

# Online Appendix

## Collateral Crises

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### Abstract

In this Online Appendix we

1. Endogeneize the assumption that borrowers have all the negotiation power by explicitly modeling competition among lenders.
2. Relax the assumption that land buyers have all the negotiation power, showing how land prices incorporate the value of land as collateral.

## 1 Lenders' Competition

In the main text we assume random matching between firms and households, and we assign the negotiation power to the firm. This implies both that firms cannot go to another household after the negotiation of a loan and that households, in their role of lenders, break even. These assumptions, however, are made just for expositional purposes. Here we show that the conclusions in the main text remain, and even strengthen, if we endogeneize the borrowers' negotiation power by modeling explicitly competition among lenders.

Households may post loan contracts under which they offer not to produce information about the collateral (information-insensitive debt), and loan contracts under which they offer to produce information (information-sensitive debt). Every firm can approach as many households as it wants anonymously. Once a loan is agreed on, it becomes public knowledge and cannot be renegotiated or refinanced. Given restrictions on the endowment, each household can lend at most to a single firm.

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We assume there are more potential lenders (households) than potential borrowers (only a fraction of firms have skills  $L^*$ , for example), which implies that households compete a la Bertrand when offering contracts, such that they are indifferent between offering the contract or not. From the analysis in the main text, if the firm can only approach a single household, these contracts are the following:

- Information-sensitive debt (IS): The contract is only offered if  $p > \frac{\gamma}{K^*(qA-1)}$ . In that case, the household produces information about the land. If the land is bad, there is no loan. If the land is good, the contract specifies the firm has to post a fraction  $x_{IS} = \frac{pK^* + \gamma}{pC}$  of land as collateral to receive a loan of  $K_{IS} = K^*$ .<sup>1</sup>
- Information-insensitive debt (II): The household does not produce information about the land and the contract specifies the firm has to post a fraction  $x_{II} = \min \left\{ \frac{K}{pC}, 1 \right\}$  of land as collateral to receive a loan  $K_{II}$ , which is the maximum loan size that avoids information acquisition, as specified in equation (5) in the main text.

Under a competitive setting, if firms can approach many households, do they still approach only a single household in equilibrium? Are these contracts still offered in equilibrium? Here we show that in a competitive setting, *IS* contracts are offered under the same conditions. However, there is a range of beliefs  $p$  for which information-insensitive contracts *are not offered*. Furthermore, this range includes the range of beliefs  $p$  for which information-insensitive contracts *are not chosen* when assuming random matching. When offered, however, *II* contracts specify the conditions above.

The difference arises because, when both contracts are offered in a competitive environment, firms that ex ante, with random matching, would have preferred to take an *II* debt, may want to deviate, first approaching an *IS* contract to learn the type of their land virtually for free. If this deviation is possible, lenders know that any *II* contract that offers a positive loan in equilibrium only attracts firms with bad collateral, so they decide not to offer any *II* contract.

Hence, we need to study the incentives for firms to approach a second lender.

1. *II* debt: A firm that approaches a household who offers an *II* contract does not improve its information set, not having incentives to approach a second potential lender, otherwise they would have done it before.
2. *IS* debt: Since we assume lending relations are anonymous, information is non-verifiable before the end of the period and contracts cannot be refinanced, basically there are no free-riding problems. A firm which chooses to approach a

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<sup>1</sup>For this loan we still assume  $qA < C/K^*$  as in the main text. Relaxing this assumption just introduces more conditions on the contract.

lender who offers an *IS* contract, and learns his land is good, cannot credibly communicate this information to another lender in order to obtain better loan terms. In contrast, a firm who chooses to approach a lender which offers an *IS* contract, and learns his land is bad, later wants to approach a lender who offers an *II* contract.

