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Valuation, Adverse Selection, and Market Collapses

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### **ABSTRACT**

We study a market for funding real investment in which valuation creates information on which adverse selection can occur. Unlike in previous models, higher amounts of valuation are associated with lower market prices and so greater returns to valuation, and this strategic complementarity in the capacity to do valuation generates multiple equilibria. In this region, the equilibrium without valuation is always more efficient despite funding projects that valuation would reveal as unprofitable. Valuation equilibria look like credit crunches. A large investor can ensure the efficient equilibrium only if it can precommit to a price and, for some parameters, only if subsidized.

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# 1 Introduction

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. Not only is external financing critical for much economic investment, but markets for external finance seem to be 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 theoretical model of a market for the external financing of real investment in which different levels of funding and asset prices arise from different levels of valuation by market participants. In our setting, valuation has an externality – it produces private information on which adverse selection can occur.<sup>1</sup> 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 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 the equilibrium without valuation is always more efficient than the equilibrium with valuation when both are possible. 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

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<sup>1</sup>As we discuss, this channel is different from that in Dang (2008) and Glode, Green, and Lowery (2012) both technically – valuation in our model is information about the joint surplus from trade – and economically – the externality in our model operates through the market price.

risk neutral real investors with projects to fund originate and sell assets at prices above their reservation value, and risk neutral financial investors compete to buy these assets given a fixed opportunity cost of capital. Sellers' projects/assets are ex ante identical but ex post payoffs are heterogeneous across assets.

There are two types of buyers. *Unsophisticated* financial investors are competitive price-takers who buy assets at their expected present discounted values. *Sophisticated* financial 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 5.3.2 and 6). Thus a sophisticated investor who values an asset, observes a bad signal of the future payoff, and does not buy it decreases the average quality of the pool of assets for other investors, which lowers the equilibrium price paid by unsophisticated investors and raises the profitability of valuation. This externality makes valuation a strategic complement.<sup>2</sup>

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 *valuation equilibrium* sophisticated investors invest in valuation capacity, value as many assets as they can, and only good assets are sold/funded. In this valuation equilibrium, because sellers compete for limited buyers 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

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<sup>2</sup>In the language of Hellwig and Veldkamp (2009), the choice of the technology to uncover information is a strategic complement, but information is a strategic substitute, in that sophisticated investors want different information from each other (information about different assets).

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.<sup>3</sup>

A pooling equilibrium has the features of a credit boom in which market volume and prices are high while the 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.<sup>4</sup> 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 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 excess rents.<sup>5</sup> Further, there is a flight to quality in two 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 this region of multiple equilibria, the benefit of valuation is not funding bad projects, yet the socially efficient outcome is the pooling equilibrium with no valuation.<sup>6</sup> This follows from the fact that the problem of the social planner choosing whether to invest in valuation capacity is (almost) the same as the problem of a single sophisticated investor expecting a pooling equilibrium choosing whether to invest in a unit of valuation capacity. Both problems

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<sup>3</sup>Over 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, buy/fund only the good ones, and unsophisticated investors buy/fund both the rejected assets and the un-valued assets.

<sup>4</sup>In 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.

<sup>5</sup>While we do not model what happens to assets once sold, in mapping to the real world, all investors potentially have mark-to-market losses on asset holdings due to the price decline.

<sup>6</sup>In this sense, our paper contributes to the literature on the value of private information (Angeletos and Pavan (2007), Mackowiak and Weiderholdt (2009), and Myatt and Wallace (2012)). Veldkamp (2011) provides an excellent and broad discussion of this literature.

involve facing the population share of good assets and choosing whether to fund unconditionally or conditionally on the outcome of valuation. This result implies that switches in equilibria of the kind just described – valuation runs – are inefficient.

More strikingly, funding all assets without valuation is more efficient even in some regions where the market delivers only the 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 bear the downside risk of valuation rather than the sophisticated investor or seller associated with the asset to be valued. Sophisticated agents ignore this externality and choose 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? First, subsidizing trade or lowering interest rates is counterproductive, in that it actually increases the region in which the valuation equilibria is the only equilibrium and the region in which it is a possible equilibrium. Second, subsidizing the payout of bad assets reduces the region in which valuation in equilibrium is possible by reducing the economic return to separating the good from the bad. Third, a tax on valuation capacity can ensure the pooling equilibrium wherever it is efficient.<sup>7</sup>

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 ob-

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<sup>7</sup>It is important to note that the model omits many benefits of valuation, most notably that valuation might reveal information about the aggregate payoff of all assets.

servable. 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 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).

While previous papers have argued that valuation can be a strategic complement, lead to breakdowns in trade, and have negative consequences for efficiency, our mechanism is theoretically and economically novel. 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 trade for a project known to be good). Unlike in Dang (2008), informed investors always trade when efficient and more valuation in the market lowers market prices.

Secondly, and more importantly, our model includes a reason that valuation is good: it can

reveal that a project is not worth funding.<sup>8</sup> Thus, valuation can be socially and privately efficient, and our results on the social inefficiency of information are non-trivial. These differences have important implications for policy, discussed in Section 6.

Our work is similarly differentiated from Glode, Green, and Lowery (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, Dang, Gorton, and Holmstrom (2009) extends the analysis of Dang (2008) to consider how to design a security to maintain maximum liquidity in a secondary market.<sup>9</sup> 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 assets rather than trading in secondary markets.

Finally, and most closely related to our paper, the contemporaneous paper Bolton, Santos, and Scheinkman (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. And Bolton, Santos, and Scheinkman (2011) focusses on a different substantive application, the size of the financial sector in the long run.

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 buyers are unable to screen previously-valued projects and

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<sup>8</sup>If in our setting there were always gains from trade as in Dang (2008) then trade would never collapse.

<sup>9</sup>Two other papers on security design are worth noting. Marin and Rahi (2000) considers security design and shows how the optimality of complete vs. incomplete markets (complete vs. incomplete revelation of private information) depends on the costs of adverse selection on private information relative to the costs of reduced ex ante insurance. And Pagano and Volpin (2012) consider security design and then a later equilibrium in which trade occurs in a noisy rational expectations equilibrium so that information can get rents. While 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 (2011))), nor is there a role for commitment and so optimal policy is different.



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 where prices are effectively set by second-price sealed bid auctions.

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 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. But since there is no incentive to produce assets of higher quality along the un-valued dimension, the share of good assets may naturally decline over time, which again makes a collapse to the valuation equilibrium possible and possibly inevitable. Third, the size of the region of multiplicity is monotonically increasing in the probability of a good signal from valuation. Thus 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)).<sup>10</sup> 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.

