, T. and M. Kuncl (2019). Loan insurance, market liquidity, and lending standards. *Bank of Canada Staff Working Paper 2019-47*.

Ambrose, B. W. and T. G. Thibodeau (2004). Have the GSE affordable housing goals increased the supply of mortgage credit? *Regional Science and Urban Economics 34*(3), 263–273.

Berger, A. and G. Udell (2004). The institutional memory hypothesis and the procyclicality of bank lending behavior. *Journal of Financial Intermediation 13*(4), 458–95.

Besanko, D. and A. V. Thakor (1987). Collateral and rationing: sorting equilibria in monopolistic and competitive credit markets. *International Economic Review*, 671–689.

Bester, H. (1985). Screening vs. rationing in credit markets with imperfect information. *American Economic Review 75*(4), 850–855.

Bostic, R. W. and S. A. Gabriel (2006). Do the GSEs matter to low-income housing markets? an assessment of the effects of the GSE loan purchase goals on California housing outcomes. *Journal of Urban Economics 59*(3), 458–475.

Buchak, G., G. Matvos, T. Piskorski, and A. Seru (2018). Fintech, regulatory arbitrage, and the rise of shadow banks. *Journal of Financial Economics 130*, 453–83.

Camargo, B., K. Kim, and B. Lester (2016). Information Spillovers, Gains from Trade, and Interventions in Frozen Markets. *Review of Financial Studies 29*(5), 1291–1329.

Chakraborty, I., I. Goldstein, and A. MacKinlay (2018). Housing price booms and crowding-out effects in bank lending. *Review of Financial Studies 31*(7), 2806–2853.

Chemla, G. and C. Hennessy (2014). Skin in the game and moral hazard. *Journal of Finance 69*(4), 1597–1641.

Chiu, J. and T. V. Koeppl (2016). Trading dynamics with adverse selection and search: Market freeze, intervention and recovery. *Review of Economic Studies 83*(3), 969–1000.

Cho, I.-K. and D. M. Kreps (1987). Signaling games and stable equilibria. *The Quarterly Journal of Economics 102*(2), 179–221.

Congressional Budget Office (2014). Transition to alternative structures for housing finance. Technical report.

Daley, B., B. Green, and V. Vanasco (2020). Securitization, ratings, and credit supply. *The Journal of Finance 75*(2), 1037–1082.

Dang, T. V., G. Gorton, B. Holmström, and G. Ordoñez (2017). Banks as Secret Keepers. *American Economic Review 107*(4), 1005–1029.

Davidson, A. (2016). An overview of GSE reform. *The Journal of Structured Finance 22*(1), 35–46.

DeMarzo, P. and D. Duffie (1999, January). A Liquidity-Based Model of Security Design. *Econometrica 67*(1), 65–100.

DeMarzo, P. M. (2005). The pooling and tranching of securities: A model of informed intermediation. *Review of Financial Studies 18*(1), 1–35.

DiPasquale, D. and E. L. Glaeser (1999). Incentives and social capital: Are homeowners better citizens? *Journal of Urban Economics 45*(2), 354–384.

Elenev, V., T. Landvoigt, and S. V. Nieuwerburgh (2016). Phasing out the GSEs. *Journal of Monetary Economics 81*, 111–32.

Fieldhouse, A. J. (2019). Crowd-out effects of us housing credit policy. *Mimeo. Cornell University*.

Finkelstein, D., A. Strzodka, and J. Vickery (2018). Credit risk transfer and de facto GSE reform. *Federal Reserve Bank of New York Economic Policy Review 24*(3), 88–116.

Frame, W. S. and L. J. White (2005). Fussing and fuming over Fannie and Freddie: How much smoke, how much fire? *Journal of Economic Perspectives 19*(2), 159–184.

Fuster, A., M. Plosser, P. Schnabl, and J. Vickery (2019). The role of technology in mortgage lending. *Review of Financial Studies 32*(5), 1854–1899.

Fuster, A. and J. Vickery (2015). Securitization and the fixed-rate mortgage. *Review of Financial Studies 28*(1), 176–211.

Gabriel, S. A. and S. S. Rosenthal (2010). Do the GSEs expand the supply of mortgage credit? New evidence of crowd out in the secondary mortgage market. *Journal of Public Economics 94*(11-12), 975–986.

Gale, W. G. (1990). Federal lending and the market for credit. *Journal of Public Economics 42*(2), 177–193.

Gale, W. G. (1991). Economic effects of federal credit programs. *American Economic Review*, 133–152.

Gonzalez-Rivera, G. (2001). Linkages between secondary and primary markets for mortgages: The role of retained portfolio investments of the government-sponsored enterprises. *The Journal of Fixed Income 11*(1), 29–36.

Gorton, G. and G. Pennacchi (1990). Financial intermediaries and liquidity creation. *Journal of Finance 45*(1), 49–71.

Gorton, G. and G. Pennacchi (1995). Banks and loan sales: Marketing nonmarketable assets. *Journal of Monetary Economics 35*(3), 389–411.

Green, R. K. and M. J. White (1997). Measuring the benefits of homeowning: Effects on children. *Journal of Urban Economics 41*(3), 441–461.

Grundl, S. and Y. S. Kim (2021). The marginal effect of government mortgage guarantees on homeownership. *Journal of Monetary Economics 119*, 75–89.

Harrison, D. M., W. R. Archer, D. C. Ling, and M. T. Smith (2002). Mitigating information externalities in mortgage markets: The role of government-sponsored enterprises. *Cityscape*, 115–143.

Holmstrom, B. and J. Tirole (2011). *Inside and Outside Liquidity.* MIT Press, Cambridge MA.

Hurst, E., B. J. Keys, A. Seru, and J. Vavra (2016). Regional redistribution through the US mortgage market. *American Economic Review 106*(10), 2982–3028.

Jeske, K., D. Krueger, and K. Mitman (2013). Housing, mortgage bailout guarantees and the macro economy. *Journal of Monetary Economics 60*(8), 917–35.

Keys, B. J., T. Mukherjee, A. Seru, and V. Vig (2010). Did securitization lead to lax screening? Evidence from subprime loans. *Quarterly Journal of Economics 125*(1), 307–62.

Lang, W. W. and L. I. Nakamura (1990). The dynamics of credit markets in a model with learning. *Journal of Monetary Economics 26*(2), 305–318.

Lang, W. W. and L. I. Nakamura (1993). A model of redlining. *Journal of Urban Economics 33*(2), 223–234.

Layton, D. (2022). Is GSE reform dead?

Ling, D. C. and S. M. Wachter (1998). Information externalities and home mortgage underwriting. *Journal of Urban Economics 44*(3), 317–332.

Loutskina, E. and P. E. Strahan (2011). Informed and uninformed investment in housing: The downside of diversification. *Review of Financial Studies 24*(5), 1447–1480.

Mankiw, N. G. (1986). The allocation of credit and financial collapse. *Quarterly Journal of Economics 101*(3), 455–470.

Mian, A. and A. Sufi (2009). The consequences of mortgage credit expansion: Evidence from the U.S. mortgage default crisis. *Quarterly Journal of Economics 124*(4), 1449–96.

Naranjo, A. and A. Toevs (2002). The effects of purchases of mortgages and securitization by government sponsored enterprises on mortgage yield spreads and volatility. *The Journal of Real Estate Finance and Economics 25*(2), 173–195.

Ono, A., I. Uesugi, and Y. Yasuda (2013). Are lending relationships beneficial or harmful for public credit guarantees? evidence from japan's emergency credit guarantee program. *Journal of Financial Stability 9*(2), 151–167.

Ouazad, A. and M. E. Kahn (2021). Mortgage finance and climate change: Securitization dynamics in the aftermath of natural disasters. *Review of Financial Studies, forthcoming*.

Painter, G. and C. L. Redfearn (2002). The role of interest rates in influencing long-run homeownership rates. *The Journal of Real Estate Finance and Economics 25*(2), 243–267.

Parlour, C. and G. Plantin (2008). Loan sales and relationship banking. *Journal of Finance 63*(3), 1291–1314.

Parlour, C. and A. Winton (2013). Laying off credit risk: Loan sales versus credit default swaps. *Journal of Financial Economics 107*(1), 25–45.

Passmore, W. (2005). The GSE implicit subsidy and the value of government ambiguity. *Real Estate Economics 33*(3), 465–486.

Pennacchi, G. (1988). Loan sales and the cost of bank capital. *Journal of Finance 43*(2), 375–96.

Philippon, T. and V. Skreta (2012). Optimal interventions in markets with adverse selection. *American Economic Review 102*(1), 1–28.

Pierri, N. and Y. Timmer (2020). The importance of technology in banking during a crisis. *Mimeo, IMF*.

Rappaport, J. (2020). What to do about Fannie and Freddie: A primer on housing finance reform. *Economic Review 105*(2).

Ruddy, J. A., M. Rajan, and I. Petsas (2017). A study of RMBS litigation cases of six major U.S. banks. *The Journal of Structured Finance 23*(3), 91–99.

Sharpe, S. A. and S. M. Sherlund (2016). Crowding out effects of refinancing on new purchase mortgages. *Review of Industrial Organization 48*(2), 209–239.

Stiglitz, J. E. and A. Weiss (1981). Credit rationing in markets with imperfect information. *The American Economic Review 71*(3), 393–410.

The New York Times (2016, May 23). Penalty against Bank of America overturned in mortgage case, url: https://www.nytimes.com/2016/05/24/business/dealbook/penalty-against-bank-of-america-overturned-in-mortgage-case.html.

The U.S. Attorney's Office (2012, October 24). Manhattan U.S. Attorney sues Bank Of America for over $1 billion for multi-year mortgage fraud against Government Sponsored Entities Fannie Mae and Freddie Mac, url: https://www.justice.gov/archive/usao/nys/pressreleases/October12/BankofAmericanSuit.php.

Tirole, J. (2012). Overcoming adverse selection: How public intervention can restore market functioning. *American Economic Review 102*(1), 29–59.

Vanasco, V. (2017). The downside of asset screening for market liquidity. *Journal of Finance 72*(5), 1937–82.

Wilcox, J. A. and Y. Yasuda (2019). Government guarantees of loans to small businesses: Effects on banks' risk-taking and non-guaranteed lending. *Journal of Financial Intermediation 37*, 45–57.

Winton, A. (2003). Institutional liquidity needs and the structure of monitored finance. *The Review of Financial Studies 16*(4), 1273–1313.

A Further extensions

A.1 Competition in lending markets

One of our interpretations of a lower loan payoff A has been a more competitive lending market. To substantiate this reduced-form approach used so far, we explicitly model competition among lenders and endogenize the loan payoff A in this subsection. We show that an increase in a measure of competition indeed reduces the equilibrium loan payoff A^*.

We consider a modified setup with a unit continuum of islands inhabitated by a pool of borrowers each. Again, good borrowers always repay and bad borrowers always default, where μ is the fraction of good borrowers. Financiers provide one unit of funding to lenders. A key feature is that there are two lenders on each island, $j \in \{1, 2\}$, that can receive funding for loan origination on their island at a hurdle rate h. Lenders can make loans to borrowers on other islands at higher funding costs $h(1 + M)$, where $M > 0$. We think of M as representing higher costs of originating a loan and collecting payments on an island where a lender is not based. Thus, M is the maximum markup over the funding costs h that avoids competition by lenders from other islands, and higher M is a proxy for the lack of competition.

To maintain a social cost of loan guarantee subsidies via reduced screening as in the main model, we consider an intensive margin of screening. Each lender chooses the screening effort ψ_j that determines the probability of finding a good borrower at a quadratic non-pecuniary cost $\xi_j \psi_j^2/2$. As in the main text, a lender who does not screen always faces an average borrower from the pool, and so does a lender who screens but the screening fails (with probability $1 - \psi_j$). When screening succeeds, a high-quality borrower is identified. We assume that the screening costs of one of the lenders on each island is prohibitive, $\xi_1 \to \infty$, so these lenders do not screen, $\psi_1 = 0$. To avoid additional complications, we consider the following timeline at $t = 0$: lenders first announce their gross loan rates A_j and borrowers then choose which lender to approach with a loan application. This timing allows us to abstract from a borrower's choice of whether to accept an offered A_j or apply to the other lender. Thus, A_j cannot be a function of the screening outcome in our model.

We have the following result.

Proposition 13. ***Competition in lending markets.*** *For $M > \max\{\underline{M}_0, \underline{M}_1\}$, there exist a pooling equilibrium in which beliefs of financiers satisfy the Intuitive Criterion. All lenders originate loans and charge a loan rate $A_j^* = A^{Pool}$, and screening lenders receive a return $h(1 + M)$ per unit of lending. Less competitive lending markets (higher M) imply a higher loan rate, $\frac{dA^{Pool}}{dM} > 0$. For $b \in (\underline{b}', \bar{b})$, some lenders with non-screened loans choose to purchase a loan guarantee. Guarantee subsidies increase the secondary market price p_N and reduce both screening effort ψ_2^* and the equilibrium loan rate A^{Pool}.*

Proof. See Appendix B.9 (in which $\underline{M}_0$, $\underline{M}_1$, and $\underline{b}'$ are defined). ■

As in the main text, we focus on the pooling equilibrium. Specifically, we consider the pooling equilibrium in which the low-cost lenders on each island screen and charge A^{Pool}

such that their return per loan achieves the maximum markup M that avoids entry into the local lending market by lenders from other islands. Lower competition by lenders from other islands (higher M) increases the loan rate, $\frac{dA^{Pool}}{dM} > 0$, which supports our interpretation of higher exogenous A in the main text as lower competition in lending markets.

