

Valuation, Adverse Selection, and Market Collapses

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Abstract

We study a market for funding real investment where *valuation*—meaning investors devoting resources to acquiring information about future payoffs—creates an adverse selection problem. Unlike previous models, more valuation is associated with lower market prices and so greater returns to valuation. This strategic complementarity in the capacity to do valuation generates multiple equilibria. With multiple equilibria, the equilibrium without valuation is most efficient despite funding some unprofitable investments. Switches to valuation equilibria, valuation runs, look like credit crunches. A large investor can ensure the efficient equilibrium only if it can precommit to a price and potentially, only if subsidized. (*JEL* D82, G01, G10, G21)

Most real investment—buying a house, starting or expanding a firm, or maintaining a business in bad times—relies on external financing, a transfer of resources today for a claim on uncertain resources in the future. Even though external financing is critical for much economic investment, markets for external finance seem fragile. History is replete with financial panics both small and large, in which the costs of funding rise and the volume of funding collapses.

In this paper, we present a model of a market for the external financing of real investment in which different funding volume and asset prices arise from different levels of valuation by market participants. By *funding*, we mean funding the origination and sale of assets. By *valuation* we mean financial investors devoting resources to acquire information on how much an asset is worth. In our setting, valuation has an externality—it produces private information on which adverse selection can occur.¹ Investors who do valuation fund only good projects, leaving the bad ones to approach unsophisticated investors. Hence more valuation worsens the pool of assets purchased by unsophisticated investors who cannot perform valuations, which in turn lowers the price that unsophisticated investors are willing to pay, which lowers the price that more sophisticated investors have to pay for good assets, which makes valuation by sophisticated investors more profitable. This price externality generates strategic complementarities in the capacity to do valuation that lead to multiple equilibria. A move from an equilibrium without valuation to an equilibrium with valuation has many features of a credit crunch: valuation equilibria have lower prices/higher interest rate spreads, lower levels of investment and trade, no investment by uninformed investors, and profitable valuation.

The private benefits to valuation exceed its social benefits so that, when both are possible,

¹As we discuss, this channel is different from that in Dang (2008) and Glode et al. (2012) both technically, as valuation in our model uncovers information about the joint surplus from trade, and economically, as the externality in our model operates through the market price.

the equilibrium without valuation is always more efficient than the equilibrium with valuation is. Further, there are parameters for which the equilibrium is unique and involves valuation, and yet funding all projects without valuation would be more efficient. In terms of policy, to ensure the efficient outcome requires not just a large, unsophisticated investor, but one with the ability to commit to a price *ex ante*, and, when the more efficient outcome is not an equilibrium, a price subsidy.

Specifically, we consider a rational expectations model of a competitive market in which risk-neutral sellers seek to originate and sell projects/assets at prices above their reservation value, and risk-neutral investors compete to buy these assets given a fixed opportunity cost of capital. Sellers' assets are *ex ante* identical, but *ex post* payoffs are heterogeneous across assets.

There are two types of investors. *Unsophisticated* investors are competitive price-takers who buy assets at their expected present discounted values. *Sophisticated* investors invest *ex ante* in capacity to perform valuation and can commit to valuing before buying any assets (modeled as an *ex ante* choice of available funds). Valuation capacity is costly and limited in aggregate. The use of a unit of valuation capacity provides a signal of the quality of an asset. Conditional on a good signal, an asset is worth more than the reservation value in expectation; conditional on a bad signal, it is not. Valuation is unobservable and nonverifiable, and all sellers are anonymous in the sense that the never-valued asset is indistinguishable from the previously-valued asset to every seller except the one that performed the valuation. This assumption is critical (and discussed in Sections 4.3.2 and 5). Thus when a sophisticated investor who values an asset, observes a bad signal of the future payoff, and does not buy it, these actions decrease the average quality of the pool of assets for other investors, which lowers the equilibrium price paid by unsophisticated investors and in turn raises the profitability of valuation. This externality makes valuation a strategic complement.²

²In the language of Hellwig and Veldkamp (2009), the choice of the technology to uncover information is a

There is a range of parameters over which the market has multiple equilibria. In a *pooling equilibrium* no asset is valued, all assets are sold, and because investors with unlimited capital compete to purchase assets, prices are high. In a *pure valuation equilibrium* sophisticated investors invest in valuation capacity, value as many assets as they can, and only good assets are sold/funded. In this pure valuation equilibrium, because sellers compete for limited investors with valuation capacity, prices are low. The multiplicity is due to the strategic complementarity. The more assets are valued, the lower the average quality of unvalued assets. If the average quality falls below the seller's reservation value, unsophisticated investors leave the market, and only assets that are valued and found to be good are traded.³

A pooling equilibrium has the features of a credit boom in which market volume and prices are high, whereas the pure valuation equilibrium has the features of a credit crunch in which market volume and prices are low. A switch from a pooling equilibrium to a pure valuation equilibrium, which we call a *valuation run*, has many of the features of a credit crunch or asset market panic.⁴ In such a switch in equilibrium, volume falls because sellers with assets that would have been sold in the pooling equilibrium are unable to get evaluated and so are unable to sell in the pure valuation equilibrium. Prices fall because sellers lose market power to sophisticated investors: unsophisticated investors that would have competed to buy assets in the pooling equilibrium are unwilling to buy, and so sellers compete for limited valuation. Sophisticated investors earn rents.⁵ Further, there is a flight to quality in two strategic complement, but information is a strategic substitute, in that sophisticated investors want different information from each other (information about different assets).

³Over a different region of parameters, the market can either be in a pooling equilibrium or a mixed equilibrium with low prices but in which sophisticated investors value as many assets as they can, purchase only the good ones, and unsophisticated investors purchase both the rejected assets and the unvalued assets.

⁴In a bank run, agents protect themselves by withdrawing funds because they expect others to do so and funds are not lent to one bank; in our model, sophisticated agents protect themselves by investing in valuation capacity because they expect others to do so and funds are not lent to many distinct entities.

⁵Although we do not model what happens to assets once sold, in mapping to the real world, all investors

senses: only good assets are traded/funded, and unsophisticated investors leave the market and hold their funds elsewhere. Finally, because of the multiple equilibria, this shift need not be tied directly to changes in fundamentals, although changes in fundamentals can bring about the possibility of collapse and/or make collapse ultimately inevitable.

In the region of multiple equilibria, the socially efficient outcome is the pooling equilibrium in which investors pay the expected present value for assets—denote this $E[D]/R$ —and there is no incentive to do valuation. To see the intuition for why this is socially efficient, consider a sophisticated investor’s decision in this pooling equilibrium. To attract a seller for valuation, the sophisticated investor must offer $E[D]/R$ for a good project (a lower offer and sellers simply sell at $E[D]/R$ without valuation). A seller approaching this sophisticated investor sells at $E[D]/R$, either to the sophisticated investor if its project is identified to be good or to an unsophisticated investor if it is identified to be bad. Therefore this seller’s payoff is unchanged, as are the payoffs of all other sellers and investors. Thus the social gain to this first unit of valuation equals the sophisticated investor’s private gain. Because in a pooling equilibrium there is no incentive to do valuation, it must be that the sophisticated investor’s private gain to valuation is negative, and hence the social gain to valuation is negative. While the private gains to valuation are larger with more aggregate valuation because of a lower market price, the social gains do not depend on price and remain negative in any region where the pooling equilibrium exists.

More strikingly, funding all assets without valuation is more efficient even in some regions where the market delivers only the pure valuation equilibrium. This follows from the fact that a seller with an asset that is valued and found to be bad can sell to an unsophisticated investor at a high price in a hypothesized pooling equilibrium. Thus, the unsophisticated investors, rather than the sophisticated investor or seller associated with the asset being valued, bear the downside risk of valuation. The sophisticated agent ignores this externality

potentially have mark-to-market losses on asset holdings because of the price decline.

and chooses to invest in valuation technology in regions where the social planner, internalizing this externality, would prefer all funding occur without valuation.

Can policy correct inefficient market outcomes? Lowering interest rates (or an equivalent subsidy to investors to buy assets) is counterproductive, in that it increases the region in which the pure valuation equilibrium is a possible equilibrium. Subsidizing the payout of bad assets is more effective in that it reduces the region in which valuation in equilibrium is possible by reducing the economic return to separating the good from the bad. A tax on valuation capacity can ensure the pooling equilibrium wherever it is efficient.⁶

More interestingly, because the pooling equilibrium is more efficient, a large unsophisticated investor can ensure the pooling equilibrium where it exists if it has the ability to commit to purchase at the pooling price before sophisticated investors invest in the capacity to do valuation. Further, there exists a subsidy for purchases such that if the large investor commits to purchase at a high enough price, the economy would be in a pooling equilibrium wherever a pooling equilibrium would be more efficient. That said, this policy could potentially be detrimental if the policy were misapplied so that the large investor did not deter valuation and instead purchased previously rejected assets at high prices.

Finally, one might consider policy changes to the model environment to make valuation observable. Such a change would eliminate the valuation externality and make all market equilibria efficient. However, the incentive of the paired sophisticated investor and seller with a bad asset is to hide both the fact of and the outcome of valuation, suggesting that such a policy might be hard to achieve.

In our model, markets can produce too much information. Most previous work on information acquisition and the trading and pricing of financial assets assumes that the information acquired either reveals information that was previously private and so solves problems

⁶Notably, the model omits many benefits of valuation, and in particular that valuation might reveal information about the aggregate payoff of all assets.

of asymmetric information, or alternatively reveals information that is common across assets and revealed by trade and prices. These modeling assumptions each imply that if anything there is too little information produced from a social perspective. In contrast, our key modeling choice is that valuation creates private information about a payoff that is common across agents but unique to the particular asset. In our paper, by creating private information before trade, valuation can cause adverse selection and market collapse, following the insights of Akerlof (1970) and Hirshleifer (1971).

Our mechanism is theoretically and economically novel relative to previous papers that argue that valuation can be a strategic complement, can lead to breakdowns in trade, and can have negative consequences for efficiency. Dang (2008) models trade as a bargaining game in which there is a fixed gain to trade and valuation provides private information about common value. In contrast, in our model, valuation provides private information about the gains from bilateral trade. As a result, in Dang (2008), valuation is a strategic complement because more information about the common value on one side of the transaction worsens the winners curse on the other side. In contrast, in our model, valuation is a strategic complement because more valuation in the market lowers the market price, which increases the private gains from valuation (and the private efficiency of trade). Unlike in Dang (2008), informed investors always trade when efficient and more valuation in the market lowers market prices.

Second, and more importantly, our model includes a reason that valuation is good: it can reveal that a project is not worth funding.⁷ Thus, valuation can be socially and privately efficient, which has implications for policy.