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<sup>10</sup>It 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, Kiefer, and O’Hara (1996)).

## 2 The model

This section describes our model. We discuss the importance of key assumptions in Section 5.3.2.

There are a unit mass of risk-neutral sellers (real investors) seeking to sell a risky claim to a real investment to a large number of competitive risk-neutral financial investors each with access to unlimited funds at constant gross interest rate  $R > 1$ . First, a subset of investors choose whether to become sophisticated and then the market opens and sellers approach buyers until they sell as described below.

Each seller has one project/asset of fixed size, has no funds, has a reservation price of 1 and must sell all the asset or none of it. If sold, the asset pays out a random amount  $D$  in the future and all sellers and investors initially have common knowledge and therefore common expectation,  $E[D]$ .

Sellers are anonymous: within the period a seller turned away from one investor is able to go to another investor and appear indistinguishable from any other seller. This assumption provides a static analog to a continuous process with valued projects indistinguishable from new entrants. We discuss a foundation for this structure in Appendix C.

If a paired seller and investor have a joint surplus (relative to their outside options) the agreed upon price gives the entire surplus to the investor. That is, the investor has all the bargaining power in a Nash bargaining situation.<sup>11</sup>

There are two types of investors. Unsophisticated investors cannot do valuation and have a flexible amount of funds. Sophisticated investors must choose at the beginning of the period (before any buying or selling) both how much capital to raise to purchase assets ( $f$  for funds) and how much valuation technology to acquire ( $h$  for human capital).<sup>12</sup> The cost of a unit of valuation capacity is  $c$  up to  $\chi_i$  for sophisticated investor  $i$ , and infinite thereafter, so  $h_i \leq \chi_i$ .<sup>13</sup>

<sup>11</sup>This for simplicity. What is important is that the informed buyer can get some of the returns to a positive signal from valuation.

<sup>12</sup>The choice of funding capacity will be shown to be a device that allows buyers to commit to buy only after valuation.

<sup>13</sup>The limit can be due to a limited number of people with the ability to do valuation. An alternative as-

We denote the aggregate amounts of funding and valuation capacity by  $F$  and  $H$  respectively, and the aggregate constraint on total valuation capacity by  $\bar{\chi} < 1$ , so

$$H \leq \bar{\chi}. \quad (1)$$

One unit of valuation technology allows the valuation of one asset which reveals additional information about the payoff of that particular asset. The information is binary, and the expected payoff of the valued asset is  $D^g = E[D|good]$  conditional on a good signal and  $D^b = E[D|bad]$  conditional on a bad signal. The signal is not perfect, but the same information is uncovered by anyone doing valuation.<sup>14</sup> A good asset is worth investing in/buying and a bad asset is not:

$$D^g > R > D^b$$

The population share of assets that are good, is  $\lambda \in (0, 1)$ , so that

$$E[D] = \lambda D^g + (1 - \lambda) D^b$$

The outcome of valuation is observed by both the investor and seller, but is not observable by other investors or sellers. Investors are not anonymous: market participants can observe available funds, investment in valuation technology, and the prices of transactions.<sup>15</sup>

To summarize, first, sophisticated investors choose funds and valuation technology, then the market opens. Each seller approaches a buyer/investor and either sells or repeats the process by continuing to another buyer. Unsophisticated investors act competitively to buy/fund assets,

sumption 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.

<sup>14</sup>An 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.

<sup>15</sup>An equivalent assumption is that buyers are anonymous and that all agent knows the amount of valuation capacity in the market when it opens for trade.

and sophisticated investors use their funds and valuation technology to value and buy assets.

An equilibrium is a mass of valuation capacity purchased, a mass of projects sold, a market price, such that all agents are optimizing. Sophisticated investors maximize profits by first choosing valuation capacity and funding capacity taking as given their own future behavior, the strategies of other sophisticated investors, and the price that will be available from unsophisticated investors. Subsequently, sophisticated investors use funds and valuation technology and choose prices taking as given the strategies of other agents and the price available from unsophisticated investors. Sellers do the same for their choices of what investors to approach and at what prices to sell. Unsophisticated investors take the share of good projects as given and compete with each other to buy these projects. We assume that indifferent agents trade. Finally, we assume that investors randomize across equivalent sellers and sellers randomize across equivalent investors and a law of large numbers allows us to ignore uncertainty from this randomization.

The next section derives value functions and the following section describes equilibria.

### 3 Equilibrium value functions

This section contains two subsections that characterize behavior and prices sufficiently to derive the value functions for sellers and buyers: a first subsection for sophisticated investors and sellers approaching them, and a second subsection for unsophisticated investors and sellers approaching them. The description of the equilibria in the introduction is useful for following the initial analysis of this section.

We denote the equilibrium price paid by a sophisticated investor for a good asset by  $P^g$  and for a bad asset by  $P^b$ , and the equilibrium price paid by an unsophisticated investor by  $P^u$ .

#### 3.1 Sophisticated investors

Consider first a sophisticated buyer/investor matched with an asset that it has valued. The potential buyer values the asset at  $D^g/R$  or  $D^b/R$ , and the seller has three options besides selling: *i*) go to another sophisticated investor; *ii*) go to an unsophisticated investor; *iii*) keep

the asset and get 1. The buyer buys the asset as long as the value of the asset is greater than the largest of these three outside options at a price equal to this largest outside option.

First note that if the asset was found to be bad, there is no price at which this asset is purchased since the last outside option – keeping the asset – gives greater value than the value of the asset ( $D^b/R - 1 < 0$ ). If the asset was found to be good, leaving this seller destroys the value of the good information the seller and buyer share. Because valuation capacity is always insufficient to value all assets and because sellers are anonymous and valuation is nonverifiable, sophisticated investors do not compete for valued assets and do not bid prices above the better of the other two options.<sup>16</sup> Thus, provided the sophisticated investor  $i$  has sufficient funds, an asset found to be good is purchased at

$$P_i^g = P^g = \max[P^U, 1] \quad (2)$$

and sellers with bad assets continue to search for buyers. The rejected seller has two remaining options: take its reservation value, 1, or go to an unsophisticated investor and sell for  $P^U$ . Summarizing this we have the following lemma.