Two condition must be satisfied for existence of this equilibrium. First, the return of high-cost lenders must exceed the funding hurdle rate h, which reduces to $M > \underline{M}_0$. High-cost lenders indeed achieve lower return than low-cost lenders. High-cost lenders cannot achieve a markup of M as this would require them asking higher gross loan rate $A_j > A^{Pool}$, resulting in all good borrowers to file loan application to the lender offering A^{Pool}. Second, low-cost lenders do not want to separate by charging a lower gross loan rate $A_j < A^{Pool}$, which reduces to $M > \underline{M}_1$. To sum up, the pooling equilibrium exists when the lending market is sufficiently non-competitive, $M > \max\{\underline{M}_0, \underline{M}_1\}$.

The key insights about loan guarantees from the main text also apply in this setup. When guarantee subsidies induce some lenders to sell loans with guarantees, such subsidies increase the price of non-guaranteed loans and reduce the screening effort. Moreover, the guarantee subsidy lowers gross loan rate A^{Pool}, so part of the benefits of guarantee subsidies are passed onto the borrowers. This implication is consistent with the benefits of guarantee subsidies being partially passed through to borrowers in insured loans (Passmore 2005, Gonzalez-Rivera 2001) and in uninsured loans (Naranjo and Toevs, 2002).

This setup also allows to study the distributional effects of guarantees on borrowers. Good borrowers who receive a loan benefit from subsidies as they pay lower gross loan rate A^{Pool}. But due to lower screening, fewer good borrowers receive funding. Bad borrowers do not benefit from lower gross loan rate as they never repay loans. If they derived a non-pecuniary and non-contractible benefits from receiving a loan, they would also benefit from lower screening because more bad borrowers receive a loan.

A.2 Microfounding the payoffs from screening

The purpose of this section is to microfound the screening payoffs used in the main text. The key difference of the subsequent extended model is that (i) screening is successful with probability $x \in (0, 1)$; (ii) when successful, screening reveals the borrower quality to the lender; (iii) when unsuccessful, the lender learns nothing; and (iv) the lender can refuse to issue loan to a borrower and consider a new loan applicant.

As in the main model, the costs of screening each loan applicant is η_i and lenders face a good borrower that never defaults with probability μ, otherwise they face a bad borrower who always defaults. Upon screening, the lender can issue a loan to the borrower of known quality or reject them and consider an application from another borrower. For simplicity, we assume that rejected borrowers cannot apply again and exit.[34] Figure 4 illustrates.

As in the main text, lenders use a threshold screening strategy. That is, lenders with $\eta_i < \eta^*$ screen, where η^* is determined by the indifference condition that equates the

[34] As in the main model, we abstract from any thinning effect of screening that could reduce the screening payoff. Thus, the probability of facing a good borrower is always μ.

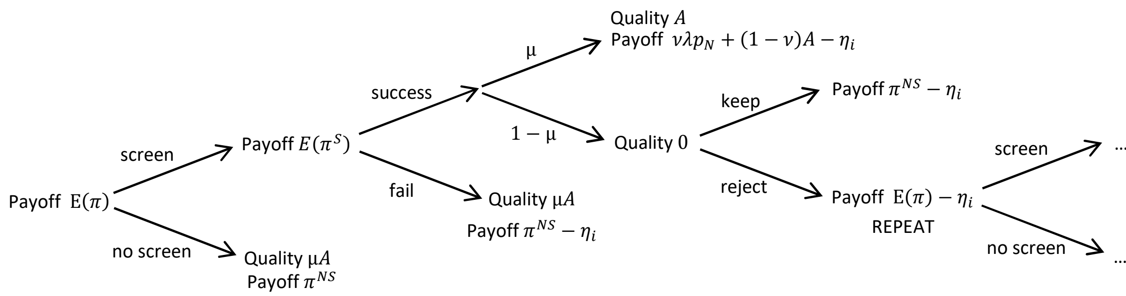

Figure 4: The effect of screening: loan qualities and lender payoffs in liquid equilibrium.

expected payoff when screening $E(\pi^S)$ to the payoff when not screening $\pi^{NS} = \kappa p_N$:

$$E(\pi^S(\eta^*)) = \kappa p_N.$$

The key finding of the extended model is that when screening privately identifies a bad borrower, lenders will choose to reject them and consider another application. This result arises because the expected payoff of issuing a loan to a bad borrower (where the screening costs is sunk and is ignored at this stage), κp_N, is lower than the payoff of screening a new application $E(\pi^S(\eta_i))$ for all $\eta_i < \eta^*$. Only the lender with $\eta_i = \eta^*$ (who are of zero mass) is indifferent between originating a loan to a bad borrower and screening a new borrower.

Note that the assumed option of lenders to approach a new borrower upon rejecting a lemon simplifies the analysis because screening an non-screening lenders do not differ in lending volume when lemons are rejected in equilibrium. This avoids any signalling issues.

The rejections of low-quality borrowers and the screening of new applicants imply that the share of high quality loans is given by an infinite sum:

$$\psi = x\mu + x(1-\mu)x\mu + x^2(1-\mu)^2 x\mu \ldots = \frac{x\mu}{1-x(1-\mu)}. \tag{7}$$

And the average quality of loans originated by low-cost lenders exceeds the quality of loans issued by high-cost lenders, $\psi + (1-\psi)\mu = \frac{\mu}{1-x(1-\mu)} > \mu$. Proposition 14 summarizes.

Proposition 14. ***Microfounded screening payoffs.*** *Consider the extended model in which screening reveals borrower quality perfectly when successful (with probability x) and lenders can reject borrowers. Lenders who screen issue a share $\psi = \frac{x\mu}{1-x(1-\mu)}$ of high-quality loans and a share $1-\psi$ of non-screened loans. They reject all borrowers identified as low-quality via screening. As a result, screening improves the average quality of loans issued.*

A.3 Loan eligibility

So far we have considered setup where all borrowers have equal repayment probability μ. In reality, borrowers with various repayment probability (based on public information in the absence of screening) co-exist in the market. GSE guarantees are eligible only for lenders with high enough μ. We thus study co-existence of borrowers with various μ and our results are consistent with the observed selection of lenders with higher screening costs into the confroming mortgages—eligible for GSE guarantees (Loutskina and Strahan, 2011) and with a positive spillover of guarantees on non-conforming loans (Naranjo and Toevs, 2002).

Consider a modified setup in which lenders can make loans in two borrower pools. Without screening, the average probability of loan repayment A is μ^h and μ^l in the two pools, respectively, where $\mu^h > \mu^l$. For simplicity, we make two assumptions. First, lender endowments exceed the size of the μ^h borrower pool. Second, for every originated loan, it is publicly observable from which pool a borrower was drawn. We have the following result.

Proposition 15. *For $\mu_l > \underline{\mu}^l(b^h)$, there exist a pooling equilibrium in which both low-cost and high-cost lenders issue loans to borrowers from both pools. Sufficient guarantee subsidies for loans from μ^h pool, $b^h > \underline{b}^h$, increase the prices for non-guaranteed loans from both pools p_N^h and p_N^l. High-cost lenders are more likely to originate loans to μ^h borrowers relative to low-cost lenders.*

Proof. See Appendix B.10. ■

We focus on the equilibrium in which loans are issued to borrowers from both pools by both high-cost and low-cost lenders. This is possible because the supply of borrowers from the μ^h pool is lower than lenders' endowment. A necessary condition is that repayment probability of non-screened lenders from the μ^l pool has to be high enough $\mu^l > \underline{\mu}^l(b^h)$.[35] In equilibrium the price in secondary markets for loans for borrowers from both pools is equal, $p_N^h = p_N^l$. This is possible because relatively more high-costs lenders originate loans to borrowers from the μ^h pool.

When the guarantee subsidy is sufficiently high such that lenders with non-screened loans from the μ^h pool start to sell the loans with guarantees, $b > \underline{b}^h$, it has a pecuniary externality in market for non-guaranteed loans from *both* pools. To sustain lending to both borrowers, the prices continue to be equal, $p_N^h = p_N^l$. Thus, the guarantee subsidy removes non-screened loans from both markets due to two effects. First, m^h fraction of lenders with non-screened loans from the μ^h pool sell at origination with guarantee as opposed to sales in the non-guaranteed market. Second, a relatively larger share of high-cost lenders choose to lend to the μ^h pool as opposed to the μ^l pool. The latter effect is consistent with the business model of some lenders with high screening costs specializing in originating eligible loans with automated underwriting systems based on hard borrower observable characteristics (thus without screening on soft criteria) for immediate sale to GSEs that provide the subsidised guarantee.

A.4 Upfront guarantee fee

We consider a guarantee fee k that must be paid at $t = 0$. Thus, a lender who sells loans with guarantee can fund only a share $1 - k$ of the loan, reducing the lending volume. We

[35] At $\mu_l = \underline{\mu}(b^h)$ only low-cost lenders issue loans to borrowers from the μ^l pool. For $\mu_l < \underline{\mu}(b^h)$, lending to borrowers from the μ^l pool takes place only if repayment payoff for borrowers from the μ^l pool exceed the repayment payoff for borrowers from the μ^h pool, $A^l > A^h$.

show that the positive implications are qualitatively the same. Since loan guarantee still has a positive impact on the price of non-guaranteed loans that is not internalized in the unregulated economy, our normative results are also qualitatively the same. Proposition 16 summarizes.

Proposition 16. ***Upfront guarantee fee.*** *The fee paid at $t = 0$ is $k^* = \frac{A(1-\mu)}{1+A(1-\mu)}$.*

1. *Loan guarantees increase the price of non-guaranteed loans, lower screening, and can increase welfare.*
2. *For $\bar{b}' > b > \underline{b}'$ and $\lambda \geq \tilde{\lambda}'_L$, the price of non-guaranteed loans is $p_N^{*\prime} \equiv \mu A - \delta + b/\kappa$, the screening threshold is $\eta^{*\prime} \equiv \psi(1-\nu)((1-\mu)A + \delta - \frac{b}{\kappa})$, and some loans are guaranteed, $m^{*\prime} = 1 - \frac{\nu\psi F((1-\mu)A - b/\kappa + \delta)}{(1-\psi F)(b/\kappa - \delta)} \in (0, 1)$, where $\delta \equiv \frac{(1-\mu)A(\mu A - 1)}{1+(1-\mu)A}$.*
3. *A planner chooses loans sales with guarantees for more loans, $m^{P\prime} \geq m^{*\prime}$.*

Proof. See Appendix B.11 (which also defines the bounds $\underline{b}'$ and $\tilde{\lambda}'_L$). ■

B Definitions, comparative statics, and proofs

B.1 Benchmark without loan guarantees

We define the equilibrium, state the liquid equilibrium and its comparative statics.

Definition 1. *An equilibrium are screening $\{s_i\}$, loan sales $\{q_{iN}\}$, financiers' beliefs about loan quality $\{\phi_{i,1}\}$, and a price of loans p_N such that: (i) at $t = 1$, for each λ_i and $E(A_i)$, each lender optimally chooses loan sales $q_{iN} \in \{0, 1\}$; (ii) at $t = 1$, financiers use Bayes' rule to update their beliefs $\phi_{i,1}(q_{iN})$ on the equilibrium path, and price p_N is set for financiers to break even in expectation; and (iii) at $t = 0$, each lender chooses screening s_i to maximize her expected utility:*

$$\begin{aligned} \max_{s_i} \quad & \mathbb{E}\left[\lambda_i c_{i1} + c_{i2} - \eta_i s_i\right] \qquad \textit{subject to} \\ c_{i1} \;=\; & q_{iN}\, p_N, \quad c_{i2} = (1 - q_{iN})A_i + n, \quad \Pr\{A_i = A\} = (\psi + (1-\psi)\mu)s_i + \mu(1 - s_i). \end{aligned}$$

Lemma 1. ***Liquid equilibrium when loan guarantees are unavailable.*** *If $\lambda \geq \underline{\lambda}_L$ and screening costs are heterogeneous enough, $\bar{\eta} > \frac{(1-\nu)\psi(1-\mu)(1-\psi)}{\nu\psi+1-\psi}A$, then there exists a unique and interior liquid equilibrium. Its cost threshold, $\eta^* \in (0, \bar{\eta})$, is implicitly given by*

$$\eta^* = \frac{(1-\nu)\psi(1-\mu)(1-\psi F(\eta^*))}{\nu\psi F(\eta^*) + 1 - \psi F(\eta^*)}A \tag{8}$$

and the price of non-guaranteed loans is $p_N^* = A - \frac{\eta^*}{(1-\nu)\psi} \in \left[\frac{A}{\lambda}, A\right)$. The lower bound on the size of the liquidity shock is $\underline{\lambda}_L = \frac{A}{p_N^*} \in (1, \infty)$.