Given this possibility, when both contracts are offered, the firm wants to first learn its land type approaching an *IS* offer, and then, if its land is bad, to take an *II* offer. This is the optimal strategy of firms with land with belief  $p$  if

$$p[K^*(qA - 1) - \frac{\gamma}{p}] + (1 - p)E(\pi|p, II) > E(\pi|p, II).$$

The left hand side represents the expected gains for the firm to approach an *IS* offer first. If the land is good the gains for the firm are  $K^*(qA - 1) - \frac{\gamma}{p}$ . If the land is bad the firm just issues an *II* debt as long as it provides a positive loan and generates  $E(\pi|p, II) > 0$ . The right hand side represents the expected gains for the firm just to issue *II* debt directly.

This condition is summarized by

$$K^*(qA - 1) - \frac{\gamma}{p} > E(\pi|p, II).$$

The left hand side is represented by the dotted black curve in Figure 1 and the right hand side cannot be larger than the solid black curve in Figure 1. If this condition holds (*IS* range in Figure 1), households know that offering an *II* contract only attracts firms with bad land, and prefer to offer just *IS* contracts.

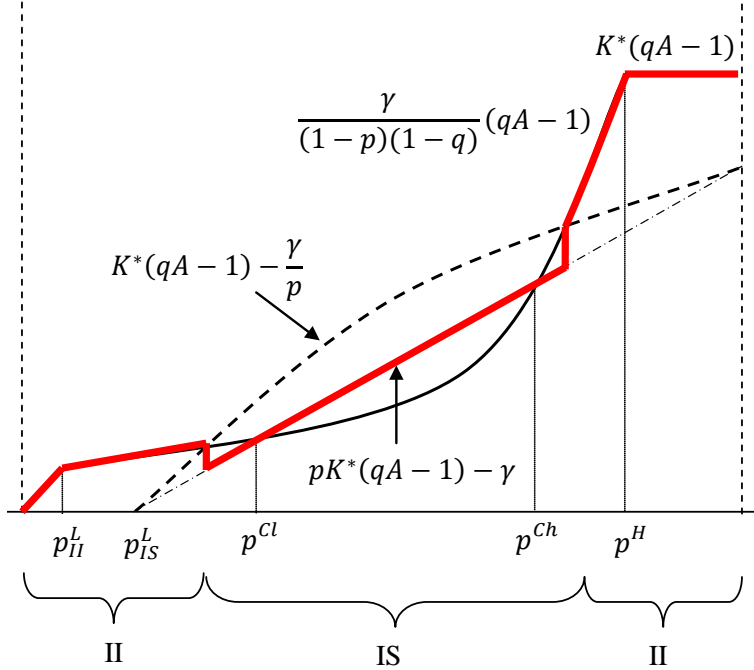
Since

$$K^*(qA - 1) - \frac{\gamma}{p} > E(\pi|p, IS) \equiv pK^*(qA - 1) - \gamma,$$

the range of the *IS* region is larger than the one characterized in the main text. This implies a discontinuity in the size of loans and the expected profits of firms (red solid function in Figure 1), when *II* debt just becomes not incentive compatible.

Naturally this characterization in a competitive setting just strengthen all the conclusions in the paper. A small shock that moves the system to the *IS* region generates a sudden and large discontinuous decline in aggregate output because of the sudden unavailability of information-insensitive debt in the economy.

Figure 1: Information Sensitiveness with Competitive Lenders



## 2 Land Prices that Include the Value of Land as Collateral

In the main text the price of land just reflects its outside option, or fundamental value, since we assumed buyers have all the negotiation power and make take-it or leave-it offers. In this extension we generalize the results assuming Nash bargaining between buyers and sellers, where the sellers' negotiation power  $\theta \in [0, 1]$  determines how much they can extract from the surplus of buyers (in the main text we assumed  $\theta = 0$ ). To simplify the exposition in the main text we also assumed no discounting (i.e.,  $\beta = 1$ ). In this extension we assume a generic discount factor  $\beta \in [0, 1]$ .

First, we assume the case without aggregate shocks and then we discuss how the introduction of aggregate shocks just enter into prices as an expectation. We denote the price of a unit of land with perceptions  $p$  as  $Q(p)$ .