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

- (i) *buys/funds the asset at  $P^g = \max[P^U, 1]$  if it is good and  $f > P^g$*
- (ii) *does not buy/fund the asset if it is bad.*

It is now useful to partially characterize  $P^U$ . Since unsophisticated investors compete to fund projects, they set prices equal to the present discounted value of dividends. When there is no valuation, this implies  $P^U = E[D]/R$ . When there is valuation, good projects are removed from this pool, and we claim (verified below) that  $P^U < E[D]/R$ .

Next, we turn to the question of the choice of funds by the sophisticated investor. If no valuation capacity is purchased, then we assume zero funds are chosen.<sup>17</sup> If valuation capacity

<sup>16</sup>It is straightforward to confirm that there is surplus.  $P^U < D^g/R$  or unsophisticated investors lose money, so that  $P^g < D^g/R$  for  $\lambda < 1$

<sup>17</sup>While it is possible that a sophisticated investor that does not invest in valuation capacity mimics an unsophisticated investor, this is not the case in our model.

is positive, sophisticated investor  $i$  chooses funds equal to the cost of purchasing all the good assets it would find using all its valuation capacity when only un-valued sellers approach it, which is  $P^g \lambda h_i$ .<sup>18</sup> It buys no bad assets and no assets without valuation. Why? If the sophisticated buyer chose less than this amount of funds, costly valuation capacity would go to waste. If it had funds to spare after funding good projects, it could buy some assets without valuation or buy some bad assets. Buying a random un-valued asset from the population of assets is strictly preferred whenever some valuation is happening because  $E[D]/R > P^U$ . But then, knowing this, sellers that have assets that they know are bad would approach this investor the same way they might approach an unsophisticated investor and the sophisticated investor would no longer be drawing a random asset from the population but instead from a pool containing both unvalued assets and those valued and found to be bad. Thus, a sophisticated investor that chooses funds sufficient to buy unvalued assets would reduce the quality of its pool of applicants and so reduce the efficiency of its use of valuation, and would do so sufficiently as to be not worth doing. These results are summarized in the following lemma, proved in appendix A (following the above logic).

**Lemma 2** (*Funding with valuation, funding capacity, and share of good assets*)

*If  $h_i > 0$ , the sophisticated investor chooses  $f_i = P^g \lambda h_i$ , gets a share  $\lambda$  of good assets, only buys after valuation finds the asset to be good, and uses all its funding capacity.*

From here on, we refer only to valuation capacity since funding capacity is equal to 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 good information times the profits made less the cost of the valuation technology:

$$J^S = -c + \lambda \left( \frac{D^g}{R} - \max[P^U, 1] \right) \quad (3)$$

sophisticated 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

<sup>18</sup> Sophisticated investors value a positive measure of assets and find a nonstochastic share of good projects.

This equation is linear and decreasing in the one endogenous variable, the market price. This linearity implies that the model has the potential for multiple equilibria if the price  $P^U$  decreases in the aggregate use of valuation.<sup>19</sup>

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

$$W^S = \lambda P^g + (1 - \lambda) \max[P^U, 0] - 1 \quad (4)$$

where the max term reflects the fact that the seller found to have a bad asset chooses between keeping the asset or selling the asset to an unsophisticated investor (and where lemma 1 implies  $P^g = \max[P^U, 0]$ )

It is worth noting that, given our assumptions, investors would like to use contract terms to screen assets and save on valuation capacity. This could be done by sophisticated investors with an ex ante fee, which in the model is ruled out twice. First, we assume that sellers have no funds: since no sellers have any funds, an application fee would make no profits and buy no assets. Second, we assume that after valuation, investors have all the power in the bargaining relationship. Given this, after valuation, the best price a seller can hope for is the market price (or reservation value), meaning that no seller would pay a fee in equilibrium.<sup>20</sup> An alternative screening mechanism would be to allow investors to impose a penalty on the seller whose asset pays off poorly – have the seller bear some risk. Two common foundations for the assumption that the seller must sell all the asset are either moral hazard on the part of the new owner (investor) or there being no resources for the investor to collect if the asset turns out to be bad.

<sup>19</sup> And this will also be true for more general cost functions as long as cost is not increasing faster than price is decreasing.

<sup>20</sup> Relaxing both these assumptions and allowing a fee, investors will generally find it profitable to choose more funds and do stochastic valuation, funding some projects without valuation. We conjecture that equilibria of similar flavor exist in a model in which valuation is noisy and the fee is capped due to the inability to commit to a share of the surplus (or due to the possibility of other agents mimicking sophisticated investors and charging a fee but not funding any applicants). But we have also found models in which no equilibria exist (for similar reasons as in insurance markets).

### 3.2 Unsophisticated investors

Since all valuation capacity is used, the aggregate share of assets that are valued in equilibrium is  $H$ . Of these,  $\lambda H$  are found to be good and so are purchased by sophisticated investors. The total number of assets remaining is the sum of the  $1 - H$  assets that are not valued and the  $H(1 - \lambda)$  that are valued and found to be bad, so that the share of assets that are good and seek to sell without valuation is

$$\frac{\lambda(1-H)}{1-\lambda H}. \quad (5)$$

When no assets are valued,  $H = 0$ , and this equals the population share of good assets,  $\lambda$ .

We denote by  $J^U$  an unsophisticated investor's value of a buying an asset without valuation.

This value is the expected discounted payout of the asset less the price paid for the asset

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

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

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

which is also the social surplus of this transaction.

Price competition among unsophisticated investors leads to zero-profits in equilibrium,  $J^U = 0$ , which implies that the price paid by the unsophisticated investors is:

$$P^U(H) = \frac{\lambda(1-H) D^g + (1-\lambda) D^b}{(1-\lambda H) R} \quad (7)$$

Thus, unsophisticated investors set the market price as a function of the average quality of assets they face in equilibrium. If that price is below the reservation value of sellers, then they do not purchase any assets.



To complete our specification, denote the market price at which transactions occur by

$$P = \max[P^U, 1] \quad (8)$$

Equation (7) and the value function of the sophisticated investors, equation (3), illustrate the main externality in the model. The profits of the 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 asset 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.

## 4 Equilibria

Equilibria can now be characterized using equations (2), (3), (4), (6), (7), (8), and our characterization of optimal choice of  $H$ .