The proof follows. In the liquid equilibrium, screening yields the expected payoff $\nu\lambda p_N + (1-\nu)[\psi A + (1-\psi)p_N] - \eta$ and not screening yields κp_N, so the cost threshold in (1) follows. Inserting (2) in (1) yields η^* determined by equation (8). Within the class of liquid equilibria, does a unique equilibrium exist? Regarding uniqueness, the left-hand side (LHS) of the equation (8) increases in η and its right-hand side (RHS) decreases in it, so at most one intersection exists. Regarding existence, we evaluate both sides at the bounds, using $F(0) = 0 < 1 = F(\bar{\eta})$. Note that $LHS(0) < RHS(0)$ always holds and $LHS(\bar{\eta}) > RHS(\bar{\eta})$ if $\bar{\eta} > \frac{(1-\nu)\psi(1-\mu)(1-\psi)}{\nu\psi+1-\psi}A$. For $\psi \to 1$, this condition always holds. For $\psi < 1$, we assume that the screening cost is heterogeneous enough. Hence, there exists a unique and interior screening threshold $\eta^* \in (0, \bar{\eta})$. The price of loans sold at $t = 1$ is given by (2) where $F(\eta^*)$ is the equilibrium share of low-cost lenders and η^* is given in equation (1). To verify the supposed liquid equilibrium, we use conditions (2) and

$$\lambda p_N \geq A. \tag{9}$$

Thus, the condition for the liquid equilibrium is $\lambda \geq \underline{\lambda}_L \equiv \frac{\nu\psi F(\eta^*)+1-\psi F(\eta^*)}{\nu\psi F(\eta^*)+\mu(1-\psi F(\eta^*))}$, where its RHS is independent of λ. We conclude with comparative statics.

Corollary 1. *The threshold η^* increases in A and after a first-order stochastic dominance (FOSD) reduction in F (cheaper screening), and decreases in μ and ν. The price p_N^**

increases in A and after a FOSD reduction. It is non-monotonic in μ and ν. The bound $\underline{\lambda}_L$ decreases in A and after a FOSD reduction and is non-monotonic in μ and ν.

B.2 Definition and characterization of liquid equilibrium, proofs of Propositions 1 and 2, and comparative statics

We first define the equilibrium when subsidised loan guarantees are available.

Definition 2. *An equilibrium comprises screening $\{s_i\}$, the sales of loans with guarantee $\{q_{iG}\}$ and sale of non-guaranteed loans $\{q_{iN}\} \in \{0,1\}$, financiers' beliefs about loan quality $\{\phi_{i,t}\}$, prices p_G and p_N, and a guarantee fee k.*

1. *At $t=1$, for each shock $\lambda_i \in \{1, \lambda\}$ and expected loan quality $E(A_i)$, each lender i optimally chooses the sales of non-guaranteed loans $q_{iN} \in \{0,1\}$.*
2. *At $t=0$, each lender i chooses screening s_i and sale of loans with guarantee q_{iG} to solve*

$$\begin{aligned}
\max_{s_i, q_{iG}} \quad & \mathbb{E}\left[\lambda_i c_{i1} + c_{i2} - \eta_i s_i\right] \qquad \textit{subject to} \\
c_{i1} &= q_{iG}\, p_G + q_{iN}\, p_N, \\
c_{i2} &= (1 - q_{iG} - q_{iN}) A_i + q_{iG} b + n - T, \\
\Pr\{A_i = A\} &= (\psi + (1-\psi)\mu) s_i + \mu(1 - s_i).
\end{aligned}$$

3. *At $t=1$, financiers use Bayes' rule to update their beliefs $\phi_{i,1}(q_{iN}, q_{iG})$ on the equilibrium path, and price p_N is set for financiers to expect to break even.*
4. *At $t=0$, financiers use Bayes' rule to update their beliefs $\phi_{i,0}(q_{iG})$ on the equilibrium path, and the fee k and price p_G is set for financiers to expect to break even.*
5. *Lump-sum taxes cover the costs of guarantees, $T = \int_i b q_{i,G} di$.*

The payoff from a guaranteed loan is independent of the screening choice and loan quality (because financiers cannot observe either), so a lender with a high-quality loan does not sell loans with guarantees. If screening lenders were to sell loans with guarantees irrespective of the quality of loans issued, then their payoff would be $\kappa p_G - \eta_i$, which is lower than the payoff of selling loans with guarantees without screening, κp_G. This contradicts the condition that screening lenders sell loans with guarantees irrespective of loan quality.

Lemma 2. ***Liquid equilibrium with loan guarantees.*** *Suppose $\bar{b} > b > \underline{b}$ and $\lambda \geq \tilde{\lambda}_L$.*

1. *The price is $p_N^* = \mu A + \frac{b}{\kappa}$, the screening threshold is $\eta^* = (1-\nu)\,\psi\left((1-\mu)\,A - b/\kappa\right)$, and the share of guaranteed loans is $m^* = 1 - \nu\psi F(\eta^*)\frac{\kappa(1-\mu)A - b}{(1-\psi F(\eta^*))b}$.*
2. *The proportion of lenders with non-screened loans who sell loans with guarantees m^* increases in b, and μ, decreases in A, ψ and upon a FOSD reduction in F and can be*

non-monotonic in ν. The screening threshold η^* increases in A, λ and ψ, decreases in μ and b and can be non-monotonic in ν. The price p_N^* increases in A, μ and b and decreases in ν and λ. The bound $\tilde{\lambda}_L$ decreases in μ and b and increases in A and ν. The bound $\underline{b}$ decreases in μ and increases in A, λ and upon a FOSD reduction in F.

The proof follows. The indifference condition for loan guarantee (3) pins down the price of non-guaranteed loans, $p_N^* = \mu A + \frac{b}{\kappa}$. Since high-cost lenders are indifferent about guarantee, the screening threshold can be obtained by equalizing the payoff of screening with the payoff of not screening and not selling loans with guarantees in equation (1). Substituting p_N^* from above into (1), the screening cost threshold stated follows.

To ensure a liquid equilibrium, the price p_N^* must satisfy $\lambda p_N \geq A$. Thus, a liquid equilibrium in which guarantees are used exists if $\lambda \geq \tilde{\lambda}_L$, where $\tilde{\lambda}_L$ is implicitly given by $\lambda = \frac{A}{\mu A + b/\kappa}$. An equivalent expression is $\mu \geq \tilde{\mu}_L \equiv \frac{1}{\lambda} - \frac{b}{\kappa A}$. When subsidised guarantees are available, the liquid equilibrium exists if $\lambda \geq \min\{\underline{\lambda}_L, \tilde{\lambda}_L\}$. The comparative statics of $\tilde{\lambda}_L$ are $\frac{d\tilde{\lambda}_L}{d\mu} < 0$, $\frac{d\tilde{\lambda}_L}{db} < 0$, $\frac{d\tilde{\lambda}_L}{d\nu} > 0$, and $\frac{d\tilde{\lambda}_L}{dA} > 0$. To prove that we use the definition of $\tilde{\lambda}_L$ to denote $Y \equiv \lambda - \frac{A}{\mu A + b/\kappa}$, we then use the IFT to derive the above comparative statics using the following partial derivatives: $\frac{\partial Y}{\partial \lambda} > 0$ and $\frac{dY}{d\mu} > 0$, $\frac{dY}{db} > 0$, $\frac{dY}{d\nu} < 0$, and $\frac{dY}{dA} < 0$.

Next, we solve for m^*. Combining the two expressions for p_N^* from the break-even condition (2') and the guarantee-indifference condition in Lemma 2 yields for p_N:

$$\frac{\nu\psi F + \mu(1-\psi F)\,(1-m)}{\nu\psi F + (1-\psi F)\,(1-m)} A = \mu A + \frac{b}{\kappa}, \tag{10}$$

which yields the share of loans of high-cost lenders with guarantees m^* in Lemma 2. Since the LHS of (10) increases in m, guarantees are used when $\frac{p_N}{A}\,|_{m=0} < \mu A + b/\kappa \Leftrightarrow$

$$b > \underline{b} \equiv \frac{\nu\psi(1-\mu)F}{1-(1-\nu)\psi F}\kappa A. \tag{11}$$

Building on the comparative statics of η^* in Corollary 1, we can show that the threshold $\underline{b}$ increases in A and λ, and after a first-order stochastic dominance shift in $F(\cdot)$ (cheaper screening), and decreases in μ.

Comparative statics: screening threshold and price of non-guaranteed loans. Using (2'), the total derivative of the price w.r.t. loan guarantees is:

$$\frac{dp_N}{dm} = \frac{\partial p_N}{\partial m} + \frac{dp_N}{d\eta}\frac{d\eta}{dp_N}\frac{dp_N}{dm} = \frac{\frac{\partial p_N}{\partial m}}{1 - \frac{dp_N}{d\eta}\frac{d\eta}{dp_N}} > 0, \tag{12}$$

since $\frac{\partial p_N}{\partial m} = \nu\psi(1-\mu)F(\eta^*)(1-\psi F(\eta^*))A\big[\nu\psi F(\eta^*) + (1-\psi F(\eta^*))(1-m^*)\big]^{-2} > 0$, $\frac{dp_N}{d\eta} = \frac{f\psi\nu A(1-\mu)(1-m)}{[\nu\psi F + (1-\psi F)(1-m)]^2} > 0$, and $\frac{d\eta}{dp_N} = -(1-\nu)\psi < 0$. Since the price increases in loan guarantees, the screening threshold falls, $\frac{d\eta}{dm} = \frac{d\eta}{dp_N}\frac{dp_N}{dm} < 0$. Since the threshold $\tilde{\lambda}_L$ decreases in the price p_N^*, it decreases in m^*: $\frac{d\tilde{\lambda}_L}{dm} = \frac{d\tilde{\lambda}_L}{dp_N}\frac{dp_N}{dm} < 0$. As a result, when guarantees are used, $m^* > 0$, the threshold for the existence of a liquid equilibrium is lower compared to the case when guarantees are unavailable, $\tilde{\lambda}_L < \underline{\lambda}_L$.

Using the screening threshold stated, we get

$$\begin{aligned}
\frac{d\eta}{db} &= -\frac{(1-\nu)\psi}{\kappa} < 0, \quad \frac{d\eta}{dA} = (1-\nu)\,\psi\,(1-\mu) > 0, \quad \frac{d\eta}{d\lambda} = \nu\psi\,(1-\nu)\,\frac{b}{\kappa^2} > 0 \\
\frac{d\eta}{d\mu} &= -(1-\nu)\,\psi A < 0, \quad \frac{d\eta}{d\psi} = (1-\nu)\left((1-\mu)A - \frac{b}{\kappa}\right) > 0,
\end{aligned}$$

since we focus on positive screening threshold $\eta > 0$ and thus on $(1-\mu)A - \frac{b}{\kappa} > 0$. The effect of ν can be non-monotonic. To show that we evaluate the derivative $\frac{d\eta}{d\nu} = -\psi\left((1-\mu)A - \frac{b}{\kappa}\left(1 + \frac{(1-\nu)(\lambda-1)}{\kappa}\right)\right)$ at both limits $\nu \to \{0,1\}$. For $\lim_{\nu\to 1} = -\psi\left((1-\mu)A - \frac{b}{\kappa}\right) < 0$ and $\lim_{\nu\to 0} = -\psi\left((1-\mu)A - b(1+\lambda)\right)$ is positive if $b > \frac{(1-\mu)A}{\lambda}$.