Our work is similarly differentiated from that of Glode et al. (2012), which models market booms and freezes as driven by variation in the volatility of the common value of the asset relative to the gains from trade following the choice of valuation capacity. Similarly, the

⁷If in our setting there were always gains from trade as in Dang (2008) then trade would never collapse.

work of Dang et al. (2009) extends the analysis of Dang (2008) to consider how to design a security to maintain maximum liquidity in a secondary market.⁸ We keep the security design problem here simple, citing reasons of moral hazard and lack of funds/collateral, but more generally, the differences between these models and ours suggest that our mechanism is more applicable to originating primary assets rather than trading in secondary markets.

Finally, and most closely related to our paper, the contemporaneous paper Bolton et al. (2011) studies an externality similar to ours in a model in which agents choose whether to become sophisticated, and then compete with unsophisticated exchanges. Unlike in our model, sellers know their type and take unobserved actions leading to a moral hazard problem, and sophisticated buyers screen with contracts, so that the policy implications of the two setups differ. Moreover, Bolton et al. (2011) focuses on a different substantive application, the size of the financial sector in the long run. See also the related paper by Farhi et al. (2013).

Our model omits many elements present in other theories of credit crunches; in what markets or under what circumstances is our model likely to apply? All markets have valuation, and every asset is valued up to some point, and then pooled with observationally equivalent assets. What distinguishes our theory is that unsophisticated investors cannot observe which projects have been previously valued and sophisticated investors are able to get rents from their information gathering. These are features of lending to small businesses and households, and some over-the-counter markets.

⁸Two other papers on security design are worth noting. Marin and Rahi (2000) considers security design and shows how the optimality of complete versus incomplete markets (complete versus incomplete revelation of private information) depends on the costs of adverse selection on private information relative to the costs of reduced *ex ante* insurance. Pagano and Volpin (2012) considers security design and then a later equilibrium in which trade occurs in a noisy rational expectations equilibrium so that information can get rents. Even though the model exhibits an externality from valuation, it does not generate multiplicity of equilibrium beyond those always possible in noisy rational expectations equilibria (Breon-Drish 2015), nor is there a role for commitment, and so optimal policy is different.

We see three situations where our model may prove useful in understanding credit crunches. First, in new markets there is little record on the performance of new types of assets and the investment associated with them. Valuation beyond a certain point is impossible and, conditional on certain characteristics, all real investment is funded. As the performance of different assets/investments is observed, valuation costs may decline over time, and as valuation costs decline, the collapse to the pure valuation equilibrium becomes possible and ultimately inevitable. In this case, the precursors to collapse are the two main factors identified by Kindleberger (2000): credit, worsened by leverage which is not present in the model, and displacement, a new technology or investment opportunity. Second, in markets where initially all assets are good, the market is automatically in a pooling equilibrium because there is no information to uncover with valuation. However, because there is no incentive to produce assets of higher quality along the unvalued dimension, the share of good assets may naturally decline over time, which again makes a collapse to the pure valuation equilibrium possible and possibly inevitable. Third, our model is most relevant when bad signals are rare. All three situations are elements of the 2007-2008 subprime mortgage crash and the financial crisis more generally (see Gorton 2010).⁹ Of course, for our model to capture aspects of a widespread financial crisis, it must be that one market is particularly important—like the mortgage market—or equilibrium selection must be correlated across markets.

1. The Model

This section describes our model. Key assumptions are discussed in Section 4.3.2.

There are a unit mass of risk-neutral sellers, each endowed with one potential asset (or project) and no cash. An asset requires an investment of 1 to originate, and if originated it pays out a random amount $D \geq 0$ in the future. Sellers have no funds and seek to sell their

⁹It is also possible that our model may prove useful in understanding high-frequency patterns where there is evidence that informed traders can “cream skim” the best deals (Seppi 1990; Easley et al. 1996).

assets to risk-neutral investors. A seller sells all or none of the asset. If the asset is sold for $P \geq 1$, then the seller invests 1 to originate the asset and keeps the remainder for a payoff of $P - 1$; and the investor's payoff is $D/R - P$, where R is the gross interest rate. If the only offered price is $P < 1$, then, because this is insufficient to originate the asset, the asset is not originated or sold and is abandoned, and the seller's payoff is 0.

Potential assets are *ex ante* identical across sellers, and initially all sellers and investors have the same information and therefore common expectation, $E[D]$. However, there are two types of investors, sophisticated investors who can acquire information about the value of an asset—we refer to this information acquisition as the valuation of an asset—and a competitive fringe of unsophisticated investors who cannot acquire any information and have access to unlimited funds. Unsophisticated investors will quote a breakeven price. We index the continuum of investors, first sophisticated, then unsophisticated, by i .

At the outset (before any buying/selling of assets) sophisticated investor i chooses how much capital to raise to purchase assets, f_i (f for funds), and how much valuation capacity to acquire, h_i (h for human capital). The choice of funding capacity is a device that allows buyers to commit to buy only after valuation. The cost of a unit of valuation capacity is c up to $\bar{h} > 0$ for sophisticated investor i , and infinite thereafter, so $h_i \leq \bar{h}$.¹⁰ Denote the aggregate amount of valuation capacity by $H = \int_{i \in \{Sophisticated\}} h di$, and the aggregate constraint on total valuation capacity by $\bar{H} = \int_{i \in \{Sophisticated\}} \bar{h} di < 1$, so

$$H \leq \bar{H} < 1. \tag{1}$$

Each unit of valuation capacity allows the valuation of one asset revealing a signal about the payoff of that particular asset. It is a binary signal, and the expected payoff of the valued

¹⁰The limit can be due to a limited number of people with the ability to do valuation. An alternative assumption with the same implications is that there is a limit on the amount of financial capital available to the sophisticated investors. That is, the aggregate constraint on valuation could be due to limits-to-arbitrage rather than a technological or resource constraint.

asset is $D^g \equiv E[D|good]$, conditional on a *good* signal and $D^b \equiv E[D|bad]$, conditional on a *bad* signal. The same information is uncovered by anyone doing valuation.¹¹ Assume that a good asset is worth investing in/buying and a bad asset is not:

$$D^g/R > 1 > D^b/R.$$

If a sophisticated investor values an asset, the investor will offer to buy the asset if (and only if) it is determined to be good. The outcome of valuation is observed by both the investor and the seller, but is not observable by other investors or sellers. Investors may also buy assets without first valuing them. The population share of good assets is $\lambda \in (0, 1)$, so $E[D] = \lambda D^g + (1 - \lambda) D^b$.

Investors are not anonymous: market participants can observe which investors are sophisticated and unsophisticated and can observe investors' available funds, their investment in valuation capacity, and the prices offered.

Sellers are anonymous. In particular, a seller who is unable to sell his asset to a sophisticated investor because the asset is determined to be bad can join the pool of sellers facing an investor who buys assets without valuing them. This assumption provides a static analog to a dynamic process with valued assets indistinguishable from new entrants. We discuss a foundation for this structure, based on Zhu (2012), in Appendix C.

Besides choosing valuation and funding capacity, h_i and f_i , each sophisticated investor also chooses a price P_i^g at which it will buy assets that it determines to be good, and a price P_i^U at which it will buy assets that it has not valued. These choices are observable by all. Each unsophisticated investor i chooses a price P_i^U at which it will buy assets. Interpret a price quote $P_i^U < 1$ as meaning that the investor will not buy unvalued assets.

¹¹An interesting paper with a similar approach to information but a different structure and implications is Broecker (1990), in which valuation is costless but noisy, and correlated across lenders. In equilibrium, the winners curse from noisy valuation interacts with the adverse selection problem to generate an equilibrium with a continuum of interest rates across different banks.

Sophisticated investors who only buy assets after valuing them are only approached by investors who have not been valued elsewhere. This is because those who were valued and found to be good are funded elsewhere, and those who were valued and found to be bad have no incentive to be valued, and found to be bad, again. Consequently for these investors, valuing h_i assets identifies a nonstochastic share λ of good assets (the population share of good assets), and consequently, asset purchases totaling $\lambda h_i P_i^g$. Therefore, this sophisticated investor i will choose funding $f_i = \lambda h_i P_i^g$. Any lower and the investor could cut cost by reducing h_i , eliminating unnecessary valuation capacity. Any higher and the investor is no longer committed to buying assets only after valuing them.

By contrast, unsophisticated investors and sophisticated investors with capital $f_i > \lambda h_i P_i^g$ may buy assets without valuing them. Therefore, these investors will be approached by sellers who were already valued and found to be bad, as they still might get funding with one of these investors. Thus, suppose a share $s \leq H$ of sellers are valued by some sophisticated investor. Then the pool that remains for investors who may buy assets without valuation includes the share $1 - s$ of sellers who were not yet valued (the probability they are good is λ) plus the share $s(1 - \lambda)$ of sellers who were already valued and found to be bad. Therefore, for this pool of sellers, the probability that a seller's asset is good is

$$\frac{(1 - s)\lambda}{(1 - s) + s(1 - \lambda)}. \quad (2)$$

Any investor who buys assets without valuing them faces an adverse selection problem and consequently the probability in (Expression (2)) is less than λ when $s > 0$.

As noted earlier, our assumption regarding the pools of sellers facing the different investors can be motivated by a dynamic model in which sellers approach investors sequentially and investors cannot observe which sellers have previously been valued by other investors.

2. Value Functions

This section derives value functions for sellers and investors: a first subsection for sophisti-

cated investors and sellers approaching them, and a second subsection for unsophisticated investors and sellers approaching them. Then we present the definition of equilibrium.

2.1 Sophisticated investors

As noted above, a sophisticated investor will not buy an asset that it determines to be bad as the value of the asset is less than the cost of originating it ($D^b/R < 1$). What price will it offer for an asset determined to be good? The price offered must be at least 1; any less and the seller could not cover the origination cost and so the asset would be abandoned. In addition, because competition will lead all unsophisticated investors to offer the same breakeven price P^U , the sophisticated investor must offer at least P^U . Because valuation capacity is insufficient to value all assets (our assumption that aggregate valuation capacity $\bar{H} < 1$), and because sellers are anonymous and valuation is nonverifiable, sophisticated investors do not compete for valued assets. Instead they offer prices that match the better of a seller's other two options (sell the asset to an unsophisticated investor or abandon it). Thus, the price offered by sophisticated investor i for an asset found to be good is (epsilon more than)

$$P_i^g = P^g = \max [P^U, 1]. \quad (3)$$

Summarizing, we have the following lemma.

Lemma 1 *A sophisticated investor matched with an asset that it has valued*

(i) buys the asset at $P^g = \max [P^U, 1]$ if it is good.

(ii) does not buy the asset if it is bad.

Next, we turn to the choice of funds by sophisticated investors. If no valuation capacity is purchased ($h_i = 0$), we assume zero funds are chosen.¹²

¹²Although it is possible that a sophisticated investor that does not invest in valuation capacity mimics an unsophisticated investor and chooses a large amount of funding capacity, this does not affect the equilibrium price or quantity, and we ignore this for ease of exposition.