### 4.1 The pooling equilibrium

In a pooling equilibrium all assets trade without valuation at the same price and no valuation technology is used. For this equilibrium to exist, a sophisticated investor must find it unprofitable to invest in valuation capacity and uninformed sellers must prefer selling to unsophisticated investors to keeping the asset, both when  $H = 0$ :

$$J^S \leq 0$$

$$W^U \geq 0$$

The second inequality implies  $P^U - 1 \geq 0$  (when  $H = 0$ ), so that with equation (7) these conditions can be written as

$$\begin{aligned} c &\geq \lambda(1-\lambda) \frac{D^g - D^b}{R} \\ \lambda &\geq \frac{R - D^b}{D^g - D^b} \end{aligned} \tag{9}$$

and all assets trade, so volume is 1, at price equal to the unconditional expected value,

$$P = \frac{\lambda D^g + (1-\lambda) D^b}{R} = E[D]/R.$$

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 without valuation is high enough. Note that the right hand side of the first inequality is equal to the probability of the asset being good ( $\lambda$ ) times the joint gain in value when it is good  $((1-\lambda) \frac{D^g - D^b}{R} = \frac{D^g}{R} - \frac{\lambda D^g + (1-\lambda) D^b}{R} = \frac{D^g}{R} - P)$ , which is the private value of information at the margin in the pooling equilibrium.

## 4.2 Equilibria with valuation

We focus on two possible types of equilibria in which investors invest in the valuation technology. First, there is a *valuation equilibrium* in which sophisticated investors value and buy as many good assets as they can and make profits, and the residual pool of assets is so poor on average that unsophisticated investors do not buy 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 is good enough on average that unsophisticated investors purchase these assets. For completeness, we also note that there is also a third type of equilibrium with valuation, also mixed, but argue that it is a knife-edge case and not interesting.

#### 4.2.1 The valuation equilibrium

For the valuation equilibrium to exist, each sophisticated investor must prefer to invest in valuation up to its capacity constraint, and each uninformed seller must prefer to go to a sophisticated investor or keep its asset instead of going to an unsophisticated investor, both when  $H = \bar{\chi}$ :

$$\begin{aligned} J^S &\geq 0 \\ 0 &\geq W^U \end{aligned}$$

Since  $0 > W^U$  implies  $P^U < 1$ , we have that  $P^S = 1$ , and these conditions become

$$\begin{aligned} c &\leq \lambda \left( \frac{D^g}{R} - 1 \right) \\ \lambda &\leq \frac{R - D^b}{(D^g - D^b) - \bar{\chi}(D^g - R)} \end{aligned} \tag{10}$$

and only good assets that have been valued trade, so volume is  $\bar{\chi}\lambda < 1$ , at price equal to the reservation value,  $P = 1$ .

The 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 transaction occurs times the gain from transacting rather than the seller keeping the asset and *ii*) the share of good assets is low enough (or  $\bar{\chi}$  high enough) that buying without valuation is not profitable after  $\bar{\chi}\lambda$  good assets are bought by sophisticated investors.

It is worth noting that in the pooling equilibrium (equation (9)), the benefit of a marginal unit of valuation is the ability to avoid the unvalued assets that are bad with probability  $1 - \lambda$ . In the valuation equilibrium, there is an additional benefit, the ability to avoid all assets that have previously been found to be bad by others. Thus, as the share of good assets in the population ( $\lambda$ ) increases to 1 (and  $\bar{\chi}$  near one), the valuation equilibrium can occur for higher valuation costs (see the first equation (10)) even though in aggregate the information gained by valuation in equilibrium is vanishing. This previews one of the results of section 5.2, that valuation can

be socially inefficient but privately optimal.<sup>21</sup>

#### 4.2.2 The mixed equilibrium

In the second possible equilibrium with valuation, sophisticated and unsophisticated investors both purchase assets. While as in the valuation equilibrium, sophisticated investors are at capacity and make profits, here valuation capacity is so limited or the share of good assets so high that the remaining, unvalued assets still have positive expected net present value and are bought without valuation by unsophisticated investors. As above, sophisticated investors have market power and earn the rents of valuation, but now compete with unsophisticated investors rather than the seller's outside option. In this equilibrium, profit maximization implies that uninformed sellers are indifferent between types of investors. Thus, for  $H = \bar{\chi}$

$$J^S > 0 \quad (11)$$

$$W^S = W^U \geq 0$$

The inequality  $W^U \geq 0$  implies  $P^U \geq 1$  which places an upper bound on  $H$

$$H < \tilde{H} := 1 - \frac{(1-\lambda)(R-D^b)}{\lambda(D^g-R)} \quad (12)$$

which implies that this equilibrium requires  $\bar{\chi} \leq \tilde{H}$ . With  $P^U \geq 1$ , the equality  $W^S = W^U$  implies

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

Given this price,  $J^S > 0$  and  $\bar{\chi} < \tilde{H}$  simplify to the two conditions for the equilibrium to exist:

$$\begin{aligned} c &< \frac{\lambda(1-\lambda)}{1-\lambda\bar{\chi}} \frac{D^g - D^b}{R} \\ \lambda &> \frac{R - D^b}{(D^g - D^b) - \bar{\chi}(D^g - R)} \end{aligned} \quad (13)$$

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<sup>21</sup>There is a discontinuity (outside our assumed range) at  $\lambda = 1$ , where the valuation equilibrium cannot occur for  $c > 0$  even when  $\chi = 1$ .

The first inequality is the reverse of a ‘scaled up’ (by  $\frac{1}{1-\lambda\bar{\chi}}$ ) version of the first inequality for the pooling equilibrium. Costs have to be low enough so that valuation is profitable, and the ‘scaling’ factor represents the difference between the temptation to purchase valuation when no other agent does (and prices are high) and the purchase of the last unit when all other agents purchase valuation (and so prices are lower). The second inequality states that the share of good assets is high enough (or  $\bar{\chi}$  low enough) that transacting without valuation is profitable after  $\lambda\bar{\chi}$  good assets are bought by sophisticated investors. As  $\bar{\chi} \rightarrow 1$ , this lower bound on  $\lambda$  goes to 1. It is the exact complement to the second equation for the pure valuation equilibrium.

### 4.2.3 The ‘unstable’ mixed equilibrium

For completeness, we note that there can also exist an equilibrium in which sophisticated investors invest in an intermediate amount of valuation capacity and lower market prices just enough to raise profits from investing in a unit of valuation to zero, and unsophisticated investors buy the remaining assets. This equilibrium is a knife-edge case, unstable in the sense that if a sophisticated investor invested in more valuation capacity, it would reduce the quality of the assets bought by the unsophisticated investors, valuation would make more profits, and all sophisticated investors would like to have invested in more capacity to do valuation. Similarly, a slightly higher share of assets choosing to use unsophisticated investors would raise the unsophisticated market price, raising  $P^S$ , and all sophisticated investors would prefer not to have invested in capacity to do valuation.