For the effect on the price, we use p_N^* given in Lemma 2 to obtain:

$$\frac{dp_N}{dA} = \mu > 0, \quad \frac{dp_N}{d\mu} = A > 0, \quad \frac{dp_N}{db} = \frac{1}{\kappa} > 0, \quad \frac{dp_N}{d\lambda} = -\frac{\nu b}{\kappa^2} < 0, \quad \frac{dp_N}{d\nu} = -\frac{(\lambda-1)b}{\kappa^2} < 0.$$

Comparative statics: share of high-cost lenders who sell loan with guarantee. Since m^* is given in Lemma 2 as a function of η^*, the total effect of parameters $\beta \in \{b, \nu, \mu, A\}$ on m^* consists of a direct and indirect effect via screening, $\frac{dm}{d\beta} = \frac{\partial m}{\partial \beta} + \frac{dm}{d\eta}\frac{d\eta}{d\beta}$:

$$\begin{aligned}
\frac{dm}{d\eta} &= -\frac{\nu\psi\,(\kappa(1-\mu)A - b)\,f}{(1-\psi F)^2 b} < 0, & \frac{\partial m}{\partial b} &= \frac{\nu\psi F\kappa(1-\mu)A}{(1-\psi F)b^2} > 0, \\
\frac{\partial m}{\mu} &= \frac{\nu\psi F A\kappa}{(1-\psi F)b} > 0, & \frac{\partial m}{\partial A} &= -\frac{\nu\psi F(1-\mu)\kappa}{(1-\psi F)b} F < 0, \\
\frac{\partial m}{\partial \nu} &= -\frac{\psi F\,((1+2\nu(\lambda-1))(1-\mu)A - b)}{(1-\psi F)b} < 0, & \frac{\partial m}{\partial \psi} &= -\frac{\nu F\,(\kappa(1-\mu)A - b)}{(1-\psi F)^2 b} < 0, \\
\frac{dm}{dF} &= -\frac{\nu\psi\,(\kappa(1-\mu)A - b)}{(1-\psi F)^2 b} < 0,
\end{aligned}$$

The following total derivatives are unambiguous, $\frac{dm}{db} > 0$, $\frac{dm}{d\mu} > 0$, $\frac{dm}{dA} < 0$, $\frac{dm}{d\psi} < 0$, and the FOSD shift. The total effect of ν on m^* can be ambiguous. For ν the direct effect is negative and the indirect one is ambiguous. A sufficient condition for non-monotonicity is the opposite sign of derivatives at both limits, $\nu \to \{0,1\}$, where $\lim_{\nu\to 1}\frac{dm}{d\nu} > 0$ and

$$\lim_{\nu\to 0}\frac{dm}{d\nu} = -\psi\frac{(1-\mu)A - b}{(1-\psi F)b}F < 0.$$

B.3 Proof of Proposition 3

Utilitarian welfare in the liquid equilibrium. Welfare is the sum of expected payoffs to lenders and financiers. Up to a constant for financiers who expect to break even, welfare W is the expected payoffs to lenders. In a liquid equilibrium, low-cost lenders, $\eta_i \le \eta^*$, of mass $\psi F(\eta^*)$ end up with a high-quality loan and receive $\nu\lambda p_N^* + (1-\nu)A - \eta_i$ and low-cost lenders of mass $(1-\psi)F(\eta^*)$ end up with non-screened loan and receive $(1-m^*)\kappa p_N^* + m^*(\kappa p_G^* + b) - \eta_i$ in expectation. This expression reflects that if lenders end up with a non-screened loan, they purchase a guarantee with probability m^*. High-cost lenders without guarantees are of mass $(1-F(\eta^*))(1-m^*)$ and receive κp_N^*, and high-cost lenders with guarantees are of mass $(1-F(\eta^*))m^*$ and receive $\kappa p_G^* + b$. All lenders also receive endownemt n and pay taxes T at $t=2$. Adding up all lenders' yields:

$$W = \overbrace{\nu\lambda\Big\{p_N^*\left[1-(1-\psi F)m^*\right] + p_G^*(1-\psi F)m^*\Big\}}^{\text{Liquidity Shock}} + \overbrace{(1-\nu)p_G^*(1-\psi F)m^*}^{\text{No shock, guarantee}} \tag{13}$$

$$+ \overbrace{(1-\nu)\left[\psi FA + p_N^*(1-\psi F)(1-m^*)\right]}^{\text{No shock, no guarantee}} + bm^*(1-\psi F) - T + n - \overbrace{\int_0^{\eta^*}\eta dF(\eta)}^{\text{Screening costs}},$$

where we used the short-hand $F = F(\eta^*)$ unless stated otherwise. Substituting the price of non-guaranteed loans, $p_N\{\nu\psi F + (1-\psi F)(1-m)\} = A\left[\nu\psi F + \mu\,(1-\psi F)\,(1-m)\right]$, price of guaranteed loans $p_G = \mu A$ and taxes $T = b\,(1-\psi F)\,m$, results in the simplified expression of welfare in Equation (5).

Planner's choice in liquid equilibrium. We derive conditions for welfare to increase in m. The total derivative of welfare in (13), $\frac{dW}{dm} = \frac{\partial W}{\partial m} + \frac{\partial W}{\partial p_N}\frac{dp_N}{dm} + \frac{\partial W}{\partial \eta}\frac{d\eta}{dp_N}\frac{dp_N}{dm} > 0$, is evaluated using

$$\begin{aligned}
\frac{\partial W}{\partial m} &= -(1-\psi F)\kappa(p_N - \mu A) < 0, \\
\frac{\partial W}{\partial p_N} &= \nu\lambda[1-(1-\psi F)m] + (1-\nu)(1-\psi F)(1-m) > 0, \\
\frac{\partial W}{\partial \eta} &= f\Big(\underbrace{(1-\nu)\psi(A-p_N) - \eta}_{=0 \text{ by } (1)} + m\psi\kappa(p_N - \mu A)\Big) > 0.
\end{aligned} \tag{14}$$

and partial derivatives in and below equation (12). After some manipulations this condition simplifies to

$$F(\lambda - 1) > \frac{f\kappa\psi(1-\mu)A}{\nu\psi F + (1-\psi F)(1-m)}(1-(1-\psi F)m), \tag{15}$$

which suggest that as long as the gains from higher allocative efficiency exceed the loses from lower productive efficiency guarantees can improve welfare.

Focusing on the extensive margin, we evaluate (15) at $m = 0$:

$$\Lambda > \Lambda^P \equiv \frac{f\psi(1-\mu)A}{F(\nu\psi F + 1 - \psi F)}, \tag{16}$$

where η is given by (8).

Next, we show that the corner case of all lenders selling loans with guarantees is not optimal, $m^P < 1$, by evaluating the condition (15) in the limit $m \to 1$. The LHS of (15) is zero as $\lim_{m\to 1} p = A$ and thus nobody screens, $\lim_{m\to 1} F = 0$. We apply l'Hospital rule on the limit for the RHS to get $\frac{-1+\frac{d\eta}{dm}f(0)\psi}{-1+\frac{d\eta}{dm}f(0)\nu\psi}f(0)\kappa(1-\mu)A > 0$. Since $-1 + \frac{d\eta}{dm}f(0)\psi < 0$ and $-1 + \frac{d\eta}{dm}f(0)\nu\psi < 0$, Condition (15) does not hold in the limit $m \to 1$, so the planner never chooses to sell loans with guarantees for all lenders, $m^P < 1$.

B.4 Proof of Propositions 4 and 5

Without loss of generality we focus on the interval $b \leq \kappa(1-\mu)A$.[36] We obtain a generalized version of the guarantee indifference condition (3):

$$m\left(p_N - p_G - \frac{b}{\kappa}\right) = 0, \tag{17}$$

with complementary slackness. Guarantees are used, $m > 0$, whenever lenders with non-screened loans are indifferent about guarantee. Thus, the regulator solves:

$$\begin{aligned} W_R^L \quad \equiv \quad & \max_b \overbrace{\nu(\lambda-1)\left[p_N(1-(1-\psi F(\eta))m) + p_G\left(1-\psi F(\eta)\right)m\right]}^{\text{Gains from trade}} \\ & + \underbrace{\left[\psi F(\eta) + \mu(1-\psi F(\eta))\right]A}_{\text{Fundamental value}} - \underbrace{\int_0^\eta \tilde{\eta} dF(\tilde{\eta})}_{\text{Screening costs}} + n - T + b\left(1-\psi F(\eta)\right)m \quad (18) \\ & \text{s.t. } (1),\ (2'),\ (17),\ \text{and } p_G = \mu A, \end{aligned}$$

Liquid equilibrium: guarantee subsidy attains welfare benchmark. Given the balance budget constraint of the planner, the objective functions of the planner in (5) and the regulator in (18) are identical, and so are the screening threshold and the non-guaranteed loan price. Hence, the subsidy is set to achieve the non-guaranteed loan price in welfare benchmark. Solving equation (3) and evaluating at $p_N(b) = p_N^P$ yields the value of b^R stated in the proposition.

Redistribution in the liquid equilibrium. All liquidity shocked lenders are net beneficiaries of the subsidy as the effect of the subsidy on their payoff is $\lambda\frac{dp_N}{db} - \frac{dT}{db} > 0$ because from (3) we get $\lambda\frac{dp_N}{db} = \frac{\lambda}{\kappa} > 1$ and $\frac{dT}{db} < 1$ as part of the taxes are paid by lenders who do not receive subsidies. Lenders with high-quality assets without the liquidity shock do not sell their loan at $t = 1$ and thus they are clearly net losers because the effect of the subsidy on their payoff, $-\frac{dT}{db} > 0$, is only though higher taxes. To evaluate the redistributive effects further we focus on the neighborhood of the optimal guarantee subsidy, $b = b^R$, where subsidy has zero marginal effect on welfare, $\frac{dW}{db} = 0$, and thus the subsidy effects are zero-sum redistribution.

Starting from $T = b(1-\psi F)m = b(\nu\psi F + 1 - F\psi) - \nu\kappa\psi F(1-\mu)A$, we get

$$\frac{dT}{db} \quad = \quad 1-(1-\nu)\psi F + f\frac{(1-\nu)\psi^2(1-\mu)A\nu(1-(1-\psi F)m)}{\nu\psi F + (1-\psi F)(1-m)} = 1-(1-\nu)\psi F + \frac{\lambda-\kappa}{\kappa}\nu F\psi,$$

where we used the condition $\frac{dW}{db} = 0$ in the form of (15) with equality. We can now evaluate the effect of subsidy on the payoff for lenders with non-screened loans

$$\kappa\frac{dp_N}{db} - \frac{dT}{db} = 1 - 1 + (1-\nu)\psi F - \frac{\lambda-\kappa}{\kappa}\nu\psi F = \frac{\psi F(1-\nu)}{\kappa},$$

[36] Higher subsidies have no effect on welfare: the payoff of guaranteed loans $\kappa\mu A + b$ exceeds the highest possible payoff from non-guaranteed high-quality loans, $\kappa p_N \mid_{m=1} = \kappa A$, so all lenders sell loans with guarantees and do not screen.

and for lenders with high-quality loans

$$\nu\lambda\frac{dp_N}{db}-\frac{dT}{db}=\frac{\nu\lambda}{\kappa}-1+(1-\nu)\psi F-\frac{\lambda-\kappa}{\kappa}\nu\psi F=-\frac{(1-\nu)(1-\psi F)}{\kappa}.$$

Note that the sum of the payoff effects weighted by shares of respective lenders is zero $(1-\psi F)\frac{\psi F(1-\nu)}{\kappa}+\psi F\left(-\frac{(1-\nu)(1-\psi F)}{\kappa}\right)=0$. Non-screening lenders get the same positive effect on payoff as lenders with non-screened loans, $\frac{\psi F(1-\nu)}{\kappa}$, and screening lenders observe a negative effect

$$(1-\psi)\frac{\psi F(1-\nu)}{\kappa}-\psi\frac{(1-\psi F)(1-\nu)}{\kappa}=-\frac{\psi(1-\nu)(1-F)}{\kappa}.$$

The effect of the subsidy on lenders with liquidity shock is

$$\lambda\frac{dp_N}{db}-\frac{dT}{db}=\frac{\lambda}{\kappa}-1+(1-\nu)\psi F-\frac{\lambda-\kappa}{\kappa}\nu\psi F=\frac{1}{\kappa}\left[\lambda(1-\nu\psi F)-\kappa(1-\psi F)\right]>0,$$

and on lenders without the liquidity shock is

$$(1-\psi F)\frac{dp_N}{db}-\frac{dT}{db}=(1-\psi F)\frac{1}{\kappa}-1+(1-\nu)\psi F-\frac{\lambda-\kappa}{\kappa}\nu\psi F=\frac{1}{\kappa}\left[-(1-\psi F)(\kappa-1)-\nu\lambda\psi F\right]<0.$$

Comparative statics for the threshold λ^P. Under a uniform distribution for screening costs, $F\sim\mathcal{U}_{[0,\bar\eta]}$, condition (16), after partial substitution of η from (8), can be rewritten as

$$\Lambda>\Lambda^P=\frac{1}{(1-\nu)\left(1-\psi\frac{\eta}{\bar\eta}\right)},\tag{19}$$

which can be also expressed also as $(\lambda-1)\,\tilde D>1$, where $\tilde D\equiv(1-\nu)(1-\psi\frac{\eta}{\bar\eta})-\nu$. This inequality can be re-expressed as

$$\lambda>\lambda^P\equiv1+\frac{1}{\tilde D},\tag{20}$$

and $\nu<\nu^P$, where ν^P is implicitly given by $\tilde D=0$. (Note that $\tilde D$ decreases in ν and is negative for $\nu\to1$ and positive for $\nu\to0$.) We can then show that

$$\frac{d\lambda^P}{d\bar\eta}=\frac{(1-\nu)\psi}{\tilde D^2}\underbrace{\frac{dF}{d\bar\eta}}_{<0}<0,\quad\frac{d\lambda^P}{dA}=\frac{(1-\nu)\psi}{\tilde D^2\bar\eta}\underbrace{\frac{d\eta}{dA}}_{>0}>0,\quad\frac{d\lambda^P}{d\mu}=\frac{(1-\nu)\psi}{\tilde D^2\bar\eta}\underbrace{\frac{d\eta}{d\mu}}_{<0}<0,$$

$$\frac{d\lambda^P}{d\psi}=\frac{(1-\nu)}{\tilde D^2\bar\eta}\left(\eta+\psi\frac{d\eta}{d\psi}\right)=\frac{2(1-\nu)F\left(1-(1-\nu)\psi F\right)}{\tilde D^2\left(1-(1-\nu)\psi F+\nu\psi\frac{F}{1-\psi F}\right)}>0.$$