Suppose valuation capacity is positive, $h_i > 0$. As discussed above, no sophisticated investor i chooses funds $f_i < P^g \lambda h_i$, which is the cost of purchasing all the good assets it would find using all its valuation capacity when only unvalued sellers approach it. Thus, because sophisticated investors can outcompete sellers' alternatives (by offering sellers epsilon more than $\max [P^U, 1]$ for good assets), all valuation capacity, H , is used.

Further, no sophisticated investor i chooses funds $f_i > P^g \lambda h_i$, which would allow it to also buy assets without valuation. As discussed above, such a choice would lead to a contamination of the pool of sellers facing this sophisticated investor by attracting sellers who have already been valued and determined to be bad. Hence, the pool of sellers facing this sophisticated investor would have the same probability of being good as those facing the unsophisticated investors, which equals $\frac{1-H}{1-\lambda H} \lambda$ (by Expression (2)). This implies that the profit derived from its valuation capacity h_i would be lower, because $h_i(-c + \frac{1-H}{1-H\lambda} \lambda (\frac{D^g}{R} - P^g)) < h_i(-c + \lambda (\frac{D^g}{R} - P^g))$ for $H > 0$. Moreover this investor cannot make up this lost profit on purchases without valuation because the investor must pay the breakeven price. Thus, $f_i = P^g \lambda h_i$, so that each sophisticated investor chooses only the funding capacity that is needed to fully use its valuation capacity. This result is summarized in the following lemma.

Lemma 2 *If $h_i > 0$, sophisticated investor i chooses funds $f_i = P^g \lambda h_i$, gets a share λ of good assets, only buys the λh_i assets found to be good, and uses all its funding capacity.*

From here on, we refer only to valuation capacity because funding capacity equals valuation capacity. We can now derive the value functions that characterize equilibria.

The value of investing in a unit of valuation technology is the probability of finding a good asset times the profits on a good asset less the cost of the valuation technology:

$$J^S (P^U) = \lambda \left(\frac{D^g}{R} - \max [P^U, 1] \right) - c, \quad (4)$$

where we are using $P^g = \max [P^U, 1]$. This equation is linear and decreasing in the one endogenous variable, $\max [P^U, 1]$, the market price for assets. This linearity implies that the model has the potential for multiple equilibria if the price P^U decreases in the aggregate use of valuation.

Turning to sellers, the (net) expected value to an uninformed seller of going to a sophisticated investor is

$$W^S = \lambda(P^g - 1) + (1 - \lambda) \max [P^U - 1, 0] \quad (5)$$

$$= \max [P^U - 1, 0], \quad (6)$$

where the max term reflects that the seller found to have a bad asset chooses between selling the asset to an unsophisticated investor or abandoning the asset, and where by Lemma 1, $P^g = \max [P^U, 1]$.

By not buying unvalued assets, sophisticated investors deter sellers who know they have a bad asset from approaching them. Is there another way to deter such sellers? Consider a contract from a sophisticated investor that (i) specifies a probability of conducting a valuation, (ii) imposes a penalty on sellers if a valuation identifies their asset to be bad, and (iii) buys both assets determined to be good and unvalued assets (possibly at different prices). For a given seller penalty and price of unvalued assets there is a valuation probability less than one that would deter sellers who know they have bad assets (the price for a good asset will not matter for the calculation here because a seller with a bad asset would never receive that price). This contract is ruled out in the analysis herein by our assumption that the seller has no cash. However, if it were feasible, such a contract could potentially add value by economizing on costly valuations.¹³

¹³Another potential screening mechanism could involve a penalty on a seller depending on the asset's payoff (rather than the valuation)—that is, have the seller bear some risk. Two common foundations that preclude such an arrangement are moral hazard on the part of the new owner (the investor) or there being no resources for the investor to collect if the asset turns out to be bad.

2.2 Unsophisticated investors

By Lemma 2, no sophisticated investors buy unvalued assets. At what price will unsophisticated investors buy assets? Using Expression (2), for the pool of sellers facing unsophisticated investors, the probability an asset is good equals:

$$\frac{\lambda(1-H)}{1-\lambda H}. \quad (7)$$

This pool contains the $1-H$ sellers who were not valued (who have a probability λ of having a good asset) and the $H(1-\lambda)$ sellers who were valued by sophisticated investors but were rejected (who have zero probability of having a good asset). When no assets are valued, $H=0$, Expression (7) equals the population share of good assets, λ . Denote by J^U an unsophisticated investor's value of a buying an asset without valuation, which is the expected discounted payoff of the asset less the price paid:

$$J^U = \frac{\left(\frac{\lambda(1-H)}{1-\lambda H}\right) D^g + \left(1 - \frac{\lambda(1-H)}{1-\lambda H}\right) D^b}{R} - P^U.$$

Price competition among unsophisticated investors leads to zero profit in equilibrium, $J^U = 0$, which implies a price paid by unsophisticated investors of

$$P^U = P^U(H) \equiv \frac{\lambda(1-H) D^g + (1-\lambda) D^b}{(1-\lambda H) R}. \quad (8)$$

Unsophisticated investors set the market price as a function of the average quality of assets they face in equilibrium. If $P^U(H) > 1$, then unsophisticated investors buy the assets not purchased by sophisticated investors. If $P^U(H) \leq 1$, then unsophisticated investors do not buy any assets.

For a seller (with or without information about its asset's value), the value of approaching an unsophisticated investor is

$$W^U = \max [P^U - 1, 0] \quad (9)$$

which, because $J^U = 0$, is also the social surplus of this transaction.

Equation (8) and the value function of the sophisticated investors, Equation (4), illustrate the main externality in the model. Profits of sophisticated investors are decreasing in P^U , which in turn is decreasing in the aggregate amount of valuation capacity purchased. More valuation worsens the pool of assets purchased by unsophisticated investors, which lowers the price they are willing to pay, which lowers the price that sophisticated investors have to pay for good assets, which makes valuation more profitable. This strategic complementarity is critical.

An equilibrium consists of $\{H, P^g, P^U\}$, where (i) total valuation capacity is $H = \int h_i di$, and $h_i \leq \bar{h}$ so $H \leq \bar{H}$, and no sophisticated investor i can increase his expected profit by choosing a different h_i ; (ii) the price at which sophisticated investors buy good assets, P^g , is given by Equation (3); and (iii) unsophisticated investors' breakeven price, P^U , is given by Equation (8).

3. Equilibria

Equilibria can now be characterized. There are four types of equilibria, two with no valuation and two with valuation.

3.1 Equilibria without valuation

There are two possibilities without valuation. There is a pooling equilibrium in which no assets are valued but all are sold, and there is a no trade equilibrium in which no assets are valued or sold.

3.1.1 The pooling equilibrium

In a pooling equilibrium there is no investment in valuation capacity, $h_i = H = 0$, and all sellers obtain funding from unsophisticated investors. Unsophisticated investors buy assets (without valuation) at price $P^U(0) = [\lambda D^g + (1 - \lambda) D^b]/R$. All assets are originated and traded, and so the volume is 1.

For the pooling equilibrium to exist, sophisticated investors must find it unprofitable to invest in valuation capacity, and unsophisticated investors must be able to break even buying

assets at a price $P^U > 1$, both when $H = 0$:

$$J^S(P^U(0)) \leq 0 \text{ and } P^U(0) > 1,$$

which is equivalent to

$$c \geq \lambda(1 - \lambda) \frac{D^g - D^b}{R} \text{ and } \lambda > \frac{R - D^b}{D^g - D^b}. \quad (10)$$

The pooling equilibrium exists as long as (i) the marginal cost of the valuation technology is large enough relative to the gain from valuation, and (ii) the population expected return is high enough. Note that the right side of the first inequality equals the probability of an asset being good (λ) times the joint gain in value when it is good, $(1 - \lambda) \frac{D^g - D^b}{R} = \frac{D^g}{R} - \frac{\lambda D^g + (1 - \lambda) D^b}{R} = \frac{D^g}{R} - P^U$, which is the private value of information at the margin in the pooling equilibrium.

3.1.2 The no-trade equilibrium

In a no-trade equilibrium there is no investment in valuation capacity, $h_i = H = 0$; $P^U \leq 1$; and no sellers are funded. Volume is 0.

For the no-trade equilibrium to exist, sophisticated investors must find it unprofitable to invest in valuation capacity and unsophisticated investors must be unable to break even buying assets at a price $P^U > 1$, both with $H = 0$:

$$J^S(P^U(0)) \leq 0 \text{ and } P^U(0) \leq 1,$$

which is equivalent to

$$c \geq \lambda \left(\frac{D^g}{R} - 1 \right) \text{ and } \lambda \leq \frac{R - D^b}{D^g - D^b}. \quad (11)$$

If the cost of valuation capacity is high enough and the population expected return is low enough, then there is no trade.

3.2 Equilibria with valuation

We focus on two types of equilibria in which investors invest in valuation capacity. First,

there is a pure valuation equilibrium in which sophisticated investors do valuation, buy as many good assets as they can, and make profits; the residual pool of assets is so poor on average that unsophisticated investors do not buy any assets. Second, there is a mixed equilibrium in which sellers sell both with and without valuation. This occurs when the pool of assets remaining after sophisticated investors value and purchase assets is good enough that purchasing assets without valuation is still profitable. For completeness, we note that there is also a third type of equilibrium with valuation, also mixed, but we show that it is a knife-edge case and hence not interesting.

3.2.1 The pure valuation equilibrium

In a pure valuation equilibrium there is maximal investment in valuation capacity, $h_i = \bar{h}$ and $H = \bar{H}$; \bar{H} sellers are valued by sophisticated investors; $P^U \leq 1$, and so no sellers obtain funding from unsophisticated investors; and the assets identified as good by sophisticated investors are purchased at $P^g = 1$. The volume of trade is $\lambda \bar{H} < 1$.

For the pure valuation equilibrium to exist, sophisticated investors must find it profitable to invest in valuation up to its capacity constraint, and unsophisticated investors must be unable to break even buying assets at a price $P^U > 1$ with $H = \bar{H}$:

$$J^S(P^U(\bar{H})) > 0 \text{ and } P^U(\bar{H}) \leq 1,$$

which is equivalent to

$$c < \lambda \left(\frac{D^g}{R} - 1 \right) \text{ and } \lambda \leq \frac{R - D^b}{(D^g - D^b) - \bar{H}(D^g - R)}. \quad (12)$$

The pure valuation equilibrium exists as long as (i) the marginal cost of valuation is low enough relative to the gain from valuation, which is the probability that a transaction occurs times the gain from transacting, and (ii) the share of good assets is low enough (or \bar{H} is high enough) that buying without valuation is not profitable after \bar{H} assets are valued by sophisticated investors.