In Appendix B, we show that this unconstrained mixed equilibrium exists for all parameters such that the pooling equilibrium exists and either the valuation equilibrium or the mixed equilibrium exists.

## 5 Analysis

We first formally state our main results that there are regions of multiple equilibria, then rank them by efficiency, and finally, turn to the dynamics of a crash from the pooling equilibrium to

a pure valuation or to the mixed equilibrium.

### 5.1 Regions of multiple equilibria

The analysis of the previous section implies the following theorem.

**Proposition 1** *(Multiple equilibria) In any period,*

- (i) *the region of parameters in which the valuation equilibrium can exist overlaps the region of parameters in which the pooling equilibrium can exist*
- (ii) *the region of parameters in which the mixed equilibrium can exist overlaps the region in which the pooling equilibrium can exist.*

**Proof.** There are allowable parameters that satisfy equation (9) and equation (10) and allowable parameters that satisfy equation (9) and equation (13). ■

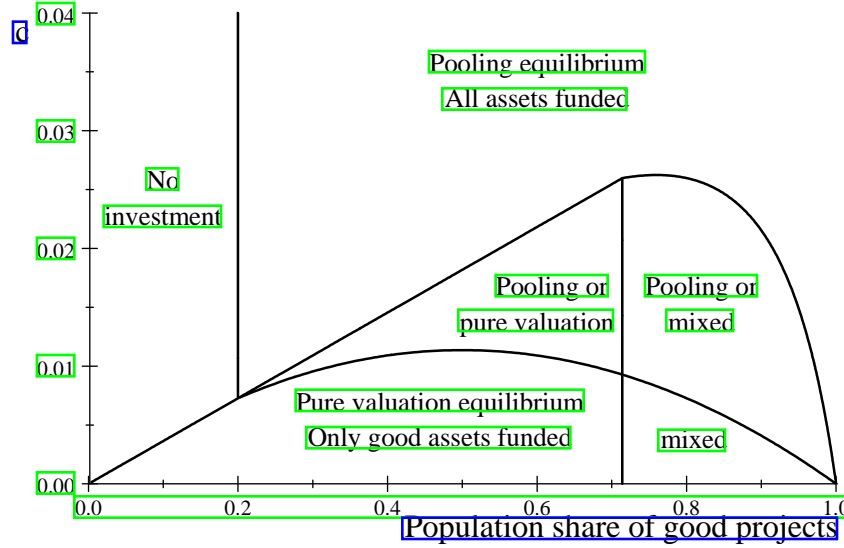


Figure 1: The regions for the pooling, valuation, and constrained valuation equilibria

Figure 1 plots the areas in which each equilibrium exists in  $\lambda - c$  space (and for  $R = 1.1$ ,  $D^g = 1.14$ ,  $D^b = 1.09$ , and  $\chi = 0.90$ ). When the cost of valuation is low enough, only equilibria with valuation exist. When it is high enough, only the pooling equilibrium is possible. When

the share of good assets is low enough, no equilibria or only the pure valuation equilibrium exist. 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.

$$(R - B) / ((G - B) - \chi(G - R)) = 0.71429$$

## 5.2 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 an equilibrium with valuation and in which it would be more efficient to buy/fund all assets without valuation (Pareto superior with transfers).

Consider the parameter set for which the mixed equilibrium exists. Since the pooling equilibrium also leads to all assets trading, but without the costs of valuation, the pooling equilibrium is more efficient than the mixed equilibrium.

We next show that the parameter set over which a sophisticated investor would choose to invest in valuation capacity is strictly larger than the parameter set over which a social planner would choose to have investment in the valuation technology. Thus, where the market can deliver either equilibrium, the pooling equilibrium is more efficient. And in a subset of the parameter space where the market delivers only the valuation equilibrium, the planner would like to prohibit valuation.

To develop intuition, first assume that  $\chi$  is arbitrarily close to one, so there is no inefficiency in the valuation equilibrium from not being able to value all assets. The planner would like to invest in a unit of valuation capacity only if the cost,  $c$ , is less than the expected social benefit. This benefit is the probability in the population that any given asset is bad  $(1 - \lambda)$ , times the gain from not trading it, which in turn is the reservation value of the seller less the present value

of the asset  $(1 - D^b/R)$ .<sup>22</sup> Given linearity (and  $\bar{\chi}$  almost one), if the planner chooses to value one asset, it would choose to value all assets and so the valuation equilibrium would be more efficient.

Now consider a sophisticated investor choosing whether to invest in a unit of valuation or instead to mimic an unsophisticated investor and buy/fund one asset without valuation. In either case, if the asset is good, the investor buys it at the market price  $P$ . The private cost of valuation capacity is the same as in the social planner's problem,  $c$ . The expected private benefit is the population probability that an asset is bad – again, as in the social planner's problem – times the gain to this sophisticated investor of not buying it, which is the market price less the payout of the bad asset  $(P - D^b/R)$ , which is greater than the benefit in the planner's problem since the pooling price is greater than or equal to the reservation value ( $P \geq 1$ ) for any parameters in which the pooling equilibrium exists. Thus, the planner prefers the pooling equilibrium for all parameter values for which a sophisticated investor acting alone does not undermine it – that is for all parameter values where it exists, including the region of multiplicity.

Further, for some parameter values for which only the pure valuation equilibrium exists, trading all assets without valuation is more efficient. Why? Because valuation allows investors to avoid buying/trading bad assets. The cost of buying/trading a bad asset is the effective price paid less the payout, where the effective price is the market price for the sophisticated investor but only the reservation price for the planner. Thus, the existence of transactions without valuation at  $P > 1$  makes valuation worth more to sophisticated investors than to the planner, which, for some parameters, undermines the existence of the pooling equilibrium where it would otherwise be more efficient.

When  $\bar{\chi} < 1$ , the argument must account for the additional inefficiency of the pure valuation equilibrium that some unvalued assets that have positive expected surplus are not traded/funded. In the pure valuation equilibrium, since sellers are all at their reservation values, total social

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<sup>22</sup>There is no gain associated with good projects since they are funded in both equilibria.