Comparative statics for optimal guarantee b^P. Assuming uniform distribution for the screening costs, Equation (15) can be expressed as

$$\frac{\eta}{\bar\eta}(\lambda-1)(\nu\psi F+(1-\psi F)(1-m))=\frac{1}{\bar\eta}\kappa\psi(1-\mu)A(1-(1-\psi F)m),$$

which after substitution of $\eta = (1-\nu)\psi(A - p_N) = \frac{(1-\nu)\psi A(1-\psi F)(1-\mu)(1-m)}{(\nu\psi F+(1-\psi F)(1-m))}$ gives an expression for the planner's guarantee provision:

$$m^P = \frac{(\lambda-1)(1-\nu)(1-\psi F) - \kappa}{(1-\psi F)\left[(\lambda-1)(1-\nu)-\kappa\right]}. \tag{21}$$

Using the above expression, we can obtain the expression for optimal price in non-guaranteed market:

$$p_N(m^P) = \frac{\nu(\lambda-1) + \frac{\mu-\nu}{1-\nu}\kappa}{\nu(\lambda-1)+\kappa}A,$$

which gives the optimal screening threshold $\eta(m^P) = \frac{\psi A\kappa(1-\mu)}{\nu(\lambda-1)+\kappa}$ and, after substitution in $b^R = \kappa\,(p_N - \mu A)$, gives the expression for the optimal subsidy size

$$b^R = \frac{\kappa\nu(1-\mu)A\left(\lambda - 1 - \frac{\kappa}{1-\nu}\right)}{\nu(\lambda-1)+\kappa}. \tag{22}$$

From there is straightforward to show that

$$\frac{db^R}{dA} > 0, \qquad \frac{db^R}{d\mu} < 0, \qquad \frac{db^R}{d\lambda} > 0.$$

Comparative statics of total tax costs of guarantee subsidies T^R. Under uniform distribution for screening costs we can express

$$T^R = b^R m^P(1-\psi F(\eta^P)) = \frac{\nu A(1-\mu)\kappa}{\nu(\lambda-1)+\kappa}\left[(\lambda-1)\left(1 - \frac{\psi^2 A\kappa(1-\mu)}{\bar\eta\,(\nu(\lambda-1)+\kappa)}\right) - \frac{\kappa}{1-\nu}\right].$$

We can unequivocally evaluate the following derivatives

$$\frac{dT^R}{d\bar\eta} > 0, \quad \frac{dT^R}{d\psi} < 0, \quad \frac{dT^R}{d\lambda} > 0. \tag{23}$$

But for parameters A and μ the total effect on T^R is not clear as their effect on subsidy size b^R has the opposite sign than their effect on the amount of subsidised loans $m^P(1-\psi F(\eta^P))$.

B.5 Proof of Proposition 6

Collateral does not affect the screening incentives in the liquid equilibrium as $\eta^* = (1-\nu)\,\psi\,(A - p_N)$, but lower screening indirectly because of higher price in secondary market:

$$\begin{aligned} p_N &= \frac{\nu\psi F + (\mu + (1-\mu)\gamma)(1-\psi F)(1-m)}{\nu\psi F + (1-\psi F)(1-m)}A \\ &= \gamma A + (1-\gamma)\underbrace{\frac{\nu\psi F + \mu(1-\psi F)(1-m)}{\nu\psi F + (1-\psi F)(1-m)}A}_{\equiv\,\bar p\,\sim\,\text{the price without collateral (2')}}. \end{aligned} \tag{24}$$

Collateral increases the price of non-guaranteed loans, $\frac{\partial p_N}{\partial \gamma} = A - \bar{p} > 0$, and decreases its sensitivity to screening, $\frac{\partial p_N}{\partial \eta} = (1-\gamma)\frac{\partial \bar{p}}{\partial \eta}$. The guarantee indifference condition for the equilibrium with guarantees, $\kappa \underbrace{[\mu + (1-\mu)\gamma]\, A}_{=p_G} + b = \kappa p_N$, implies that the price when guarantees are used in equilibrium, $p_N = [\mu + (1-\mu)\gamma]\, A + b/\kappa$, is also increasing in collateral. Higher price in turn lowers again screening incentives, $\frac{d\eta}{d\gamma} = -(1-\nu)\psi \frac{dp_N}{d\gamma} < 0$. Collateral increases the guarantees both directly and indirectly through lower screening:

$$\frac{dm}{d\gamma} = \underbrace{\frac{\partial m}{\partial \eta}}_{<0} \underbrace{\frac{d\eta}{d\gamma}}_{<0} + \underbrace{\frac{dm}{d\gamma}}_{>0} > 0,$$

where $m = 1 - \frac{\nu\psi F}{(1-\psi F)b}\left[(1-\mu)(1-\gamma)\kappa - b\right]$. Define $\underline{b} = \frac{\nu\psi F(1-\mu)(1-\gamma)A\kappa}{1-(1-\nu)\psi F}$. Collateral also increase guarantees on the extensive margin:

$$\frac{d\underline{b}}{d\gamma} = \underbrace{\frac{\partial \underline{b}}{\partial \eta}}_{>0} \underbrace{\frac{d\underline{b}}{d\gamma}}_{<0} + \underbrace{\frac{d\underline{b}}{d\gamma}}_{<0} < 0,$$

Next we show that the planner want to use more guarantees when collateral is higher. Using the same steps as in the Appendix B.3 we can simplify the condition $\frac{dW}{dm} > 0$ to

$$F(\lambda - 1) > \frac{f\kappa\psi(1-\mu)(1-\gamma)A}{\nu\psi F + (1-\psi F)(1-m)}(1-(1-\psi F)m),$$

Taking the limit $m \to 0$ determines the threshold which under uniform distribution of screening costs collapses to the same functional form of the condition for the planner's use of guarantees (19) or alternatively (20). We can then show that collateral affects the threshold for provision of guarantees only indirectly through the screening incentives $\frac{d\Lambda^P}{d\gamma} = \frac{(1-\nu)\psi}{(1-\nu)(1-\psi\frac{\eta}{\bar{\eta}})^2\bar{\eta}}\frac{d\eta}{d\gamma} < 0$ and $\frac{d\lambda^P}{d\gamma} = \frac{(1-\nu)\psi}{\tilde{D}^2\bar{\eta}}\frac{d\eta}{d\gamma} < 0$.

Under uniform distribution the optimal level of guarantees is given again by (21) and thus collateral increases the planner's choice of guarantees through the indirect effect on screening effort, $\frac{dm^P}{d\gamma} = \underbrace{\frac{dm^P}{d\eta}}_{<0} \underbrace{\frac{d\eta}{d\gamma}}_{<0} > 0$.

Consider parameters such that the liquidity shock is severe, $\Lambda > \frac{1}{1-\nu}$, the relatively more restrictive condition for the planner's use of guarantee subsidies (19) can be expressed as $\gamma > \gamma^P$, where γ^P is implicitly given by $\eta(\gamma^P) = \frac{\bar{\eta}}{\psi}\left(1 - \frac{1}{(1-\nu)\Lambda}\right)$. Since screening effort decreases in both γ and μ, $\frac{d\eta}{d\gamma} < 0$ and $\frac{d\eta}{d\mu} < 0$, the threshold γ^P decreases in μ, $\frac{d\gamma^P}{d\mu} < 0$.

B.6 Proof of Proposition 7

In the absence of guarantee subsidies, the illiquid equilibrium exists for $\lambda < \bar{\lambda}_{IL} = 1/\mu$. If the price of non-guaranteed loans is μA, only non-screened loans are sold in this market, which justifies $p_N^* = \mu A$. Threshold $\bar{\lambda}_{IL}$ is given by the indifference about loans sale of liquidity-shocked lenders with high-quality loans, $\lambda\mu A = A$. The screening threshold is given by the indifference of the marginal lender who compares payoffs from screening, $\psi A + (1-\psi)\kappa p_N - \eta$, and not screening, κp_N. Equating those yields the stated threshold. In the absence of subsidies, lenders with non-screened loans are indifferent about guarantees.

Modified planner's problem. The planner can also select the equilibrium (liquid or illiquid), thus solving $\max\{W^L, W^{IL}\}$, where welfare in the liquid W^L solves (5) subject to (1), (2'), $\lambda p_N \geq A$, and $p_G = \mu A$, and the welfare in the illiquid (IL) equilibrium solves

$$\begin{aligned} W^{IL} \quad &= \quad \max_m \nu(\lambda-1)(p_N + m(p_G - p_N))\left[1 - \psi F(\eta)\right] + \left[\mu + \psi(1-\mu)F(\eta)\right] A - \int_0^\eta \eta dF \\ &\quad\quad \text{s.t.}\, \eta = \psi(1-\kappa\mu)A, \quad \lambda\, p_N = \lambda\mu A < A, \quad \text{and} \quad p_G = \mu A. \end{aligned} \tag{25}$$

Planner compares illiquid and liquid equilibrium. Next, we define the threshold λ_L^P and show that it exists and is unique. Welfare in the liquid equilibrium is

$$W^L = \nu(\lambda-1)\left[p_N + (\mu A - p_N)\left(1 - \psi F(\eta^L)\right)m^L\right] + \left[\mu + \psi(1-\mu)F(\eta^L)\right] A - \int_0^{\eta^L} \eta dF, \tag{26}$$

subject to η^L in (1), p_N in (2'), and $\lambda\, p_N \geq A$. Welfare in the illiquid equilibrium is

$$W^{IL} = \nu(\lambda-1)\mu A\left[1 - \psi F(\eta^{IL})\right] + \left[\mu + \psi(1-\mu)F(\eta^{IL})\right] A - \int_0^{\eta^{IL}} \eta dF(\eta), \tag{27}$$

where $\eta^{IL} = \psi(1-\kappa\mu)A$. At some λ_L^P given in

$$\overbrace{\nu(\lambda_L^P - 1)\left[p_N + (\mu A - p_N)(1-\psi F(\eta^L))m^L - \mu A(1-\psi F(\eta^{IL})\right]}^{\text{Higher gains from trade in liquid equilibrium}} \equiv \overbrace{\psi(1-\mu)A\left[F(\eta^{IL}) - F(\eta^L)\right] - \int_{\eta^L}^{\eta^{IL}} \tilde{\eta} dF}^{\text{Higher net benefits of screening in illiquid equilibrium}}, \tag{28}$$

the planner is indifferent between both equilibria, $W^{IL} \equiv W^L$. This equation implicitly and uniquely defines a $\lambda_L^P \in (1, \infty)$. For existence, the gains from trade term dominates for $\lambda \to \infty$, so $\lambda_L^P < \infty$, while this term vanishes for $\lambda \to 1$. The existence of λ_L^P follows from continuity.

For uniqueness, we show that the welfare difference $W^L - W^{IL}$ increases in λ. But first we need to characterize the liquid equilibrium at $\lambda = \lambda_L^P$, which does not exist for in the unregulated economy. The liquid equilibrium can only be sustained with a high enough share of guaranteed loans that satisfy $\lambda\, p_N \geq A$. Hence, the FOC for m^P is $\frac{dW^L}{dm} + \gamma\frac{dp_N}{dm} = 0$, where γ is the Lagrange multiplier on $\lambda\, p_N \geq A$. When the planner values the price dimension of allocative efficiency (i.e. increase price in already liquid equilibrium), $p_N^P > A/\lambda$, the liquid equilibrium is preferred ($\lambda > \lambda_L^P$). At $\lambda = \lambda_L^P$, by construction the planner is indifferent between the illiquid equilibrium and the liquid equilibrium with the highest possible screening consistent with $p_N = A/\lambda$, so $\gamma > 0$. Next, $\frac{dW^L}{dm} + \gamma\frac{dp_N}{dm} = 0$ and $\frac{dp_N}{dm} > 0$ imply $\frac{dW^L}{dm} < 0$ at $\lambda = \lambda_L^P$, so the planner would sell fewer loans with guarantees without the binding constraint for a liquid equilibrium.

The total derivative of the difference $W^L\mid_{p_N = A/\lambda} - W^{IL}$ with respect to λ is:

$$\underbrace{\frac{dW^L}{dm}}_{<0}\underbrace{\frac{dm\mid_{p_N=A/\lambda}}{d\lambda}}_{<0}+\underbrace{\nu\left(\frac{A}{\lambda}+\left(\mu A-\frac{A}{\lambda}\right)[1-\psi F(\eta^L)]m-\mu A\left[1-\psi F(\eta^{IL})\right]\right)}_{\text{higher gains from trade in liquid equilibrium}(>0)}>0. \quad (29)$$

This derivative is positive because both effects of a higher size of the liquidity shock λ are positive: the indirect effect through a lower level of guaranteed loans and the direct effect of higher gains from trade. For $\gamma > 0$, guarantees m^P target $p_N = A/\lambda$, thus a higher λ means that less guarantees are needed to achieve the reduced price necessary to liquify the market (recall that $\frac{dp_N}{dm} > 0$). Equation (28) has already established that the gains from trade in the liquid equilibrium are higher and thus the direct effect is also positive. For $\gamma = 0$, the indirect effect of higher λ on the welfare difference is 0 because guarantees are set such that $\frac{dW^L}{dm} = 0$, so the total effect is still positive. In sum, the welfare difference between a liquid and illiquid equilibrium monotonically increases in λ, so equation (28) defines λ_L^P uniquely.