It is worth noting that, with \bar{H} near 1, the private benefits to valuation in the valuation equilibrium rise as the share of good assets in the population, λ , rises near 1 ($J^S(1)$ is increasing in λ). Thus, the pure valuation equilibrium can occur for a larger range of valuation costs as λ rises (see the first inequality in Condition (12)). However, as λ increases, it is also the case that the social benefits from being in a valuation equilibrium decline relative to a pooling equilibrium. As λ rises, the share of bad assets declines, and the social benefits of the valuation equilibrium come from not funding bad assets. Although there are other factors at work, this previews one of the results of Section 4.2, that valuation can be socially inefficient but privately optimal.¹⁴

3.2.2 The mixed equilibrium

In a mixed equilibrium there is maximal investment in valuation capacity, $h_i = \bar{h}$ and $H = \bar{H}$; \bar{H} sellers are valued by sophisticated investors, and $\lambda\bar{H}$ of these are funded; the remaining $(1 - \lambda)\bar{H}$ along with $1 - \bar{H}$ unvalued sellers are funded by unsophisticated investors; and assets are purchased (both by sophisticated and unsophisticated investors) at a price of

$$P^g = P^U(\bar{H}) = \frac{\lambda(1 - \bar{H})D^g + (1 - \lambda)D^b}{(1 - \lambda\bar{H})R}.$$

All assets trade, so volume is 1. As in the pure valuation equilibrium, sophisticated investors have market power and earn the rents of valuation, but now they compete with unsophisticated investors rather than the seller's abandonment option. Thus, sophisticated investors pay $P^U(\bar{H})$ for assets instead of 1.

For the mixed equilibrium to exist, sophisticated investors must find it profitable to invest in valuation up to its capacity constraint and unsophisticated investors must be able to break even buying assets at a price $P^U > 1$, with $H = \bar{H}$:

¹⁴There is a discontinuity (outside our assumed range) at $\lambda = 1$, where the valuation equilibrium cannot occur for $c > 0$ even when $\bar{H} = 1$.

$$J^S(P^U(\bar{H})) > 0 \text{ and } P^U(\bar{H}) > 1, \quad (13)$$

which is equivalent to

$$c < \frac{\lambda(1-\lambda)}{1-\lambda\bar{H}} \frac{D^g - D^b}{R} \text{ and } \lambda > \frac{R - D^b}{(D^g - D^b) - \bar{H}(D^g - R)}. \quad (14)$$

The first inequality in Condition (14) places an upper bound on the valuation cost relative to the value of the information uncovered. The right side of this inequality is a scaled-up (by $1/(1-\lambda\bar{H})$) version of the right side of the first inequality in Condition (10) for the pooling equilibrium. The scaling reflects the difference in the price of assets between the pooling equilibrium and the mixed equilibrium, where the price is lower in the latter equilibrium. The second inequality states that the share of good assets λ is high enough (or \bar{H} is low enough) that transacting without valuation is profitable after \bar{H} assets are valued by sophisticated investors. As $\bar{H} \rightarrow 1$, this lower bound on λ goes to 1. It is the exact complement to the second inequality for the pure valuation equilibrium.

3.2.3 The “unstable” mixed equilibrium

For completeness, we note that there can also exist an equilibrium in which sophisticated investors invest in positive but less than maximal valuation capacity and earn zero profit while unsophisticated investors break even buying the remaining assets. This equilibrium is unstable in the sense that if sophisticated investors invested in slightly more valuation capacity, the quality of assets bought by unsophisticated investors would be reduced. This in turn would reduce the price of assets, making valuation more profitable, and inducing sophisticated investors to invest in valuation capacity up to the maximal level. Similarly, a slightly higher share of sellers choosing to obtain financing from unsophisticated investors would raise the price of assets, inducing all sophisticated investors to make no investment in valuation capacity. In Appendix B, we show that this unstable mixed equilibrium exists for all parameters such that the pooling equilibrium exists and either the pure valuation

equilibrium or the mixed equilibrium exists. Because this equilibrium is a knife-edge case, we do not consider it further.

4. Analysis

We first formally state our main results that there are regions of multiple equilibria. Second, we rank equilibria by efficiency. Third, we discuss our key assumptions and interpret a switch in equilibrium from the pooling equilibrium to a pure valuation or mixed equilibrium as a credit crunch or valuation run.

4.1 Regions of multiple equilibria

The following proposition characterizes the possible equilibria.

Proposition 1 *Equilibria*

- (i) *At least one of the four equilibria exists.*
- (ii) *There can be a unique equilibrium with any one of the pooling, pure valuation, mixed, or no-trade equilibria.*
- (iii) *There can be multiple equilibria. Multiple equilibria must involve either the pooling and pure valuation equilibria; or the pooling and mixed equilibria.*

The proof (in Appendix A.1) follows from the conditions for each equilibrium to exist given in the previous section.

[Figure 1 about here]

Figure 1 plots the areas in which each equilibrium exists in $\lambda - c$ space (for $R = 1.1$, $D^g = 1.14$, $D^b = 1.09$, and $\bar{H} = 0.90$). When the cost of valuation is low enough, only equilibria with valuation exist. When it is high enough, either the no-trade equilibrium or the pooling equilibrium exists. When the share of good assets is low enough, only the no-trade equilibrium exists. When the share of good assets is large enough, only the pooling equilibrium exists. For intermediate costs of valuation and an intermediate share of good assets, multiple equilibria exist.

The pooling and pure valuation equilibria may both exist. In such a region, in the pooling equilibrium there is no adverse selection problem facing unsophisticated investors, and the price they pay for assets is high (the expected value of an asset). This high price eliminates the incentive to perform valuations. Alternatively, in the pure valuation equilibrium, unsophisticated investors face a severe adverse selection problem, and buy no assets and the price of assets is low. This low price allows sophisticated investors to profit by doing valuation and buying good assets at low prices. Similar forces are at work when both the pooling and mixed equilibrium exist, except that in this case, when sophisticated investors are performing valuations, the adverse selection problem is not severe enough to drive unsophisticated investors out of the market.

4.2 Efficiency of equilibria

We define efficiency as maximizing social surplus: the sum of the value functions of the unit mass of sellers and all investors who buy assets. We show that in the region of multiplicity, the socially efficient outcome is always the pooling equilibrium. More strikingly, there is a region where the market delivers only the pure valuation equilibrium and in which it would be more socially efficient for investors to buy all assets without valuation (Pareto superior with transfers).

Social surplus in a no-trade equilibrium is $V^n = 0$ as no assets are purchased and there is no expenditure on valuation capacity. Social surplus in a pooling equilibrium is given by

$$V^p = \frac{\lambda D^g + (1 - \lambda) D^b}{R} - 1 \quad (15)$$

as all assets are purchased and there is no expenditure on valuation capacity. Social surplus in a pure valuation equilibrium is given by

$$V^v = \bar{H} \left(-c + \lambda \left(\frac{D^g}{R} - 1 \right) \right) \quad (16)$$

as \bar{H} assets are valued at cost $\bar{H}c$, and $\lambda\bar{H}$ assets are identified as good and are purchased. The remaining unpurchased assets include the $(1 - \lambda)\bar{H}$ assets that are valued but determined

to be bad, and the $1 - \bar{H}$ assets that are not valued and not purchased. Finally, social surplus in a mixed equilibrium is given by

$$V^m = -\bar{H}c + \frac{\lambda D^g + (1 - \lambda) D^b}{R} - 1. \quad (17)$$

While \bar{H} assets are valued, all assets are purchased. Sophisticated investors purchase the $\lambda \bar{H}$ assets that they identify as good, and unsophisticated investors purchase the $(1 - \lambda) \bar{H}$ assets that are valued but determined to be bad and the $1 - \bar{H}$ assets that are not valued.

We rank the equilibria in terms of social surplus in the following proposition, proved in the Appendix A.2.

Proposition 2 *Ranking of equilibria*

(i) *For parameters such that the pooling equilibrium exists, the pooling equilibrium is more efficient than the pure valuation equilibrium, $V^p > V^v$, and the mixed equilibrium, $V^p > V^m$ (the other two equilibria that may exist);*

(ii) *For parameters such that the pooling equilibrium does not exist:*

(a) *if the pure valuation equilibrium exists and $E[D] > R$, then this equilibrium is less efficient than an outcome with the sale of all assets without valuation if and only if*

$$c \geq c^{Eff} \equiv \frac{(1 - \lambda \bar{H}) R - (1 - \lambda) D^b - (1 - \bar{H}) \lambda D^g}{\bar{H} R}. \quad (18)$$

(b) *if the mixed equilibrium exists, then this equilibrium is less efficient than an outcome with the sale of all assets without valuation.*

(c) *if the no trade equilibrium exists, then this equilibrium is more efficient than an outcome with the sale of all assets without valuation.*

That the pooling equilibrium is more efficient than a mixed equilibrium is obvious. In both, all assets trade. However, in the mixed equilibrium this comes with the cost of valuing

\bar{H} sellers. Recall that in the mixed equilibrium, even the assets determined to be bad are sold (to unsophisticated investors). Thus, even if the pooling equilibrium does not exist, the sale of all assets without valuation still leads to higher social surplus than in the mixed equilibrium.

To see why the pooling equilibrium, if it exists, is more efficient than the pure valuation equilibrium is, note that in the latter, sophisticated investors buy $\lambda\bar{H} < 1$ assets (valuing \bar{H} assets and buying the good assets which are fraction λ of the total). Because the pooling equilibrium exists, the first inequality in Condition (10) is satisfied. This means that the valuation cost c is high enough that sophisticated investors would, at best, break even buying the good assets it identifies at a price of $E[D]/R$. Hence with $\lambda\bar{H}$ assets sold for $E[D]/R$, social surplus (investors' gains plus sellers' gains) is, at best, the sellers' gains of $\lambda\bar{H}(E[D]/R - 1)$. By contrast, in a pooling equilibrium, unsophisticated investors break even buying all assets, and social surplus is higher, with sellers' gains of $E[D]/R - 1$. Note that for a given number of good and bad assets sold, social surplus does not depend on the price paid, as this is just a transfer. Given the large difference in social surplus between the two equilibria (social surplus in the pooling equilibrium is $1/\lambda\bar{H}$ times higher), even if the pooling equilibrium does not exist and the first inequality in Condition (10) is not satisfied, the sale of all assets without valuation may still lead to higher social surplus. In addition, these results hold even as \bar{H} approaches 1. Thus, the lower social surplus is not simply the result of being unable to value all assets.

[Figure 2 about here]

The shaded region in Figure 2 shows the region for which the purchase of all assets without valuation is most efficient. The lower bound of this region is the line (in $\lambda - c$ space) that runs from the point on the boundary between the pure valuation and pooling equilibria where $P = 1$ to the maximum λ where the pure valuation equilibrium exists and $c = 0$

(where $P = 1$ also).