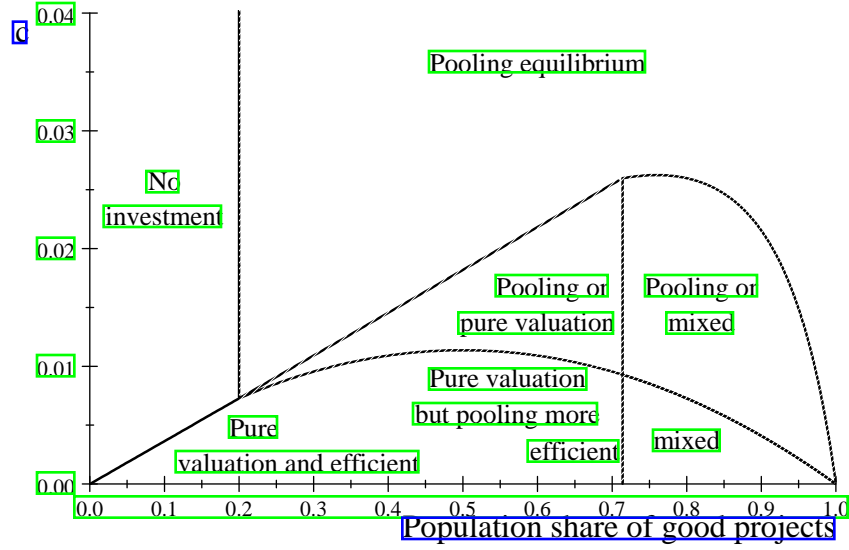


Figure 2: The region where funding without valuation is more efficient than equilibria with valuation

surplus is given by the sum of the profits of the valuation done by sophisticated investors:

$$\bar{\lambda} \left( -c + \lambda \left( \frac{D^g}{B} - 1 \right) \right)$$

If instead all assets are traded without valuation, investors all make zero profits and total social surplus is given by the total payouts to the unit mass of sellers:

$$\frac{\lambda D^g + (1 - \lambda) D^b}{B} = 1$$

Subtracting gives that no-valuation and having all assets sold/funded is socially preferred to the valuation equilibrium whenever the total cost of valuation capacity and the cost of not trading the unvalued assets exceeds the benefits of not buying the valued assets found to be bad:

$$\bar{\lambda} c + (1 - \bar{\lambda}) \left( \frac{\lambda D^g + (1 - \lambda) D^b}{B} - 1 \right) \geq (1 - \lambda) \bar{\lambda} \left( 1 - \frac{D^b}{B} \right)$$

As shown in Figure 2, 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  $\lambda$  where the pure valuation equilibrium exists and  $c = 0$  (where  $P = 1$  also).

To sum up, we state these results formally

**Proposition 2** *Ranking of equilibria*

i) For parameters such that the pooling equilibrium exists, it is more efficient than the pure valuation equilibrium, and the mixed equilibrium,

ii) for parameters such that the only market equilibrium is the mixed equilibrium, this equilibrium is less efficient than no valuation and trading all assets without valuation,

iii) for parameters such that the only market equilibrium is the pure valuation equilibrium, it

$$c \geq c^{Eff} := \frac{(1 - \lambda\bar{\chi})R - (1 - \lambda)D^b - (1 - \bar{\chi})\lambda D^g}{\bar{\chi}R} \quad (14)$$

then the market equilibrium is less efficient than no valuation and trading all assets without valuation.

### 5.3 Discussion

This subsection first discusses implications and interpretation of our model, and then the importance of five assumptions (others are discussed elsewhere, notably screening with contracts at the end of section 3.1).

#### 5.3.1 Implications and interpretation

A switch in equilibrium from a pooling to a pure valuation equilibrium exhibits many of the stylized features of investment crashes. In particular, the increase in valuation is associated with: a) *Investment collapse*: The volume of transactions declines from 1 to  $\bar{\chi}\lambda$  as only sellers that can get their assets valued and who have good assets sell/are funded. b) *Price collapse*: Transaction prices fall from  $\frac{\lambda D^a + (1 - \lambda)D^b}{R}$  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) Credit crunch:* Some assets that would have been sold/funded in the pooling equilibrium, even some unvalued assets (and so some good assets), cannot get sold/funded in the valuation equilibrium. *e) Flight to quality:* Unsophisticated investors leave the market as the chance of buying a bad asset increases and only good assets trade. *f) Profits for sophisticated investors:* Sophisticated investors make profits/valuation capacity earns rents.

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

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

While our model is static, it is straightforward to consider repeated static model in which all unsold assets disappear at the end of each period. One might then consider as an application of the model a new investment opportunity which is expected to be quite profitable but which is also initially hard to value along some dimension. Over time, returns are observed the cost of valuation may (exogenously) decline. Similarly, since capital is flowing into the market without careful valuation along this dimension, the quality of new assets may 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 may enter a region where a valuation equilibrium is also possible.<sup>23</sup>

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<sup>23</sup>As an aside, there is also no higher payment to the sellers of good assets relative to bad assets in the pure valuation equilibrium as both receive their reservation values. This result would change if sophisticated investors

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.

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 (forthcoming). 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 non-verifiable information on the quality of the investment. As such, our explanation is closer to Ruckes (2004) and Dell’Ariccia and Marquez (2006), which both consider how adverse selection and lending standards leads to contractions of credit in bad times.<sup>24</sup> The former shows how the probability that a borrower is of a bad type changes the private value of information which in turn is amplified through 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 of new projects, about which no bank has information, and existing projects, about which some bank has private information. In the model, fewer new projects implies a lower share of good projects approaching banks and a tightening of lending standards and reduced credit.<sup>25</sup>

### 5.3.2 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 purchased, our results would be qualitatively similar (if increasing ‘enough’) except that the sophisticated investors would not earn rents (which instead would presumably accrue to the providers of the valuation capacity). A capacity

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sometimes valued the same asset and competed to buy it.

<sup>24</sup>Postdating our paper, Gorton and Ordóñez (forthcoming) also draws out new insights for fluctuations in informed lending by incorporating secondary markets.

<sup>25</sup>Similarly, and postdating our paper, Kurlat (2012) defines a new equilibrium concept in a different model of valuation skill in which increases in volume for sale leads to entry of valuation skill and worse adverse selection problems and lower prices, thus rationalizing declines in price associated with fire sales through valuation effects.

constraint significantly simplifies the analysis.

Second, instead of assuming that valuation capacity is sunk, we could have assumed that the unsophisticated investors are small and competitive price takers as in the equilibrium concept in Dubey and Geanakoplos (2002). This would lead to the same regions, would not require that sophisticated investors be competitive, but would change the importance of commitment for policy, discussed next. Without sunk valuation, competition in prices by deep-pocketed unsophisticated investors could eliminate the possibility of multiple equilibria (but not change outcomes in the region in which the valuation equilibrium is unique but funding without valuation more efficient).