To summarize, at $\lambda = \lambda_L^P$, the planner is indifferent between the two equilibria. Screening incentives and productive efficiency is higher in the illiquid equilibrium, while the social gains from trade (allocative efficiency) are higher in the liquid equilibrium. These forces transparently show up in the definition of λ_L^P in Equation (28).

For $\lambda \leq \lambda_L^P$, the social gains from trade have a lower impact on welfare, so the planer prefers the illiquid equilibrium. Since the guarantees have no externality in the illiquid equilibrium, the planner does not alter the guarantee choice of non-screened loans who are indifferent about guarantees ($m^P = m^* < 1$).

Modified regulator's problem.

Definition 3. *A modified regulated equilibrium comprises screening $\{s_i\}$, loan sales with guarantees $\{q_{iG}\}$ and sale of non-guaranteed loans $\{q_{iN}\} \in \{0, 1\}$, beliefs of financiers about loan quality $\{\phi_{i,t}\}$, a guarantee subsidy b, lump-sum taxes T, prices p_G and p_N, and a guarantee fee k such that:*

1. *At $t = 1$, for each λ_i and $E(A_i)$, each lender i optimally chooses non-guaranteed loan sales q_{iN}.*

2. *At $t = 0$, each lender i chooses screening s_i and loan sales with guarantee q_{iG} to solve*

$$\begin{aligned}
\max_{s_i, q_{iG}} \quad & \mathbb{E}\left[\lambda_i c_{i1} + c_{i2} - \eta_i s_i\right] \qquad \textit{subject to} \\
c_{i1} &= q_{iG}\, p_G + q_{iN}\, p_N, \qquad c_{i2} = (1 - q_{iG} - q_{iN})A_i + q_{iG}\, b + q_{iN}\, b_N + n - T, \\
\Pr\{A_i = A\} &= (\psi + (1-\psi)\mu)s_i + \mu(1 - s_i).
\end{aligned}$$

3. *At $t = 1$, financiers use Bayes' rule to update their beliefs $\phi_{i,1}(q_{iN}, q_{iG})$ on the equilibrium path, and price p_N is set for financiers to expect to break even.*

4. *At $t = 0$, financiers use Bayes' rule to update their beliefs $\phi_{i,0}(q_{iG})$ on the equilibrium path, and the fee k and price p_G is set for financiers to expect to break even.*

5. *At $t = 0$, the regulator chooses the subsidy b to maximize welfare subject to a balanced budget, $T = b \int q_{iG} di$.*

The regulator solves $\max\{W_R^L, W_R^{IL}\}$, where welfare in the illiquid equilibrium is defined below and welfare in the liquid equilibrium solves:

$$
\begin{aligned}
W_R^L \quad \equiv \quad & \max_b \overbrace{\nu(\lambda-1)\left[p_N + (p_G - p_N)\left(1-F(\eta)\right)m\right]}^{\text{Gains from trade}} \\
& + \underbrace{\left[\psi F(\eta) + \mu(1-F(\eta))\right]A}_{\text{Fundamental value}} - \underbrace{\int_0^\eta \tilde{\eta} dF(\tilde{\eta})}_{\text{Screening costs}} + n - T + b\int q_{iG} di \qquad (30) \\
& \text{s.t. } (1),\ (2'),\ (17),\ p_G = \mu A, \quad \text{and} \quad \lambda p_N \geq A.
\end{aligned}
$$

B.7 Proof of Proposition 8

The additional learning at $t = 0$ implies that a fraction $(1-\psi)(1-\mu)$ of low-cost lenders learn that they have lemons. They could sell these at the market for non-guaranteed loans or sell them with guarantees. This creates additional multiplicity of equilibria. There can be an equilibrium where both markets are frozen with $p_N = p_G = 0$. Though here we focus on the case where the market for non-guaranteed loans is liquid, $\lambda p_N > A$.

Illiquid guarantee market. For sufficiently low subsidy, $b < \tilde{b}^{AS}$ there exist an illiquid guarantee market, $p_G = 0$, where $\tilde{b}^{AS} = \kappa \max\{\mu A, p_N \mid_{m^h=m^l=0}\}$, m^l is the share of low-cost lenders with lemons selling loans with guarantees and m^h is the share of high-cost lenders selling loans with guarantees. Zero price for guaranteed loans and the low-cost lenders selectively selling lemons with guarantees are mutually consistent. A sufficiently high subsidy makes guarantees attractive to high-cost lenders and eliminates the illiquid guarantee equilibrium. In other words, an equilibrium with $p_G = 0$ is eliminated if high-cost lenders prefer sell with guarantee (payoff b) to not selling with guarantees (payoff $\nu\lambda p_N + (1-\nu)\max\{\mu A, p_N\}$). Note high-cost lenders never sell loans with guarantees when $p_N < \mu A$ because when they are indifferent about guarantees ($\nu\lambda p_N + (1-\nu)\mu A = \kappa p_G + b$), lenders with lemons will have to strictly prefer guarantees as they have lower outside option ($\kappa p_N < \kappa p_G + b$). But when all lemons are guaranteed, then $p_N > \mu A$, which represents a contradiction.

Liquid guarantee market - Positive analysis. Consider the equilibrium with liquid market for loan guarantees, where high-cost lenders purchase guarantees at $t = 0$ and thus $p_G > 0$, and a liquid non-guaranteed market, where high-quality loans are sold by liquidity shocked lenders and thus $\lambda p_N > A$. Additional learning by low-cost lenders at $t = 0$ creates adverse selection in the loan guarantee market. In the interior equilibrium high-cost lenders and lenders with lemons will be indifferent between selling loans with guarantees or selling loans in the market for non-guaranteed loans. Because of the adverse selection, the price of guaranteed loans will be lower than in the benchmark model

$$
p_G = \mu A \left(1 - \overbrace{\frac{F(1-\psi)(1-\mu)m^l}{(1-F)m^h + F(1-\psi)(1-\mu)m^l}}^{\text{adverse selection discount}}\right). \qquad (31)
$$

Similarly the adverse selection in the market for non-guaranteed loans will be higher. Since p_G is lower, guarantee indifference condition implies also lower p_N compared to the benchmark model for a given subsidy, $p_N = p_G + {}^{b}/_{\kappa}$. We can prove by contradiction that this equilibrium has $p_N > \mu A$. Suppose that $p_N < \mu A$, then for $p_G > 0$ we need high-cost lenders to be indifferent about guarantees, $\nu\lambda+(1-\nu)\mu A = \kappa p_G+b$. This would imply that low-cost lenders with lemons will strictly prefer to sell loans with guarantees as $\kappa p_N < \kappa p_G + b$ and thus $m^l = 1$. If all low-cost lenders with lemons sell them with guarantees then only high-quality loans and loans of high-cost lenders are sold in the non-guaranteed loans market and thus $p_N > \mu A$, which contradicts the original assumption. Since $p_N > \mu A$, high-cost lenders will sell their loan even in the absence of the liquidity shock. The break even condition of outside financiers thus implies the following price in the market for non-guaranteed loans:

$$p_N = \frac{\nu\tilde{\psi}F + \mu(1-F)(1-m^h)}{\nu\tilde{\psi}F + (1-F)(1-m^h) + (1-\psi)(1-\mu)F(1-m^l)}A, \tag{32}$$

where $\tilde{\psi} \equiv \psi + \mu(1-\psi)$. This differs from the benchmark model because high-quality loans of low-cost lenders with unsuccessful screening and without liquidity shock (quantity $(1-\nu)(1-\psi)F\mu$) are now not sold and not guaranteed. The additional private benefit of screening in terms of private learning and lower price p_N imply that the screening is higher than in the benchmark model:

$$\eta = (1-\nu)\tilde{\psi}(A - p_N). \tag{33}$$

We can then show that

$$\frac{\partial p_N}{\partial \eta} = \frac{A\nu(1-\mu)(\nu\tilde{\psi} - \mu(1-\psi)(1-m^l))}{\left[\nu\tilde{\psi}F + (1-F)(1-m^h) + (1-\psi)(1-\mu)F(1-m^l)\right]^2} > 0$$

because $(\nu\tilde{\psi} - \mu(1-\psi)(1-m^l)) > 0$ is a necessary condition for $p_N > \mu A$. We can also show that $\frac{d\eta}{dp} = -(1-\nu)\tilde{\psi} < 0$, $\frac{\partial p}{\partial m^h} > 0$ and $\frac{\partial p}{\partial m^l} > 0$. The lowest subsidy compatible with a liquid guarantee equilibrium would be under $m^l = 0$ and $m^h \to 0$: $\underline{b}^{AS} = \kappa\left(p_N - p_G\right)|_{m^l=0,m^h\to 0} = \kappa A\left(\frac{\nu F\tilde{\psi}+\mu(1-F)}{\nu F\tilde{\psi}+(1-F)+(1-\psi)(1-\mu)F} - \mu\right)$. Under such a low subsidy the non-guaranteed markets are liquid when $\lambda > \underline{\lambda}_L^{AS} \equiv \frac{\nu F\tilde{\psi}+(1-F)+(1-\psi)(1-\mu)F}{\nu F\tilde{\psi}+\mu(1-F)}$, where η is given by $\eta = \frac{(1-\nu)\tilde{\psi}(1-\mu)(1-\psi F(\eta))A}{\nu F(\eta)\tilde{\psi}+(1-F(\eta))+(1-\psi)(1-\mu)F(\eta)}$ and independent on λ.

Liquid equilibrium - Normative analysis. First, recall that planners' choice of b would not pin down a unique equilibrium as various combinations of m^l and m^h can be consistent with it and imply different p_N and η. Thus, next we show that a planner can commit to a particular price target p_N by pledging a budget for the subsidy T, which uniquely determines the screening η and the welfare, irrespective of the particular combination of m^l, m^h, and b. The costs of the subsidy program is given by

$$T = \kappa(p_N - p_G)(F(1-\psi)(1-\mu)m^l + (1-F)m^h).$$

Rearranging the break-even condition of financiers we can express

$$
\begin{aligned}
p_N\left(F(1-\psi)(1-\mu)m^l+(1-F)m^h\right) &= p_N(\nu F\tilde{\psi}+w(1-F)+(1-\psi)(1-\mu)F)\\
&\quad +m^h\mu A(1-F)-\nu F\tilde{\psi}A-w\mu A(1-F),
\end{aligned}
$$

where if the target price satisfies $p_N < \mu A$, then $w = 0$, otherwise $w = 1$. Using the above and the expression for p_G we can express total costs of the subsidy program as

$$
T=\kappa\left(p_N(\nu F\tilde{\psi}+w(1-F)+(1-\psi)(1-\mu)F)-\nu F\tilde{\psi}A-w\mu A(1-F)\right), \tag{34}
$$

which is independent of a particular combination of b, m^l and m^h.

Similarly we can simplify the expression for welfare

$$
\begin{aligned}
W &= \nu\lambda p\left[F\tilde{\psi}+F(1-\psi)(1-\mu)(1-m^l)+(1-F)(1-m^h)\right]+(1-\nu)F\tilde{\psi}A+(1-\nu)FA\\
&\quad +(1-w)(1-F)\mu A+(1-\nu)p_N\left[F(1-\psi)(1-\mu)(1-m^l)+w(1-F)(1-m^h)\right]\\
&\quad +\left[F(1-\psi)(1-\mu)m^l+(1-F)m^h\right]\left(\frac{\mu A(1-F)m^h\kappa}{F(1-\psi)(1-\mu)m^l+(1-F)m^h}+b\right)+n-T-\int_0^\eta \tilde{\eta}dF(\tilde{\eta}),\\
&= \nu(\lambda-1)\left[p_N+(p_G-p_N)(F(1-\psi)(1-\mu)m^l+(1-F)m^h)\right]+\left[F\tilde{\psi}+(1-F)\mu\right]-\int_0^\eta \tilde{\eta}dF(\tilde{\eta})\\
&= \nu(\lambda-1)\left[F\tilde{\psi}(\nu A+(1-\nu)p_N)+(1-F)(w\mu A+(1-w)p_N)\right]+\left[F\tilde{\psi}+(1-F)\mu\right]-\int_0^\eta \tilde{\eta}dF(\tilde{\eta}),
\end{aligned}
$$

which is independent of a particular combination of b, m^l, m^h. Thus, we can pick a particular case of $m^h = m^l = m$ and solve the planner problem using the same steps as in B.3. We focus on the subcase where $\psi > \underline{\psi}(0)$ but the result generalizes. The planner solves

$$
\begin{aligned}
\max_m W &= \max_m \nu\lambda p_N\tilde{\psi}F+(1-\nu)\tilde{\psi}FA+\kappa\left[F(1-\psi)(1-\mu)+1-F\right](1-m)\\
&\quad +\left[F(1-\psi)(1-\mu)+1-F\right]m\left(\frac{\mu A(1-F)\kappa}{F(1-\psi)(1-\mu)+1-F}+b\right)+n-T-\int_0^\eta \tilde{\eta}dF(\tilde{\eta}),
\end{aligned}
$$

where $T = b\left[F(1-\psi)(1-\mu)+1-F\right]m$, and subject to (32) and (33). Using the same steps as in section B.3 we can express the condition $\frac{dW}{dm} > 0$ as $F(\lambda-1) > \frac{f\kappa(1-\mu)A\left(\tilde{\psi}-\mu(1-\psi)(1-m)/\nu\right)}{\nu\tilde{\psi}F+(1-F)(1-m)+(1-\psi)(1-\mu)F(1-m)}(1-(1-F)m)$. For $m \to 0$ this condition simplifies to

$$
\Lambda > \Lambda^{P,AS} \equiv \frac{f(1-\mu)A\left(\psi-\mu(1-\psi)(1-\nu)/\nu\right)}{F\left(\nu\psi F+(1-\psi F)-\mu(1-\psi)(1-\nu)F\right)}, \tag{35}
$$

where η is given by combining (32) and (33):

$$
\eta=\frac{(1-\nu)\tilde{\psi}(1-\mu)(1-\psi F)}{\nu\psi F+(1-\psi F)-\mu(1-\psi)(1-\nu)F}A \tag{36}
$$

The screening threshold given by (36) is higher than in the benchmark (8). This reflects higher benefits to screening from private information acquisition and from lower price in secondary markets for non-guaranteed loans.