The surplus of a unit of land for the seller is just its expected intrinsic value

$$J_S(p) = pC.$$

The surplus of land for the buyer is the expected profit from a firm plus the expected price of the land. If  $p$  is such that debt is information-sensitive, the surplus is

$$J_B(p|IS) = E(\pi|p, IS) + \lambda[pQ(1) + (1-p)Q(0)] + (1-\lambda)Q(\hat{p}),$$

where  $E(\pi|p, IS) = [pK(1) + (1-p)K(0)](qA - 1) - \gamma$ .

If  $p$  is such that debt is information-insensitive, the surplus is

$$J_B(p|II) = E(\pi|p, II) + \lambda Q(p) + (1 - \lambda)Q(\hat{p}),$$

where  $E(\pi|p, II) = K(p)(qA - 1)$ .

Then

$$Q(p) = \beta[\theta J_B(p) + (1 - \theta)J_S(p)] \quad (1)$$

since  $Q(p) = J_S(p) + \theta(J_B(p) - J_S(p))$ .

## 1. Borrowing as a function of land price

Firms can compute the possible borrowing with both information-sensitive and insensitive debt and determine which one is higher. In the main text we impose the price of land as the sellers' outside option and we determine the optimal borrowing as a function of that price. Now the price of land also depends on the optimal borrowing, and then they should be determined simultaneously.

In the case of information-sensitive debt,  $R_{IS}(1) = x_{IS}(1)Q(1)$  and  $R_{IS}(0) = x_{IS}(0)Q(0)$  because debt is risk-free. Lenders break even when,

$$p[x(1)Q(1) - K(1)] + (1-p)[x(0)Q(0) - K(0)] = \gamma$$

where  $x(1)Q(1) \geq K(1)$  and  $x(0)Q(0) \geq K(0)$ .

In the case of information sensitive debt,  $R_{II}(p) = x_{II}(p)Q(p)$  because debt is risk-free. Lenders break even when,

$$x(p)Q(p) = K(p).$$

with the constraint that

$$p[x(p)(qQ(p) + (1-q)Q(1)) - K(p)] \leq \gamma$$

or, which is the same as

$$K(p) \leq \frac{\gamma}{(p\frac{Q(1)}{Q(p)} - p)(1-q)}. \quad (2)$$

In the main text, where  $\theta = 0$ ,  $Q(1) = C$ ,  $Q(p) = pC$  and then  $K(p) \leq \frac{\gamma}{(1-p)(1-q)}$ .

## 2. Solving Borrowing and Land Prices Simultaneously

We now show how to solve simultaneously for optimal borrowing and land prices.

1. When  $\gamma > 0$ , firms with collateral  $p = 0$  and  $p = 1$  prefer to borrow without producing information.

This is clear because knowing the type of the collateral (which is the case with  $p = 0$  and  $p = 1$ ), it does not make sense for the borrower to pay  $\gamma$ .

2.  $K(1) = K^*$

Since  $K(1)$  is not financially constrained in the information-insensitive case.

3. Determination of  $K(\hat{p})$ ,  $Q(\hat{p})$  and  $Q(1)$ . There are three possible cases.

- (a)  $\hat{p}$  is information-insensitive and  $K^* \leq \frac{\gamma}{(\hat{p}\frac{Q(1)}{Q(\hat{p})} - \hat{p})(1-q)}$ : This implies  $K(\hat{p}) = K^*$  and

$$Q(\hat{p}) = \frac{\beta(1-\theta)\hat{p}C + \beta\theta K^*(qA-1)}{1-\beta\theta}.$$

- (b)  $\hat{p}$  is information-insensitive and  $K^* > \frac{\gamma}{(\hat{p}\frac{Q(1)}{Q(\hat{p})} - \hat{p})(1-q)}$ : Since  $Q(\hat{p})$  and  $Q(1)$  just depend on  $K(\hat{p})$ , it is obtained from equation (2).