4.3 Discussion

4.3.1 Implications and interpretation

A switch in equilibrium from a pooling to a pure valuation equilibrium is a valuation run that exhibits many of the stylized features of a credit crunch. In particular, the increase in valuation is associated with: (a) Investment collapse: the volume of transactions declines from 1 to $\bar{H}\lambda$ as only sellers that can get their assets valued and who have good assets sell/are funded. (b) Price collapse: transaction prices fall from $\frac{\lambda D^g + (1-\lambda)D^b}{R}$ to 1 (spreads or interest rates increase). This occurs because in the pooling equilibrium, assets are scarce and valuation is not required to invest without losses, so sellers get high prices and marginal investment earns the opportunity cost of funds. In the valuation equilibrium, only sophisticated investors purchase assets; sellers compete for this limited valuation technology; and prices for assets are low as skilled investors earn profits and sellers receive their outside option. (c) Nonfundamental volatility: the crash is not driven by fundamentals, but rather, could be triggered by any small coordinating event. (d) Flight to quality: unsophisticated investors leave the market as the chance of buying a bad asset increases and only good assets trade. (e) Profits for sophisticated investors: sophisticated investors make *ex post* profits/valuation capacity earns rents.

A switch in equilibrium from the pooling to the mixed equilibrium also exhibits many of the features of a credit crunch. In this case, the switch in equilibrium also exhibits an increase in valuation, a collapse in price (but smaller), *ex post* profits for sophisticated investors, and is not driven by fundamentals. However, trade volume does not decline and there is no flight to quality.

Importantly, either type of switch in equilibrium is always inefficient.

Our model is static, but we can consider a repeated static model in which unsold assets disappear at the end of each period. One might then consider as an application of the model

a new investment opportunity that is expected to be quite profitable but is also initially hard to value along some dimension. Over time, as returns are observed, the cost of valuation might decline. Alternatively, because capital is flowing into the market without careful valuation along this dimension, the quality of new assets might decline along this dimension over time. In either case, the market can begin in a region in which it is necessarily in a pooling equilibrium and all assets are traded at high prices. As valuation costs decline or the share of bad assets increases, the market could enter a region where a valuation equilibrium is also possible. In such a dynamic, investment collapses from a switch to an equilibrium with valuation are always inefficient when they occur, although they may be ultimately inevitable.¹⁵

The idea that fluctuations in the strength of adverse selection in financial markets explain their volatility is not new; notable examples driven by factors other than valuation include Mankiw (1986), Eisfeldt (2004), Kurlat (2010), Morris and Shin (2012), Philippon and Skreta (2012), and Malherbe (2014). Our explanation rests on what we believe are the key features of external finance: the opportunity to not undertake the investment and the possibility of acquiring nonverifiable information on the quality of the investment. As such, our explanation is closer to Ruckes (2004) and Dell’Ariccia and Marquez (2006), both of which consider how adverse selection and lending standards lead to contractions of credit in bad times.¹⁶ The former shows how fluctuations in a borrower’s default risk change the private value of information, which in turn is amplified because of the winner’s curse. The latter focusses not on the creation of information but rather on contract terms (specifically collateral requirements) and how these change in response to exogenous changes in the share

¹⁵As an aside, there is also no higher payoff to the sellers of good assets relative to bad assets in the pure valuation equilibrium because both receive their reservation values. This result would change if sellers with good assets received some of the rents.

¹⁶Gorton and Ordonez (2014) also draws out new insights for fluctuations in informed lending by incorporating secondary markets.

of new projects, about which no bank has information, and existing projects, about which some bank has private information. In the model, the existence of fewer new projects implies a lower share of good projects approaching banks and a tightening of lending standards and reduced credit.¹⁷

4.3.2 Key assumptions

Turning to assumptions, first, it is not essential that valuation capacity be strictly limited, but it must have increasing costs. If the cost of valuation capacity to sophisticated investors were increasing in the aggregate amount of valuation capacity purchased, our results would be qualitatively similar (if increasing “enough”) except that rents would presumably accrue to the providers of the valuation capacity. A capacity constraint significantly simplifies the analysis.

Second, a sophisticated investor gets all the surplus when matched with a seller known to be good. A more equal division of surplus would alter the equations that determine where different regions occur and what parties earn rents in the valuation equilibria but would not alter the existence of regions with multiple equilibria or the general character of the welfare implications (as long as the investor gets some of the surplus). This follows because, in equilibria with valuation, sophisticated investors are making sellers weakly prefer to sell to them, so changing this to a strict condition does not change the qualitative results. What is important for the qualitative results is that there exists a region in which investors get sufficient surplus to cover the costs of valuation.¹⁸

¹⁷Similarly, Kurlat (2012) analyzes a model in which increases in the volume of assets for sale induces the entry of valuation skill. This worsens adverse selection problems and lower prices, rationalizing declines in prices associated with fire sales.

¹⁸An alternative set up with identical results has sellers, after a possible valuation, sell through a second-price sealed-bid auction with a reservation price of 1. The optimal bid in a second-price auction is one’s valuation. Thus a sophisticated investor who knows the asset is good wins the auction and pays either the reservation price (as in the pure valuation equilibrium) or the bid of unsophisticated investors (as in the

Third, our assumption that a seller turned away from one investor is able to go to another investor and appear indistinguishable from any other seller is a static analog to a dynamic process with valued projects indistinguishable from new entrants. As a more formal foundation, we discuss in Appendix C that our model has the same implications if we instead assume that sellers pursue sequential search but investors do not know in what order the seller approaches potential investors, an information structure borrowed from Zhu (2012).¹⁹

Finally, that valuation is not observed—that a seller with a previously-valued asset is indistinguishable from a seller with a valued and rejected asset—is critical. However, it is important to note that it is in the joint interest of a seller-investor pair not to reveal that the seller was denied funding, because this allows the seller to seek funding elsewhere. Further, notice that sophisticated investors prefer equilibria with valuation, and unsophisticated investors are indifferent as they make zero profit. Sellers prefer the equilibrium without valuation. This ordering makes it suspect that investor groups that self-regulate and share information, such as through industry-wide credit bureaus, actually share the type of information that we study herein.²⁰ If the act of valuation were observable, the negative externality from valuation would be corrected in the current model (see Section 5.2).

5. Policy

There is the potential for efficiency-improving coordination or government policy in the regions of the parameter space for which there are multiple equilibria and for which the mixed equilibrium). If no sophisticated investor has valued the asset, then an unsophisticated investor wins the auction, paying the bid of other unsophisticated investors (as in the pooling equilibrium).

¹⁹Guerrieri and Shimer (2014) and Chang (2011) analyze fire sales in a model in which sellers who know the quality of their asset can signal their information by delaying the sale of their asset.

²⁰It seems more likely that credit bureaus, like ratings agencies, simply segment assets into markets, each of which is either in a pooling equilibrium or valuation equilibrium, where buyers do or do not investigate beyond the credit check. It is notable that credit bureaus may not reveal the identity of those who conduct credit checks and so do not reveal the purpose of the check (information that an unsophisticated investor would find useful).

market delivers only the valuation equilibrium and $c > c^{Eff}$. Given that the model omits any social benefits of private information and is solved as a rational expectations equilibrium, it is worth emphasizing that this section studies optimal policy in the model not in the real world. Therefore, consider the following policies that eliminate adverse selection or deter valuation where inefficient.

5.1 A tax on valuation

Begin with a tax on valuation capacity, raising the valuation cost from c to $c + \tau$. Suppose a pooling equilibrium is most efficient, that is, $V^p > 0$ and $V^p > V^v$. There are two cases. First say the pure valuation equilibrium exists (implying that the mixed equilibrium does not exist). With a tax on valuation capacity of $\tau = \lambda \left(\frac{D^g}{R} - 1 \right) - c > 0$, the first inequality in Condition (12) no longer holds (replacing c with $c + \tau$). Therefore the pure valuation equilibrium no longer exists and the mixed equilibrium still does not exist. Because $\lambda \left(\frac{D^g}{R} - 1 \right) > \lambda(1 - \lambda) \frac{D^g - D^b}{R}$ (by $V^p > 0$), the first inequality in Condition (10) is satisfied if we replace c with $c + \tau$. In addition, because the second inequality in Condition (10) is satisfied, the tax leaves only the pooling equilibrium (which will exist with the tax but depending on c may not exist without the tax). Second suppose that the mixed equilibrium exists (so the pure valuation equilibrium does not exist). With a tax on valuation capacity of $\tau = \frac{\lambda(1-\lambda)}{1-\lambda H} \frac{D^g - D^b}{R} - c > 0$, the first inequality in Condition (14) no longer holds. Thus, the mixed equilibrium no longer exists, and the pure valuation equilibrium still does not exist. Because $\frac{\lambda(1-\lambda)}{1-\lambda H} \frac{D^g - D^b}{R} > \lambda(1 - \lambda) \frac{D^g - D^b}{R}$, the first inequality in Condition (10) is satisfied. Moreover, because the second inequality in Condition (10) is satisfied, the tax leaves only the pooling equilibrium (which will again exist with the tax, but depending on c , may not exist without the tax). Hence, taxing valuation can ensure that the efficient pooling equilibrium prevails. Of course, such a tax has the real-world problems both of distinguishing this type of valuation from other types of valuation (such as about value that is common across assets)

and of monitoring and observing valuation.²¹

5.2 Common knowledge that an asset has been valued

Eliminating the adverse selection that follows from valuation is more effective in that it allows the use of valuation when privately efficient while eliminating its social loss. Such a policy is at odds with the assumptions of the model and not straightforward to implement given agents' incentives. Nevertheless consider making it public knowledge that an asset had been valued. Then valued and rejected assets would remain unsold. Unvalued assets would be sold to unsophisticated investors at the pooling equilibrium price (iff $E[D]/R \geq 1$). Sellers would only approach sophisticated investors if the expected value of their outside options after valuation were at least equal to the price available without valuation. Sophisticated investors offer the minimum price to attract unvalued assets, which is P^g such that

$$\lambda(P^g - 1) \geq \frac{\lambda D^g + (1 - \lambda) D^b}{R} - 1.$$

Valuation would be undertaken when it is profitable, which is when

$$c \leq (1 - \lambda) \left(1 - \frac{D^b}{R} \right). \quad (19)$$

This boundary lies above the boundary for efficiency of the pooling equilibrium with anonymity, Condition (18). (Conditions (18) and (19) converge to the same condition as $\bar{H} \rightarrow 1$.)