B.8 Proof of Propositions 9 and 10

Recourse without adverse selection in guarantees. Suppose that only lenders with non-screened loans sell loans with guarantees, then $p_G = \mu A$, $k^l = \alpha(1-\mu A)$ and $k^G = (1-\alpha)(1-\mu)A$. The payoff of lenders with non-screened loans are unchanged and thus their guarantee indifference condition is again $p_N = p_G + b/\kappa$. Lenders with high-quality loans have unchanged payoff from not selling loans with guarantees, but higher payoff from selling loans with guarantees: $\kappa p_G + b + k^l$. These lenders can provide recourse at no costs as their loans do not default, but cash the guarantee fee that reflects that the average guaranteed loan quality is μA. This higher guarantee payoff for lenders with high-quality loans lowers the subsidy threshold $\bar{b}$ above which all lenders sell loans with guarantees. We can obtain $\bar{b}$ by combining $p_G = \mu A$ and the indifference condition about guarantees for both lenders:

$$\begin{aligned}
\nu\lambda p_N + (1-\nu)A &= \kappa p_G + b + (1-\mu)A\alpha \\
\kappa p_N &= \kappa p_G + b,
\end{aligned}$$

to get $p_N = \left(1 - \frac{(1-\mu)\alpha}{1-\nu}\right) A$ and $\bar{b}(\alpha) = \kappa(1-\mu)A\left(1 - \frac{\alpha}{1-\nu}\right)$.

When $b < \bar{b}$, then α does not affect equilibrium outcomes. The recourse costs are compensated by the guarantee fee and thus the guarantee indifference condition for lenders with non-screened loans is not affected by α.

When $b > \bar{b}$, then all lenders sell loans with guarantees as in the main text. But some lenders do screen because they can benefit from lower costs of recourse for high-quality loans identified by screening. The payoff of lenders with high-quality loans is $\kappa p_G + b + k^l$ and of lenders with non-screened loans is $\kappa p_G + b + k^l - (1-\mu)A\alpha$, where $k^l = (1-\xi)A\alpha$ and $\xi = \psi F + \mu(1-\psi F)$ is the probability of repayment of a guaranteed loan. As before we obtain the screening threshold by equalizing screening and non-screening payoffs:

$$\begin{aligned}
-\eta + \kappa p_G + b + \psi(1-\xi)A\alpha - (1-\psi)(\xi-\mu)A\alpha &= \kappa p_G + b - (\xi-\mu)A\alpha, \\
\eta &= \psi\alpha(1-\mu)A.
\end{aligned}$$

Note that exogenous recourse $\alpha \in (0,1)$ does not achieve a separating equilibrium, where only lenders with high-quality loans sell loans with guarantees and where $p_G = A$ and thus $k^l = 0$ and $p_N = \mu A$. This is because lenders with non-screened loans would always want to mimic lenders with high-quality loans:

$$\kappa\mu A < \kappa A + b - (1-\mu)A\alpha \;\; \forall b \geq 0, \alpha \in (0,1).$$

Recourse with adverse selection in guarantees. We combine the recourse with the adverse selection in guarantees from Section 5.3. Consider the equilibrium in Section 5.3 where both markets for guaranteed and non-guaranteed loans are liquid, $p_G > 0$, $p_N > 0$ and $\lambda p_N > A$. We are looking for conditions where guarantees will no longer have a positive pecuniary externality on non-guaranteed market.

Introducing recourse can eliminate the adverse selection in the market for lender's guarantee provision is more costly for originators of lemons than for originators of a non-screened loan in expectation. If all identified lemons of quantity $(1-\psi)(1-\mu)F$ are being sold in the market for non-guaranteed loans, then the price can drop below the fundamental value of loans held by high-cost lenders, $p_N < \mu A$. Consider that $\mu A < p_N < \lambda\mu A$, thus high-cost lender will sell their non-guaranteed loans in the market only when liquidity shocked (quantity $\nu(1-F)(1-m)$). Price is then given by

$$p_N = \frac{\nu F\tilde{\psi} + \nu\mu(1-F)(1-m)}{\nu F\tilde{\psi} + \nu(1-F)(1-m) + (1-\psi)(1-\mu)F}. \tag{37}$$

We can thus derive the first condition for this equilibrium: $p_N < \mu A$ after substitution of p_N becomes $\psi < \bar{\psi} \equiv \frac{(1-\nu)\mu}{\nu+(1-\nu)\mu}$. The second condition for this equilibrium is that indeed all lemon holders prefer not to sell loans with guarantees. We can use the guarantee indifference condition for lenders with non-screened loans, $\nu p_N + (1-\nu)\mu A = \kappa\mu A + b$ to simplify the condition for originators who identified they have originated a lemon to prefer not selling them with guarantees:

$$\kappa p_N > \kappa\mu A + b + k^l - A\alpha$$

to get $\alpha > \underline{\alpha} \equiv \frac{(1-\nu)(\mu A - p_N)}{\mu A}$. When these conditions ($\psi < \bar{\psi}$, $\alpha > \underline{\alpha}$) are satisfied and guarantees are being used by some lenders with non-screened loans, $\bar{b} > b > \underline{b}$, then differently from the main text, increasing the guarantee subsidy lowers the price on non-guaranteed loans $\frac{dp_N}{db} < 0$ and increases the screening threshold $\frac{d\eta}{db} > 0$. To see that we can use (37) and expression for screening $\eta = (1-\nu)(\tilde{\psi}A + (1-\tilde{\psi})p_N - (1-\nu)\mu A)$ to evaluate the derivatives

$$\begin{aligned}
\frac{\partial p_N}{\partial \eta} &= \frac{fA\nu(1-\mu)(1-m)}{\nu F\tilde{\psi} + \nu(1-F)(1-m) + (1-\psi)(1-\mu)F}(\nu\tilde{\psi} - \mu(1-\psi)) < 0, \\
\frac{\partial p_N}{\partial m} &= \frac{FA\nu(1-\mu)}{\nu F\tilde{\psi} + \nu(1-F)(1-m) + (1-\psi)(1-\mu)F}(\nu\tilde{\psi} - \mu(1-\psi)) < 0, \\
\frac{d\eta}{dp_N} &= (1-\nu)(1-\tilde{\psi}) > 0,
\end{aligned}$$

where the signing of some of the above derivatives is conditional on $\psi < \bar{\psi}$. We can combine the above to evaluate the effect of guarantees:

$$\frac{dp_N}{db} = \frac{dm}{db}\frac{\frac{\partial p_N}{\partial m}}{1 - \frac{\partial p_N}{\partial \eta}\frac{d\eta}{dp_N}} < 0, \qquad \frac{d\eta}{db} = \frac{d\eta}{dp_N}\frac{dp_N}{db} < 0.$$

B.9 Proof of Proposition 13

The screening problem of the low-cost lender is

$$\max_{\psi_2} \psi_2\left(\nu\lambda p_N + (1-\nu)A^{Pool}\right) + (1-\psi_2)\kappa p_N - \xi_2\psi_2^2/2,$$

wich yields the following first order condition:

$$\psi_2 = \frac{(1-\nu)(A^{Pool} - p_N)}{\xi_2}. \tag{38}$$

The price reflects that in the pooling equilibrium the screening lender serves half of the island's borrowers

$$p_N = \frac{0.5\psi_2\nu + (1 - 0.5\psi_2)\mu}{0.5\psi_2\nu + 1 - 0.5\psi_2} A^{Pool} > \mu A^{Pool}.$$

Combining the above two equations we can get $\frac{d\psi_2}{dA^{Pool}} > 0$ and $\frac{dp_N}{dA^{Pool}} > 0$. The gross loan rate A^{Pool} is given in equilibrium by equalizing the expected payoff per loan of the low-cost lender to $h(1+M)$:

$$\psi_2\left(\nu\lambda p_N + (1-\nu)A^{Pool}\right) + (1-\psi_2)\kappa p_N - \xi_2\psi_2^2/2 = h(1+M), \tag{39}$$

where ψ_2 is given by (38). Since the LHS of (39) is increasing in A^{Pool} but independent of M and the RHS of (39) is independent of A^{Pool} and increasing in M, we obtain that equilibrium A^{Pool} increases in M, $\frac{dA^{Pool}}{dM} > 0$.

This pooling equilibrium exists if two conditions are satisfied. First, expected lending return of high-cost lenders need to exceed the hurdle rate, $\kappa p_N > h$. Since $\frac{dp_N}{dA^{Pool}} > 0$ and $\frac{dA^{Pool}}{dM} > 0$, then $\frac{dp_N}{dM} > 0$. Thus the condition can be rewritten as $M > \underline{M}_0$, where $\underline{M}_0$ is given by $\kappa p_N(\underline{M}_0) = h$. Note that for $M \to 0$ the condition is not satisfied $\kappa p_N < h$; and for $M \to \infty$, the condition is satisfied as $p_N \to \infty$.

The second condition for the existence of this pooling equilibrium is that low-cost lenders do not want to deviate by signaling their type with a lower A_j. The highest possible A_j that high-cost lenders would not want to choose even if it is interpreted by investors as a signal of being low-cost A^{Sep} is $\kappa p_N^S(A^{Sep}) = h$, where the price function $p^S(A^{Sep})$ reflects that investors believe that the lender is low-cost:

$$p_N^S = \frac{\nu\psi_2 + (1-\psi_2)\mu}{\nu\psi_2 + 1 - \psi_2} A^{Sep}.$$

Combining the above equations gives $p^S = \frac{h}{\kappa}$ and $A^{Sep} = \frac{h}{\kappa}\frac{\nu\psi_2+1-\psi_2}{\nu\psi_2+(1-\psi_2)\mu}$. Low-cost lender prefers to deviate by choosing $A^{Sep} < A^{Pool}$ and thus not only credibly signaling that he has screened but also driving high-cost out of lending and thus capturing the whole lending market on the island. This is true if the payoff of deviating exceeds the payoff in the pooling equilibrium:

$$\begin{aligned}
\psi_2\left(\nu\lambda p_N + (1-\nu)A^{Sep}\right) + (1-\psi_2)\kappa p_N - \xi_2\psi_2^2/2 &> \frac{1}{2}h(1+M) \\
\frac{h}{\kappa}\left[\psi_2\left(\nu\lambda + (1-\nu)\frac{\nu\psi_2 + 1 - \psi_2}{\nu\psi_2 + (1-\psi_2)\mu}\right) + (1-\psi_2)\kappa\right] - \xi_2\psi_2^2/2 &> \frac{1}{2}h(1+M), \quad (40)
\end{aligned}$$

where screening effort is implicitly given by

$$\psi_2 = \frac{(1-\nu)(A^{Pool} - p_N)}{\xi_2} = \frac{h}{\kappa}\frac{1-\nu}{\xi_2}\frac{(1-\psi_2)(1-\mu)}{\nu\psi_2 + (1-\psi_2)\mu}.$$

Since the LHS of (40) is independent of M, the condition for deviation not to be profitable can be rewritten as $M > \underline{M}_1$, where $\underline{M}_1$ is implicitly defined by (40) with equality.

The effect of guarantee subsidies. In the poling equilibrium, guarantees are used if the subsidy exceed $\underline{b}'$, where analogously to steps in B.2 we get

$$\underline{b}' = \frac{0.5\psi_2\nu(1-\mu)}{1-0.5(1-\nu)\psi_2}.$$

The price of non-guaranteed loans is given again by the break-even condition of financiers

$$p_N = \frac{0.5\psi_2\nu + \mu(1-0.5\psi_2)(1-m)}{0.5\psi_2\nu + (1-0.5\psi_2)(1-m)} A^{Pool}.$$

As in the main text subsidies increase the price of non-guaranteed loans following the guarantee indifference condition $p_N = \mu A^{Pool} + \frac{b}{\kappa}$. Using (39) we can show that that $\frac{dA^{Pool}}{db} < 0$. To see that denote the difference of the LHS and the RHS of (39) as G, then

$$\frac{dA^{Pool}}{db} = -\frac{\left(\overbrace{\frac{\partial G}{\partial p_N}}^{>0} + \overbrace{\frac{\partial G}{\partial \psi_2}}^{=0 \text{ by } (38)} \overbrace{\frac{d\psi_2}{dp_N}}^{<0}\right) \overbrace{\frac{dp_N}{db}}^{>0}}{\underbrace{\frac{dG}{dA^{Pool}}}_{>0}} < 0. \tag{41}$$

Guarantee subsidies lower the screening effort $\frac{d\psi_2}{db} = \underbrace{\frac{\partial \psi_2}{\partial A^{Pool}}}_{>0} \underbrace{\frac{dA^{Pool}}{db}}_{<0} + \underbrace{\frac{\partial \psi_2}{\partial p_N}}_{<0} \underbrace{\frac{dp_N}{db}}_{>0} < 0.$

B.10 Proof of Proposition 15

Let's denote x^S and x^{NS} the share of low-cost and high-cost lenders originating loans to borrowers from the μ^l pool, respectively. The maximum amount of loans that can be made to borrowers in the μ^h pool is $y < 1$. Thus $F(1-x^S) + (1-F)(1-x^{NS}) = y$.