- (c)  $\hat{p}$  is information-sensitive: When information reveals the collateral is bad, and assuming the firm maximizes borrowing  $x_{IS}(0) = 1$ . The following two equations jointly determine  $K(0)$  and  $K(\hat{p})$ :

$$K(\hat{p}) = \hat{p}K^* + (1-\hat{p})K(0) - \frac{\gamma}{(qA-1)}, \quad (3)$$

$$K(0) = Q(0) = \frac{\beta\theta[K(0)(qA-1) + (1-\lambda)Q(\hat{p})]}{1-\beta\theta\lambda}, \quad (4)$$

where  $Q(\hat{p})$  just depends on  $K(\hat{p})$ .

In these three cases  $K(\hat{p})$  is solvable, and the prices

$$Q(\hat{p}) = \frac{\beta(1-\theta)\hat{p}C + \beta\theta K(\hat{p})(qA-1)}{1-\beta\theta}$$

and

$$Q(1) = \frac{\beta(1-\theta)C + \beta\theta[K^*(qA-1) + (1-\lambda)Q(\hat{p})]}{1-\beta\theta\lambda}$$

are well-defined. Similarly, expected profits for  $\hat{p}$  in both the cases of information-sensitive and insensitive can be computed such that firms choose the highest possible amount of borrowing.

4. Determination of  $K(0)$  and  $Q(0)$ .

These are determined by

$$K(0) = Q(0) = \frac{\beta\theta[K(0)(qA-1) + (1-\lambda)Q(\hat{p})]}{1-\beta\theta\lambda}.$$

5. *Determination of  $K(p)$  and  $Q(p)$ .*

There are two cases, from which the firm chooses the highest possible borrowing:

(a)  $p$  is information-insensitive:

$$K(p) = \frac{\gamma}{(p\frac{Q(1)}{Q(p)} - p)(1 - q)}.$$

(b)  $p$  is information-sensitive:

$$K(p) = pK^* + (1 - p)K(0) - \frac{\gamma}{(qA - 1)}.$$

where in both cases  $Q(p)$  only depends on  $K(p)$ ,

$$Q(p) = \frac{\beta(1 - \theta)pC + \beta\theta[K(p)(qA - 1) + (1 - \lambda)Q(\hat{p})]}{1 - \beta\theta\lambda}.$$

The determination of which regions are information-sensitive and insensitive is similar to the case in the main text. Expected profits with information-sensitive debt is linear while expected profits with information-insensitive debt depend on the shape of the land prices.

### 3. Multiplicity

In the previous steps we show how to solve the optimal borrowing when land prices are endogenous. However these steps do not guarantee uniqueness of the solution (for example under information-insensitiveness, equation (2) does not imply uniqueness). The intuition is the following: If there is no confidence that in the future low quality collateral can be used to sustain borrowing, this will reduce the price of the collateral, reinforcing the fact that it will not be able to sustain such a borrowing. This “complementarity” between the price of collateral and borrowing capabilities is what creates potential multiplicity.

An interesting example is the extreme opposite to the one assumed in the main text, this is  $\theta = 1$ . In this extreme case, the potential multiplicity takes a very clear form. Assume an equilibrium where all collateral sustain borrowing of  $K^*$  without producing information, regardless of the perception  $p$  that land is good. If this is the case, the price for all collateral is independent of  $p$ ,

$$Q(p) = \frac{\beta K^*(qA - 1)}{1 - \beta}.$$

Given these prices, borrowing without information acquisition is not binding because  $Q(1) = Q(p)$  and then  $K^* < \frac{\gamma}{(p-p)(1-q)} = \infty$ , from equation (2). As conjectured, all collateral can borrow  $K^*$  regardless of  $p$ . In general, a larger  $\theta$  allows for the existence of an equilibrium that sustains a lot of credit without information acquisition, but fragile to beliefs about whether land with low  $p$  can sustain high credit.