[Figure 3 about here]

In Figure 3, the solid lines delineate the four equilibria (dotted lines delineate the regions in the original model; and the dash lines delineates the boundary of the region in which funding without valuation was efficient in the original model). There is a larger region in

²¹Even though we do not see this as a realistic feature of asset markets, similar policies are imposed in insurance markets where insurance cannot be predicated on testing. In addition, auctioneers as market makers may not make items available for inspection prior to the auction.

which the pooling equilibrium exists, determined by Condition (10), with the first inequality replaced by the complement of Condition (19). There is a new type of mixed equilibrium in which the price is the same as the price in the pooling equilibrium, trade is $\lambda\bar{H} + (1 - \bar{H})$, and $(1 - \lambda)\bar{H}$ bad assets are not traded, determined by Conditions (10) and (19). Third, there is a region of pure valuation in which the price is 1 and trade is $\lambda\bar{H}$, determined by Condition (12) with the second inequality replaced by $\lambda \leq \frac{R-D^b}{D^g-D^b}$. Finally, there a region of no trade that covers the same region as before.

Three results follow. First, with observed valuation and without anonymity, the market equilibrium is always efficient; there are no externalities and no regions of multiplicity (this follows from arguments similar to those in Section 4.2). Second, some valuation is efficient for a larger set of parameters than in the original model with anonymity because valued assets that are found to be bad are not traded, and therefore they do not reduce the average quality of assets remaining after valuation. Finally, there are strict efficiency benefits to making valuation observable and eliminating anonymity if and only if the original market equilibrium has valuation, and unvalued assets are worth selling/funding (in Figure 3, any region with valuation in the baseline model (dotted lines) and to the right of the vertical line $\lambda = \frac{R-D^b}{D^g-D^b}$).

Whether such a policy is optimal of course depends on its cost to implement. Further, such a policy is not incentive compatible given only lack of anonymity. Sophisticated investors and assets found to be bad have a joint incentive to hide the fact that a valuation was done.²²

5.3 A large unsophisticated investor with commitment

Another reason why the market does not deliver the more efficient equilibrium is that unso-

²²Sorkin (2009) describes several episodes during the U.S. financial crisis of commercial banks valuing an investment bank for purchase in which both parties, but especially the investment bank, tried to keep secret the fact that a valuation was occurring.

phisticated agents do not have the ability to commit—before sophisticated investors choose their valuation capacity—to purchase at high prices. Where there are multiple equilibria, if unsophisticated investors could commit *ex ante*, a large unsophisticated investor could post a price equal to $E[D]/R$, which would ensure that the market is in the pooling equilibrium. This is because if the pooling equilibrium exists, a sophisticated investor has no incentive to do valuations when unsophisticated investors are offering $P^U = E[D]/R$. If private agents were unable and the government were able, the government could commit to purchase at the pooling equilibrium price.

Alternatively, suppose D^g and D^b are payoffs rather than conditional expected payoffs. Then before any valuation capacity is chosen, the government could commit to insure all assets at the *ex ante* fair price for the pooling equilibrium. That is, an insurance premium of $(1 - \lambda)(D^g - D^b)/R$ would guarantee a payoff of D^g . Unsophisticated investors would have the incentive to buy this insurance (irrespective of how serious is the adverse selection problem), and then the incentive to pay $E[D]/R$ for assets. Given a market price $E[D]/R$, the sophisticated investors would not find it profitable to do valuation, even if they could choose to buy the insurance after indentifying a bad asset. In equilibrium, the insurance would be fairly priced.

However, the ability of a large unsophisticated investor to commit does not ensure that valuation is not used outside the region of multiplicity where the efficient outcomes still involves no valuation. To ensure this, the government further has to subsidize purchases by the large investor, as for example by a proportional subsidy σ that implies $P^U = (1 + \sigma) \frac{\lambda D^g + (1 - \lambda) D^b}{R}$ and $J^S(P^U) < 0$. That is, if $c^{Eff} \leq c < \lambda(1 - \lambda) \frac{D^g - D^b}{R}$, then the minimum proportional subsidy is

$$\underline{\sigma} = \frac{(1 - \lambda)(D^g - D^b) - cR/\lambda}{E[D]}.$$

Along with *ex ante* commitment by a large unsophisticated agent $\sigma > \underline{\sigma}$ ensures a price P^U

such that $J^S(P^U) < 0$ and the economy is in a pooling equilibrium wherever it is more efficient (before factoring in the deadweight costs of the subsidy).

The model provides an interpretation of the government-sponsored enterprises Fannie Mae and Freddie Mac. In the market for conforming mortgages, a small fraction of assets (mortgages) are “bad” so that λ is close to 1. For λ close to 1, equilibria with valuation when they exist are inefficient for a wider range of parameters than when λ is lower. A large investor with commitment and a subsidy that funds a large fraction at high prices can keep others from investing in valuation capacity and so optimally ensure the efficient equilibrium. One might then interpret the collapse of these institutions as being due to their committing to purchase at the expected present discounted value of a random (unvalued) mortgage with λ too low to support this as a pooling equilibrium price. In this case, the commitment to purchase (or insure) mortgages assuming no adverse selection when the market actually has valuation and adverse selection is extremely costly to the government (or government-sponsored enterprise). It is also worth noting that, as with some other mechanisms to eliminate adverse selection, there are incentives to undermine this policy: in the pooling equilibrium, unsophisticated investors earn no rents, while in the valuation equilibrium, sophisticated investors make profits.

This policy is related to securitization and shares some insights with the literature on how informed issuers hide information to create a pooling equilibrium (Gorton and Pennacchi 1990; Demarzo and Duffie 1999; Demarzo 2005; Axelson 2007). Our contribution to this literature is that, in our model in which private information is endogenous, the elimination of adverse selection through securitization requires a commitment to purchase securitizable assets at high prices. Though, having done this, explicit securitization is not required in our model. Our results also highlight an alternative dimension of securitization: market participants have an incentive to undermine the process through information acquisition.

5.4 Interest rates

First, cutting the interest rate is counterproductive. The set of (other) parameters for which equilibria with valuation are possible with a lower interest rate covers that with a higher interest rate. In contrast, raising the interest rate can help reduce valuation. These effects work by changing the present value of the information gathered by valuation, which is proportional to $\frac{D^g - D^b}{R}$ without changing its cost. Figure 4 shows how raising the interest rate (from $R = 1.10$, dotted lines to $R = 1.11$, solid lines) reduces the size of the region of multiplicity and the size of the region in which valuation can occur in conjunction with pooling. Note that the policy also increases the region in which no investment occurs.

[Figure 4 about here]

5.5 *Ex post* transfers from good to bad assets

Second, policies that reduce the difference in payoffs across assets of different quality reduce the size of the regions in which equilibria with valuation are possible. Such policies reduce the incentive to do valuation by reducing the benefits to separating the good from the bad. Figure 5 depicts how subsidizing the payout of the bad assets (from $D^b = 1.090$, dotted line, to $D^b = 1.095$, solid line) increases the size of the region where the pooling equilibrium exists, as well as the size of the region where it is the only equilibrium. This policy has some of the flavor of the TARP programs that provided funding and took some of the downside risk of private investors' asset purchases.

[Figure 5 about here]

More generally, for any given parameterization, efficiency can be ensured through a balanced-budget subsidy (σ) to ultimately bad assets that is paid for by a tax (τ) on ultimately good assets that satisfies

$$c \geq \lambda \left(\frac{(1-\tau)D^g}{R} - 1 \right) \quad \text{if} \quad \lambda \leq \frac{R - D^b}{(D^g - D^b) - \bar{H}(D^g - R)},$$

$$c \geq \frac{\lambda(1-\lambda)}{1-\lambda\bar{H}} \frac{(1-\tau)D^g - (1+\sigma)D^b}{R} \quad \text{if} \quad \lambda > \frac{R - D^b}{(D^g - D^b) - \bar{H}(D^g - R)},$$

where $\tau\lambda D^g = \sigma(1 - \lambda) D^b$ ensures revenue neutrality. Of course this policy is effective because private agents are assumed unable to commit to a similar insurance contract. Similar to a tax on valuation, in practice this solution blunts any incentives to buy good assets in other (unmodeled) dimensions in which valuation may be optimal.²³

5.6 Policies in the related literature

How does the optimality of these policies contrast with those if the information friction were of the type in Dang (2008) or Glode et al. (2012)? In both papers, eliminating valuation achieves the first best because valuation has no social benefit. In our model, the optimality of valuation depends on the cost of valuation since valuation can have social benefits. Publicizing that a valuation was performed does nothing to improve the outcomes in Dang (2008) or Glode et al. (2012), as agents in these models make the correct inference about whomever they are facing. Finally, in these papers, committing to purchase at the unconditional expected value of the asset is generically extremely costly. Agents still have the incentive to value the asset and transact only when valuable to them. The only way to eliminate inefficiency in these other models, absent banning valuation, is to make public the private information about common value.

6. Conclusion

In this paper we have considered a model in which valuation creates private information about the payoff from a new investment opportunity and in which the rents of this information are captured by the informed investor. We show the possibility of multiple equilibria with different levels of valuation and rank these equilibria by efficiency. Where equilibria with and without valuation exist, the equilibrium with valuation is always more socially inefficient, and where equilibria without valuation do not exist, selling/funding all assets without valuation can still be more socially efficient than the existing valuation equilibria are. This result

²³Although, if the tax and subsidy plan were balanced-budget and orthogonal to the mean payoff, then such a policy could avoid diminishing the incentive to collect information about asset-class wide payoffs.

stands in contrast to most research on financial markets, which studies the discovery of information that is common to a class of assets and is transmitted by actions through prices. In our model, too much information is created because it creates asymmetric information and causes problems of adverse selection, whereas in the canonical model, information tends to be underproduced and markets learn too late.

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Appendix A. Proofs

Appendix A.1 Proof of Proposition 1

Proposition 1 Equilibria

- (i) At least one of the four equilibria exists.
- (ii) There can be a unique equilibrium with any one of the pooling, pure valuation, mixed, or no-trade equilibria.
- (iii) There can be multiple equilibria. Multiple equilibria must involve either the pooling and pure valuation equilibria; or the pooling and mixed equilibria.

Proof. (i) We show that if the pooling, pure valuation, and mixed equilibria do not exist, then the no-trade equilibrium does exist, at least one equilibrium exists.