Third, the assumption that the investor gets all the surplus when matched with a seller known to be good is important only for the equations that determine where different regions occur (as long as the investor gets some of the surplus) and for what parties earn rents in the valuation equilibria. This follows because, in equilibria with valuation, sophisticated buyers 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 investors get sufficient surplus to cover the costs of valuation for some parameter values.

Two alternative assumptions with the same implications are i) that sophisticated investors post prices at which they are committed to transact if they transact and ii) that sellers after a possible valuation sell through a second-price sealed-bid auction. The proof of the first claim follows from the fact that being able to make a take-it-or-leave-it offer is equivalent having all the bargaining power in this environment. The proof of the second claim follows from the fact that the optimal bid in a second price auction is the private value so that a buyer with information that an asset is good wins the auction and pays the market price.

Fourth, 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 what must really be a dynamic process with valued projects indistinguishable from new entrants. As a more formal foundation, we show in Appendix C that our model has the same implications if we instead assume that sellers pursue sequential search but buyers do not know in what order the

seller approaches potential buyers, an information structure borrowed from Zhu (forthcoming).<sup>26</sup>

Finally, the fact 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. But as noted, it is also incentive compatible for the buyer-seller pair with a known-bad asset. Further, notice that sophisticated investors prefer equilibria with valuation and unsophisticated investors are indifferent as they make no pure profits. 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 this type of information.<sup>27</sup>

If the act of valuation were observable, the negative externality from valuation would be corrected in the current model. Section 6 considers this as a potential regulatory intervention and shows that the equilibria of this alternative model are unique and always efficient.

## 6 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 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 expectation equilibrium, it is worth emphasizing that this section studies optimal policy in the model not the real world.

To begin, why does the market not deliver the more efficient equilibrium? The first answer is that valuation has social costs greater than its private benefits – it creates information on which adverse selection can occur. Thus a first approach to optimal policy is to tax valuation or eliminate adverse selection.

One optimal policy is to tax units of valuation capacity with tax,  $\tau$ , so that the use of

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<sup>26</sup>To be clear, implicit in this assumption is the inability of sellers with unvalued projects to commit to delay sale as in Guerrieri and Shimer (2012) and Chang (2011).

<sup>27</sup>It 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 typically do not reveal the identity of those who conduct credit checks and so do not reveal the purpose of the check (something that an unsophisticated investor would find useful).

valuation is deterred where it is inefficient, which is any  $\tau$  such that

$$\tau + c \geq \begin{cases} \lambda \left( \frac{D^g}{R} - 1 \right) & \text{if } c \geq c^{Eff} \text{ and } \lambda \leq \frac{R - D^g}{(D^g - D^b) - \bar{\lambda}(D^g - R)} \\ \frac{D^g - D^b}{R} & \text{if } c \geq c^{Eff} \text{ and } \lambda \geq \frac{R - D^g}{(D^g - D^b) - \bar{\lambda}(D^g - R)} \end{cases}$$

This tax ensures the pooling equilibrium wherever it is ex ante socially efficient. This of course has the real-world problems of both distinguishing this type of valuation from other types of valuation (such as about value that is common across assets) and monitoring and observing valuation.<sup>28</sup>

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 agent's incentives. But 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  $\geq 1$ ). And unvalued 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, which cannot happen unless either sophisticated investors pay fees to unvalued sellers prior to valuation or sophisticated sellers can commit to posted prices.<sup>29</sup> Considering the case of commitment to posted prices, the sophisticated investor would post the minimum price to attract unvalued assets, which is  $P^g$  such that

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

<sup>28</sup> While 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. And auctioneers as market makers may not make items available for inspection prior to the auction.

<sup>29</sup> The ability of sophisticated investors to commit to prices would not change the results of sections 4 and 5. A fee would have the same implications as the price described in the main text and would satisfy

$$\lambda \left( \frac{\lambda D^g + (1 - \lambda) D^g}{R} \right) + (1 - \lambda) + fee = \frac{\lambda D^g + (1 - \lambda) D^b}{R}$$

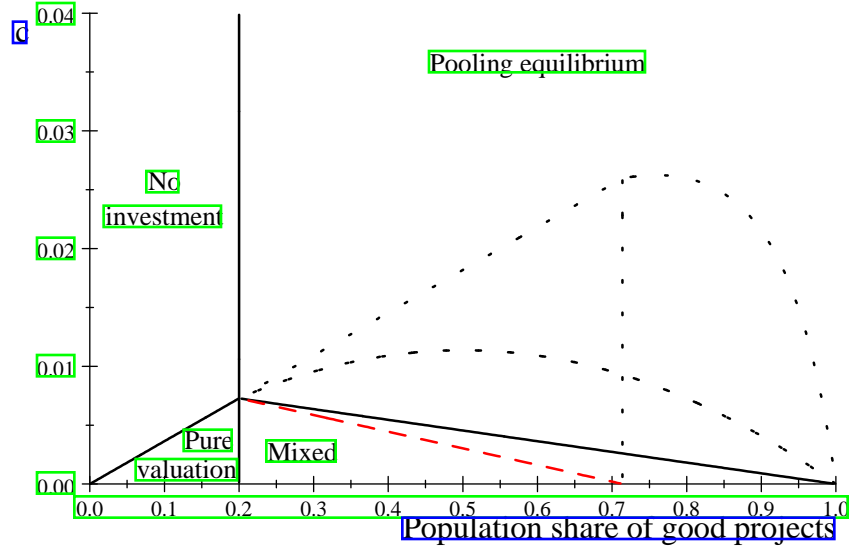


Figure 3: The region where eliminating adverse selection delivers the efficient outcome

Valuation would be undertaken when  $J^S \geq 0$  (with  $P^U = 1$ ), which is when

$$\lambda \leq \left( \frac{D^g}{R} - 1 \right) \quad (15)$$

This boundary lies above the boundary for efficiency of the pooling equilibrium with anonymity (equation (14); equations (14) and (15) converge as  $\bar{\chi} \rightarrow 1$ ).