Consider a liquid pooling equilibrium where low-cost and high-cost are indifferent about issuing loans to either pool of borrowers. The expected payoff of low-cost lenders is $\psi\left(\nu\lambda p_N^i + (1-\nu)A\right) + (1-\psi)\kappa p_N^i$ and of high-cost lenders is κp_N^i, where $i \in \{l, h\}$. Thus both lender types are indifferent if $p_N^h = p_N^l$.

In the absence of guarantee subsidies the condition $p_N^h = p_N^l$ can be written as

$$\frac{\nu\psi F x^S + \mu^l\left[(1-F)x^{NS} + (1-\psi)F x^S\right]}{\nu\psi F x^S + \left[(1-F)x^{NS} + (1-\psi)F x^S\right]} = \frac{\nu\psi F(1-x^S) + \mu^h\left[(1-F)(1-x^{NS}) + (1-\psi)F(1-x^S)\right]}{\nu\psi F(1-x^S) + \left[(1-F)(1-x^{NS}) + (1-\psi)F(1-x^S)\right]}$$

Since $\mu^l < \mu^h$ the above condition implies that $x^S > x^{NS}$, implying that low-cost lenders need to lend relatively more to borrowers from the μ^l pool. Since $x^S \leq 1$ we can derive the necessary requirement for μ^l for this equilibrium to exist, $\mu^l > \underline{\mu}^l(0)$, where $\underline{\mu}^l(0)$ is implicitly given by the above conditions with $x^S \to 1$:

$$\frac{\nu\psi F + \underline{\mu}^l(0)\left[(1-F)x^{NS} + (1-\psi)\right]}{\nu\psi + \left[(1-F)x^{NS} + (1-\psi)\right]} = \mu^h,$$

where the argument in the share of screening lenders $F = F(\eta)$ is given by (1), $p_N^h = p_N^l = \mu^h A$ and x^{NS} is given by the equation that reflects that $1 - x^{NS}$ fraction of high-cost lenders originate all loans to borrowers from the μ^h pool, $y = (1-F)(1-x^{NS})$.

Guarantee subsidies for loans originated in the μ^h pool, b^h, will increase the price p_N^h to satisfy the indifference condition (3) that takes the form $p_N^h = \mu^h A + {b^h}/{\kappa}$. This is again because a share of lenders with non-screened loans from μ^h pool, m^h, will decide to sell loans with guarantees, where m^h is implicitly given by

$$\frac{\nu\psi F(1-x^S) + \mu^h\left[(1-F)(1-x^{NS}) + (1-\psi)F(1-x^S)\right](1-m^h)}{\nu\psi F(1-x^S) + \left[(1-F)(1-x^{NS}) + (1-\psi)F(1-x^S)\right](1-m^h)} A = \mu^h A + \frac{b^h}{\kappa}.$$

For the indifference condition $p_N^h = p_N^l$ and the funding condition for μ^h loans, $F(1-x^S) + (1-F)(1-x^{NS}) = y$, to be satisfied, subsidies need to increase p_N^l in equilibrium, ${dp_N^l}/{db^h} > 0$. This implies that ${dx^S}/{db^h} > 0$ and ${dx^{NS}}/{db^h} < 0$. Guarantee subsidies also restrict the parameter space where such equilibrium with spillover exists to $\mu^l > \underline{\mu}^l(b^h)$, where $\underline{\mu}^l(b^h)$ is implicitly given by

$$\frac{\nu\psi F + \underline{\mu}^l(b^h)\left[(1-F)x^{NS} + (1-\psi)\right]}{\nu\psi + \left[(1-F)x^{NS} + (1-\psi)\right]} A = \mu^h A + \frac{b^h}{\kappa},$$

where the argument in the share of screening lenders $F = F(\eta)$ is again given by (1), $p_N^h = p_N^l = \mu^h A + \frac{b^h}{\kappa}$ and x^{NS} is given by the equation that reflects that $1 - x^{NS}$ fraction of high-cost lenders originate all loans to borrowers from the μ^h pool, $y = (1-F)(1-x^{NS})$.

For $\mu^l < \underline{\mu}^l(b^h)$ reallocation of low-costs lenders towards the borrowers from μ^l pool is not sufficient to keep lenders indifferent about which pool to originate loans. To keep lending to μ^l pool the repayment of borrowers from μ^l pool, A^l, would have to exceed the repayment of the borrowers from the μ^h pool, A^h.

B.11 Proof of Proposition 16

In the equilibrium with guarantees, the competitive guarantee fee solves $k = (1-k)A(1-\mu)$, yielding the k^* stated. Lenders with non-screened loans are indifferent between loan sales with a guarantee, $\kappa(1-k)A + b = \kappa(\mu A - \delta) + b$, and no guarantee, $\kappa p_N'$, which yields the stated expressions for $p_N^{*\prime}$. Combining this equation with the competitive price in equation (2') gives $m^{*\prime}$ stated in the proposition. Finally, substituting $p_N^{*\prime}$ into equation (1) gives the screening cost threshold $\eta^{*\prime}$ stated in the proposition. Since the price $p_N^{*\prime}$ must satisfy condition (9), a necessary condition for a liquid equilibrium when guarantees collapses to $\lambda \geq \tilde{\lambda}_L' \equiv \frac{A}{\mu A + {b}/{\kappa} - \delta}$. Guarantees takes place on the subset $b > \underline{b}'$, where thresholds $\underline{b}'$ is implicitly defined by combining $p_N^{*\prime}$ and equation (2') evaluated at $m^{*\prime} = 0$:

$$\underline{b}' = \frac{\nu\psi(1-\mu)FA\kappa}{1-(1-\nu)\psi F} + \delta\kappa. \tag{42}$$

Guarantees of all loans are avoided if lenders with high-quality loan prefers not to guarantee, $\nu\lambda p_N\mid_{m=1} + (1-\nu)A > \kappa(1-k)A + b$. This condition collapses to $b < \bar{b}' \equiv ((1-\mu)A + \delta)\kappa$.

Regarding normative implications, it is easy to show that the planner's choice of guarantees exceeds the unregulated level, following the same steps as in Appendix B.3.

B.12 Proof of Proposition 11

This proof proceeds as follows. First, we show that the pooling equilibrium in the main text exists if $\mu\lambda > 1$.[37] Second, we show that conditional precommittment to risk retention via partial loan sales can result in a separating equilibrium in which loan quality is revealed before $t = 2$. Finally, we show that our main results carry over to the separating equilibrium that satisfies the Intutive Criterion.

Existence of the pooling equilibrium with $q_N^* = 1$. A pooling equilibrium exists if (i) shocked lenders with high-quality loans prefer to sell loans rather than hold on to them, $\lambda p_N > A$; (ii) lenders with non-screened loans and no shock want to pool, $p_N > \mu A$, which is satisfied if condition in (i) holds, and means that shocked lenders with non-screened loans also want to pool; (iii) shocked lenders with high-quality loans cannot gain by lowering q_{iN}. We focus on the last condition.

Shocked lenders with high-quality loans would gain from choosing q' the following payoff $\lambda q' p_N(q') + (1 - q')A - \lambda p_N^*$. Lenders with non-screened loans and no shock would gain from mimicking, $q = q'$, the following payoff $q' p_N(q') + (1 - q')\mu A - p_N^*$. When $\mu\lambda > 1$, then for any price $p_N(q')$ such that shocked lenders with high-quality loans prefer to deviate, lenders with non-screened loans and no shock also prefer to deviate. To see that rearrange the condition for positive payoff gain of lenders with high-quality loans $q' p_N(q') > p_N^* - (1-q')\frac{A}{\lambda}$ and of lenders with non-screened loans $q' p_N(q') > p_N^* - (1-q')\mu A$. Comparing the two we find that conditional on lenders with high-quality loans wanting to deviate, lenders with non-screened loans would deviate too if $(1 - q')\mu A \geq (1 - q')\frac{A}{\lambda}$, which simplifies to $\mu\lambda \geq 1$. Thus indeed, under strict inequality $\mu\lambda > 1$, lenders with non-screened loans and no shock are more willing to reduce q_{iN} than shocked lenders with high-quality loans as they benefit under larger set of responses $p_N(q')$. Thus, under D1 beliefs, a lender with $q_{iN} < 1$ is considered to be a lender with non-screened loans and no shock. The implied price is lower, $p_N(q_{iN} < 1) = \mu A < p_N^*$, and thus shocked lenders with high-quality loans prefer to pool at p_N^*.

Risk retention as signal of loan type with conditional precommittment. Suppose there is a separating equilibrium in which lenders with different loan qualities choose different risk retention, so financiers learn the loan quality reflected in the loan sale price. Sellers of high-quality loans choose $q_N \in (0, 1]$ (since optimal $q_{iG} \in \{0, 1\}$), and sellers of non-screened loans choose $q'_N \neq q_N$, and thus $p_N(q_N) = A$ and $p_N(q'_N) = \mu A$. For this equilibrium to exist, the sellers of non-screened loans must find it optimal to reveal their type:

$$\max_{q'_N \neq q_N} \left(q'_N \nu(\lambda - 1) + 1\right) \mu A = \kappa\mu A > q_N \kappa A + (1 - q_N)\mu A,$$

[37] The definition of the equilibrium is equivalent to Definition 2 except that q_{iN} is not constrained to be $q_{iN} \in \{0, 1\}$ but is instead $q_{iN} \in (0, 1)$.

which simplifies to

$$q_N < \frac{\mu\nu(\lambda-1)}{\kappa-\mu} \equiv \bar{q}_N < 1.$$

Moreover, the lenders with high-quality loans need to be willing to separate at the cost of such loan retention:

$$\nu\left[q_N\lambda A + (1-q_N)A\right] + (1-\nu)A > \max_{q'_N \neq q_N} q'_N \nu\lambda\mu A + (1-\nu+\nu(1-q'_N))A,$$

which simplifies to

$$q_N > \frac{\mu\lambda-1}{\lambda-1} \equiv \underline{q}_N.$$

For $\nu > \underline{\nu}$, $\bar{q}_N > \underline{q}_N$ and thus the set of separating equilibria with $q_N^* \in \left[\underline{q}_N, \bar{q}_N\right]$ is non-empty. The separating equilibrium with lowest retention $q_N^* = \bar{q}_N$ satisfies the Intuitive Criterion.

The effect of loan guarantees. Subsidised guarantees increase the payoff of lenders with non-screened loans. As a result, the highest fraction of loans that liquidity shocked lenders with high-quality loans can sell while still not being mimicked,

$$q_N^* = \bar{q}_N = \frac{\mu\nu(\lambda-1) + \frac{b}{A}}{\kappa-\mu},$$

increases in the guarantee subsidy $\frac{dq_N^*}{db} > 0$. Thus subsidies increase allocative efficiency. However, the screening threshold given by $\eta = \psi A\left[\nu(1+\bar{q}_N(\lambda-1)) + 1 - \nu - \kappa(\mu + \frac{b}{A})\right]$ decreases in the guarantee subsidy $\frac{d\eta}{db} < 0$. To evaluate the effect on the overall welfare, we can express the wealth as a sum of lenders payoffs (up to a constant for financiers):

$$W = F\left[\psi A\left(\nu\bar{q}_N(\lambda-1)+1\right) + (1-\psi)(\kappa\mu A + b)\right] + (1-F)\kappa(\mu A + b) + n - T - \int_0^{\eta^*} \eta dF(\eta).$$

After cancelling the b and T terms with the balanced budget condition, $T = b(1-\psi F)$, we can evaluate that, at $b=0$, welfare increases in the subsidy:

$$\left.\frac{dW}{db}\right|_{b=0} = \frac{\partial W}{\partial \bar{q}_N}\frac{d\bar{q}_N}{db} + \frac{\partial W}{\partial \eta}\frac{d\eta}{db} > 0,$$

since

$$\frac{\partial W}{\partial \bar{q}_N} = F\psi A(\lambda-1) > 0, \qquad \frac{\partial W}{\partial \eta} = f\psi A\left[\nu(1+\bar{q}_N(\lambda-1)) + 1 - \nu - \kappa\mu\right]|_{b=0} = 0.$$

This implies that the welfare-maximizing guarantee subsidy is positive, $b^P > 0$.