We first show that if the pooling, pure valuation, and mixed equilibria do not exist then $\lambda \leq \frac{R-D^b}{D^g-D^b}$. Suppose instead

$$\frac{R - D^b}{D^g - D^b} < \lambda \leq \frac{R - D^b}{(D^g - D^b) - \bar{H}(D^g - R)}. \quad (\text{A.1})$$

The first inequality in Condition (A.1) implies that

$$0 < \lambda \left[\frac{\lambda D^g + (1 - \lambda) D^b}{R} - 1 \right] = \lambda \left[\frac{D^g}{R} - 1 - (1 - \lambda) \frac{D^g - D^b}{R} \right] \quad (\text{A.2})$$

and we have

$$\lambda \left(\frac{D^g}{R} - 1 \right) > \lambda (1 - \lambda) \frac{D^g - D^b}{R}. \quad (\text{A.3})$$

Given Condition (A.1), nonexistence of the pooling equilibrium requires $c < \lambda(1 - \lambda) \frac{D^g - D^b}{R}$ and nonexistence of the pure valuation equilibrium requires $c \geq \lambda \left(\frac{D^g}{R} - 1 \right)$. By Condition (A.3) these conditions cannot both be satisfied and we have a contradiction. Now suppose

$$\lambda > \frac{R - D^b}{(D^g - D^b) - \bar{H}(D^g - R)}. \quad (\text{A.4})$$

Given Condition (A.4), nonexistence of the pooling equilibrium requires $c < \lambda(1 - \lambda) \frac{D^g - D^b}{R}$ and nonexistence of the mixed equilibrium requires $c > \frac{\lambda(1 - \lambda)}{1 - \lambda \bar{H}} \frac{D^g - D^b}{R}$. Because $0 < 1 - \lambda \bar{H} <$

1, these conditions cannot both be satisfied, and we have a contradiction. Thus we have shown that $\lambda \leq \frac{R-D^b}{D^g-D^b}$.

With $\lambda \leq \frac{R-D^b}{D^g-D^b}$, nonexistence of the pure valuation equilibrium requires $c \geq \lambda(\frac{D^g}{R} - 1)$, and these two conditions imply that the no-trade equilibrium exists. Hence at least one of the four equilibria exists.

(ii) Say (λ, c) satisfy

$$c \geq \lambda\left(\frac{D^g}{R} - 1\right) \text{ and } \frac{R - D^b}{D^g - D^b} < \lambda \leq \frac{R - D^b}{(D^g - D^b) - \overline{H}(D^g - R)}. \quad (\text{A.5})$$

Then it can be verified that the conditions for the pooling equilibrium are satisfied and the conditions for the other equilibria are not satisfied. Say (λ, c) satisfy

$$c < \lambda(1 - \lambda)\frac{D^g - D^b}{R} \text{ and } \frac{R - D^b}{D^g - D^b} < \lambda \leq \frac{R - D^b}{(D^g - D^b) - \overline{H}(D^g - R)}. \quad (\text{A.6})$$

Then it can be verified that the conditions for the pure valuation equilibrium are satisfied and the conditions for the other equilibria are not satisfied. Say (λ, c) satisfy

$$c < \lambda(1 - \lambda)\frac{D^g - D^b}{R} \text{ and } \lambda > \frac{R - D^b}{D^g - D^b - \overline{H}(D^g - R)}. \quad (\text{A.7})$$

Then it can be verified that the conditions for the mixed equilibrium are satisfied and the conditions for the other equilibria are not satisfied. Finally, if (λ, c) satisfy the conditions for the no-trade equilibrium, then it can be verified that the conditions for the other equilibria are not satisfied.

(iii) Consider λ that satisfy Condition (A.1). For such λ , Condition (A.3) is satisfied.

Thus for such λ and c that satisfies

$$\lambda\left(\frac{D^g}{R} - 1\right) > c \geq \lambda(1 - \lambda)\frac{D^g - D^b}{R}, \quad (\text{A.8})$$

Conditions (10) and (12) are simultaneously satisfied and both the pooling and pure valuation equilibria exist. For (λ, c) such that

$$\lambda > \frac{R - D^b}{(D^g - D^b) - \overline{H}(D^g - R)} \text{ and } \lambda(1 - \lambda)\frac{D^g - D^b}{R} \leq c < \frac{\lambda(1 - \lambda)}{1 - \lambda\overline{H}}\frac{D^g - D^b}{R}, \quad (\text{A.9})$$

Conditions (10) and (14) are simultaneously satisfied and both the pooling and mixed equilibria exist.

Next we show that no other combinations of multiple equilibria are possible. In Part (ii) it was noted that the conditions for the no-trade equilibrium are mutually exclusive of the conditions for the other equilibria, so multiple equilibria cannot include the no-trade equilibrium. Finally, the conditions on λ for the pure valuation and mixed equilibria are mutually exclusive so multiple equilibria cannot include both of these. ■

A.2 Proof of Proposition 2

Proposition 2 Ranking of Equilibria

(i) For parameters such that the pooling equilibrium exists, the pooling equilibrium is more efficient than are the pure valuation equilibrium, $V^p > V^v$, and the mixed equilibrium, $V^p > V^m$ (the other two equilibria that may exist);

(ii) For parameters such that the pooling equilibrium does not exist:

(a) If the pure valuation equilibrium exists, then this equilibrium is less efficient than an outcome with the sale of all assets without valuation if and only if

$$c \geq c^{Eff} \equiv \frac{(1 - \lambda \bar{H}) R - (1 - \lambda) D^b - (1 - \bar{H}) \lambda D^g}{\bar{H} R}. \quad (\text{A.10})$$

(b) If the mixed equilibrium exists then this equilibrium is less efficient than an outcome with the sale of all assets without valuation.

(c) If the no-trade equilibrium exists, then this equilibrium is more efficient than an outcome with the sale of all assets without valuation, $V^n > V^p$.

Proof. (i) $V^v = \bar{H} \left(-c + \lambda \left(\frac{D^g}{R} - 1 \right) \right) \leq \bar{H} \left(-\lambda (1 - \lambda) \frac{D^g - D^b}{R} + \lambda \left(\frac{D^g}{R} - 1 \right) \right) = \bar{H} \lambda \left(\frac{\lambda D^g + (1 - \lambda) D^b}{R} - 1 \right) < \frac{\lambda D^g + (1 - \lambda) D^b}{R} - 1 = V^p$, where the first inequality follows from Condition (10). $V^m = -\bar{H}c + \frac{\lambda D^g + (1 - \lambda) D^b}{R} - 1 < \frac{\lambda D^g + (1 - \lambda) D^b}{R} - 1 = V^p$.

(ii) a) $V^v = \bar{H} \left(-c + \lambda \left(\frac{D^g}{R} - 1 \right) \right) \leq \bar{H} \left(-\frac{(1 - \lambda \bar{H}) R - (1 - \lambda) D^b - (1 - \bar{H}) \lambda D^g}{\bar{H} R} + \lambda \left(\frac{D^g}{R} - 1 \right) \right) =$

$\frac{\lambda D^g + (1-\lambda)D^b}{R} - 1 = V^p$, where the first inequality follows from Condition (18).

(ii b) $V^m = -\overline{H}c + V^p < V^p$.

(ii c) $V^n = 0 > \frac{\lambda D^g + (1-\lambda)D^b}{R} - 1 = V^p$, where the first inequality follows from Condition (11). ■

Appendix B. The Unstable Mixed Equilibrium

This equilibrium can occur if for some $H \in (0, \overline{H})$,

$$J^S (P^U (H)) = 0 \text{ and } W^S = W^U \geq 0. \tag{A.11}$$

As for the mixed equilibrium, $P^g = P^U$. Condition (A.11) implies $P^g = \frac{D^g}{R} - \frac{c}{\lambda} = P^U (H)$, which, together with Equation (8), implies that the level of valuation capacity that gives indifference is

$$H^* = \frac{1}{\lambda} - (1 - \lambda) \frac{D^g - D^b}{R} \frac{1}{c}. \tag{A.12}$$

Thus, this equilibrium exists when

$$H^* \in (0, \overline{H}) \tag{A.13}$$

or

$$\begin{aligned} c &> \lambda(1 - \lambda) \frac{D^g - D^b}{R} \\ c &\leq \lambda \min \left[\frac{D^g}{R} - 1, \frac{1 - \lambda}{1 - \lambda \overline{H}} \frac{D^g - D^b}{R} \right]. \end{aligned}$$

The first inequality is a strict inequality version of the first condition for the pooling equilibrium (Condition (10)) and implies that valuation must be costly enough that not all sophisticated investors choose to do valuation. The second inequality is the same as the second inequality for the mixed equilibrium, and so is the reverse of a scaled-up (by $\frac{1}{1-\lambda\overline{H}}$) version of the first inequality for the pooling equilibrium. The final inequality is a strict inequality version of the first condition for the valuation equilibrium (Condition (12)).

It is straightforward to verify three properties. First, H^* is unique and thus that there is at most one unstable mixed equilibrium for any parameter configuration. Second the union of the two regions of multiplicity described in Proposition 2 defines the region in which the unstable mixed equilibrium exists, and third, following the logic of Proposition 2, wherever the unstable mixed equilibrium exists, it is less efficient than is the pooling equilibrium.

Appendix C. Equilibrium with Sequential Search as in Zhu (2012)

The trading structure of Zhu (2012) is designed to capture transactions in over-the-counter markets. This structure adapts easily to our environment and delivers the same equilibrium conditions as our main assumptions.

In Zhu (2012), each seller has one unit of an indivisible asset she wishes to sell and approaches randomly chosen investors sequentially. When a seller approaches an investor, the investor quotes a price. The seller can accept the price, in which case the asset is sold at that price to that buyer. The seller can proceed to the next investor and get another quote. Or the seller can return to a previous investor for another quote. Investors do not observe negotiations elsewhere in the market. Thus investors face “contact-order uncertainty—uncertainty regarding the order in which the competing investors are visited by the seller.” Zhu (2012) analyzes a situation in which investors have noisy signals of fundamental value and shows among other things that contact-order uncertainty leads to lower quotes because of adverse selection: any seller that an investor observes may have approached other investors and been offered only low prices, implying that their noisy signals of value were low. Thus an investor—unsure whether it is seeing a seller who has been looked at by other investors first or a seller who has not been—offers a price well below that implied by its own noisy signal of asset value to avoid the winners curse.

This over-the-counter structure delivers the same equilibrium conditions as our model’s. Sophisticated investors value assets and quote the market price to good projects and reject bad projects. Unsophisticated investors approached by sellers are unsure whether the asset

has been previously valued and found to be low value or whether it has not. As a result, they quote prices equal to the expected present value derived in the paper. The maximum of this and the reservation value of one determines the observed market price, as in the main body of the paper.

Figure 1

The regions for the pooling, valuation, and constrained valuation equilibria

Note: The solid lines delineate the regions in which each equilibrium can exist.

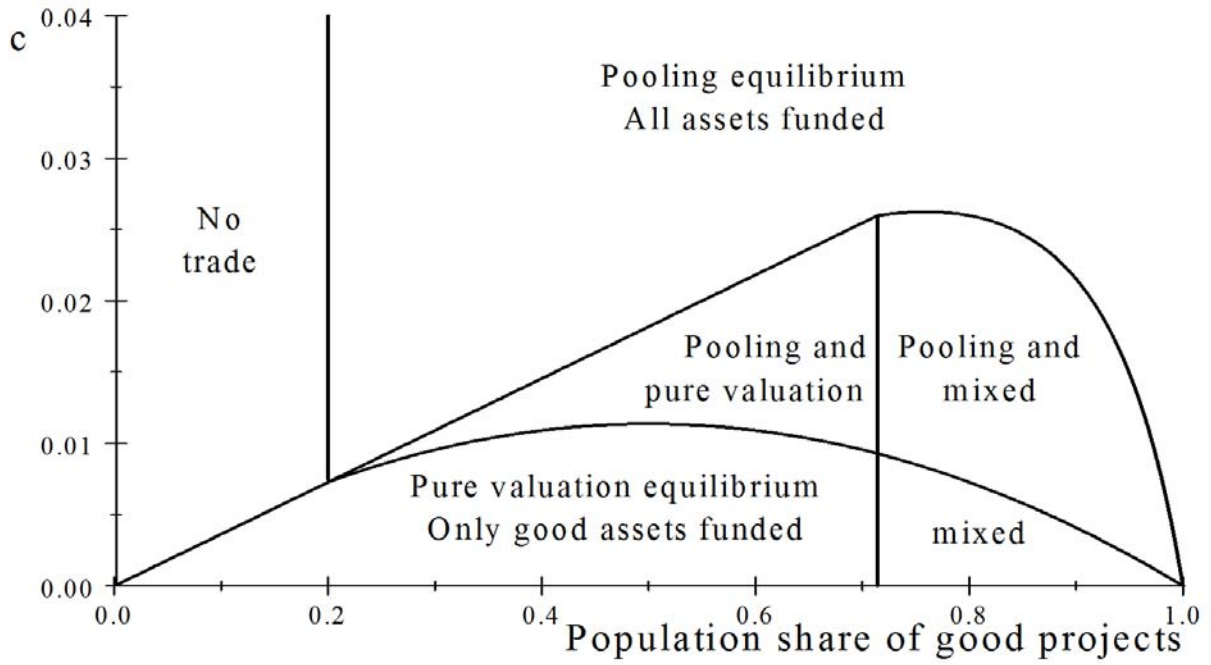


Figure 2

The region where funding without valuation is more efficient than equilibria with valuation

Note: The solid lines delineate the regions where different equilibria of the model occur. The shaded region is the region for which the purchase of all assets without valuation is more efficient than no trade or than any equilibrium with valuation.

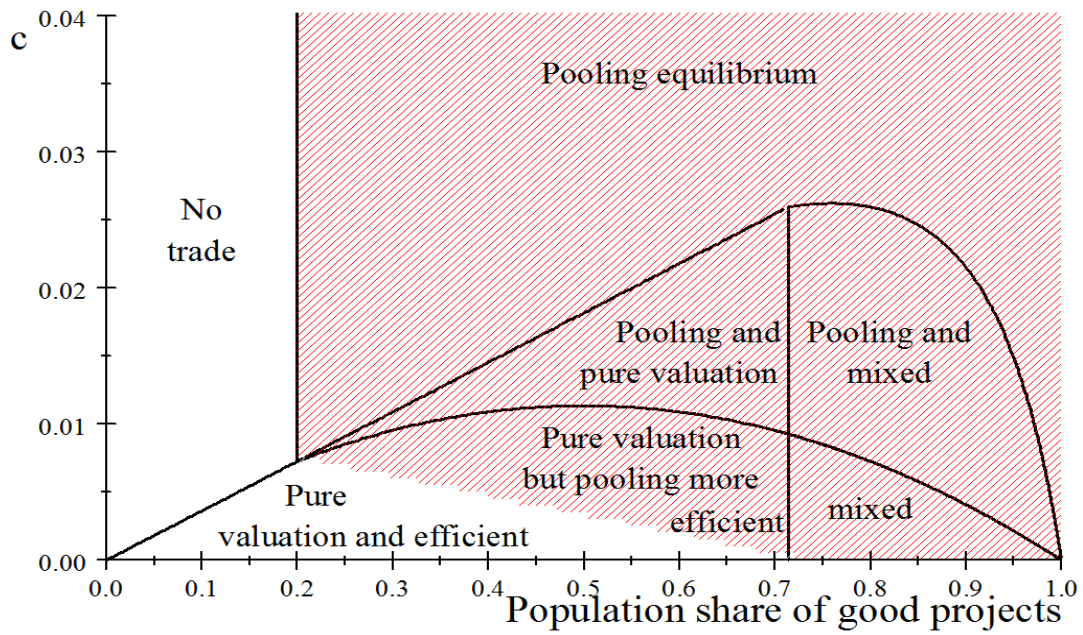


Figure 3

The region where eliminating adverse selection delivers the efficient outcome

Note: The solid lines delineate the regions where different equilibria occur for a market in which assets are not anonymous and valuation is observed. The dotted lines delineate the regions in which the different equilibria exist in the original model with anonymous assets and unobserved valuation; these correspond to the lines in Figure 1. The dashed line delineates the lower bound of the region in which funding without valuation is the most efficient outcome; this corresponds to the boundary of the shaded region in Figure 2.

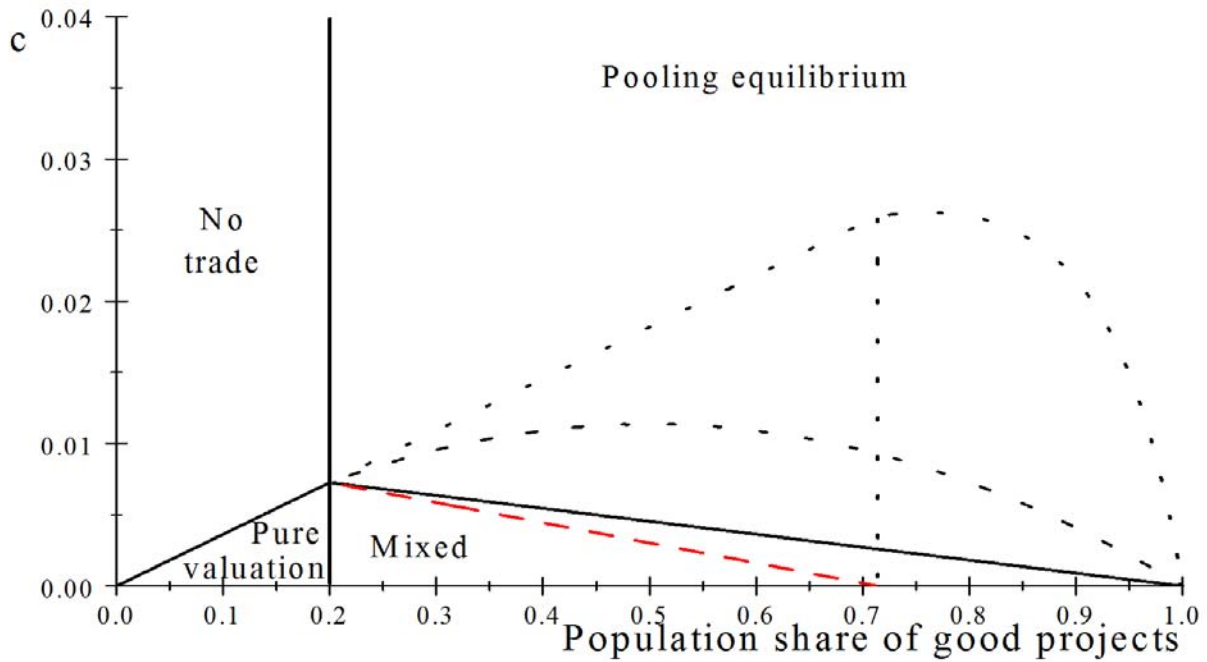


Figure 4

The effect of a higher real interest rate

Note: The solid lines delineate the regions where the different equilibria occur for a relatively higher interest rate ($R = 1.11$), whereas the dotted lines delineate the regions where the different equilibria occur for a relatively lower interest rate ($R = 1.10$) and which correspond to the lines in Figure 1.

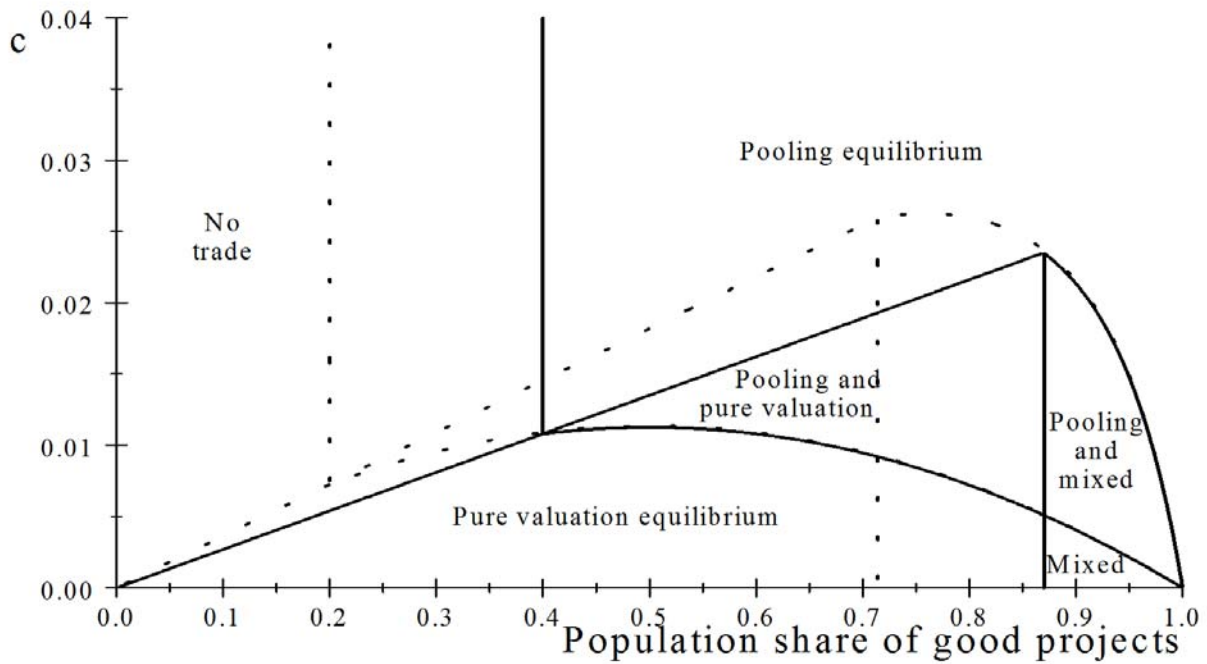


Figure 5

The effect of a higher value of bad project

Note: The solid lines delineate the regions where the different equilibria occur for a relatively higher bad payout to the asset ($D^b = 1.095$); the dotted lines delineate the regions where the different equilibria occur for a relatively lower bad outcome for the asset ($D^b = 1.090$) and which correspond to the lines in Figure 1.