In Figure 3, the solid lines delineate the three equilibria when there is price commitment (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 which the pooling equilibrium exists, determined by equation (9) with the first inequality replaced by the complement of equation (15). There is a new type of mixed equilibrium in which the price is the same as the pooling equilibrium, trade is  $\lambda\bar{\chi} + (1 - \bar{\chi})$  and  $(1 - \lambda)\bar{\chi}$  bad assets are not traded, determined by equations (9) and (15). Third, there is a region of pure valuation in which the price is 1 and trade is  $\lambda\bar{\chi}$ , determined by equation (10) with the second inequality replaced by  $\lambda \leq \frac{R - D^g}{D^g - D^b}$ . Finally, there a region of no trade which



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.<sup>30</sup> 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 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 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  $\lambda = \frac{R - E^b}{D^g - D^b}$ ).

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.<sup>31</sup>

The second answer to why the market does not deliver the more efficient equilibrium is that unsophisticated agents do not have the ability to commit to purchase at high prices (they do not compete in contracts with commitment). If unsophisticated investors had commitment, a large unsophisticated investor could post a price equal to the price in the pooling equilibrium,  $P = \frac{\lambda D^g + (1-\lambda) D^q}{R}$ , which would ensure that the market is in the pooling equilibrium wherever it exists as a market equilibrium. This result follows from the efficiency of the pooling equilibrium.<sup>32</sup> Thus, if private agents were unable and the government were able, the government could commit to purchase at the pooling equilibrium price. Or alternately, the government could commit to insure all mortgages at the ex ante fair price for the pooling equilibrium.<sup>33</sup>

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

<sup>30</sup>This follows from similar arguments to section 5.2.

<sup>31</sup>Sorkin (2009) describes several episodes during the US 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.

<sup>32</sup>Since  $P^S \geq P$  to compete, it is straightforward to verify that  $J^S < 0$  wherever the pooling equilibrium is possible, so that no sophisticated investors would invest in valuation and the multiplicity is eliminated.

<sup>33</sup>It is not sufficient to insure the mortgages at an ex post fair price, since then sophisticated investors can do valuation, insure only the bad assets, and destroy the insurance scheme.

no valuation. To ensure this, the government further has to subsidize purchases by the large investor, as for example by a proportional subsidy  $\sigma$  that implies  $P^U = (1 + \sigma) \frac{\lambda D^g + (1 - \lambda) D^b}{R}$  and  $J^S \leq 0$ . That is, if  $c \geq c^{Eff}$  and  $c \leq \lambda(1 - \lambda) \frac{D^g - D^b}{R}$ , then

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

(along with ex ante commitment by a large unsophisticated agent) ensures that  $J^S < 0$  and the economy is in a pooling equilibrium wherever it is more efficient (ignoring the cost 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  $\lambda$  is close to one. For  $\lambda$  close to one, equilibria with valuation when they exist are inefficient for a wider range of parameters than when  $\lambda$  is lower. And 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 demise of these institutions as due to their committing to purchase at the expected present discounted value of a random (unvalued) mortgage with  $\lambda$  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 GSE). 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 destroy information to create a pooling equilibrium (Gorton and Pennacchi (1990), DeMarzo and Duffie (1999), DeMarzo (2005), and Axelson (2007)). Our contribution to this literature is that, when private information is endogenous, securitization requires commitment and can be effectively achieved without actually securitizing assets. Our results also

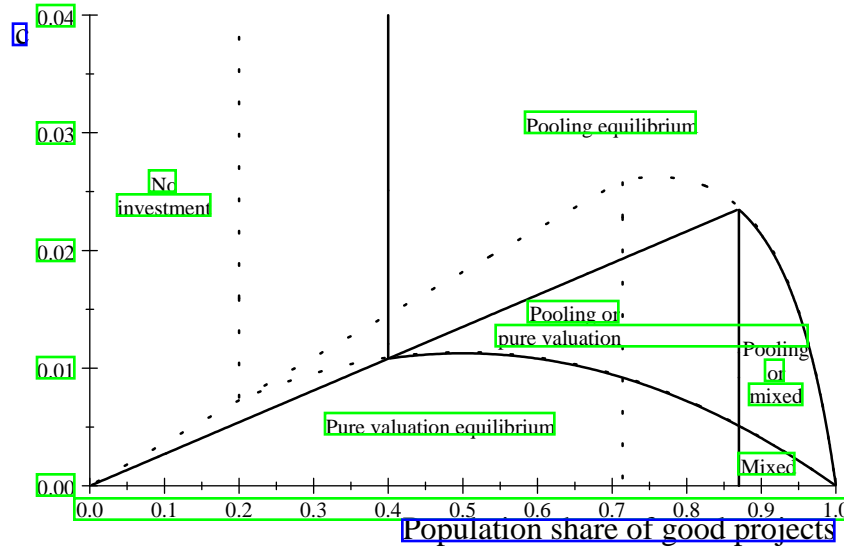


Figure 4: The effect of a higher real interest rate

highlight an alternative dimension of securitization – that market participants have an incentive to undermine the process through information acquisition.

We conclude by considering two policies in which the government changes parameters of the market.

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 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.

Second, policies which 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

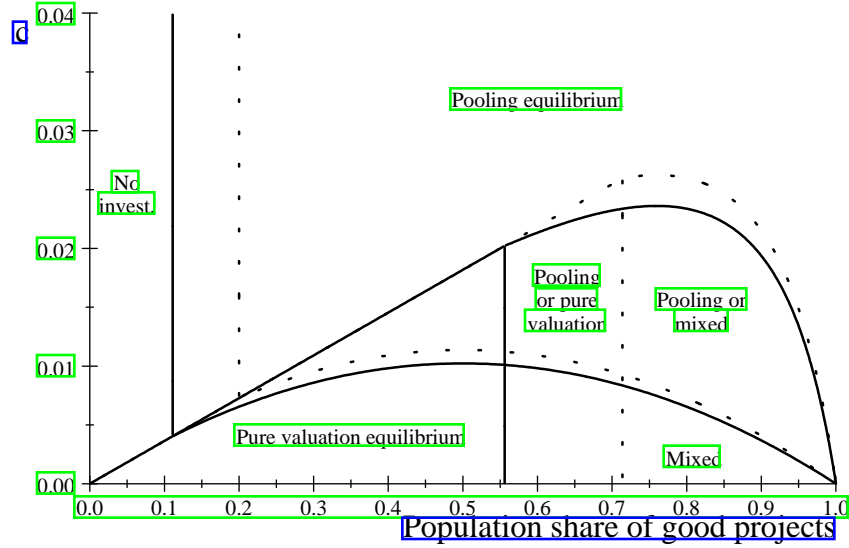


Figure 5: The effect of a higher value of bad project

5 depicts how subsidizing the payout of the bad asset bad assets (from  $D^b = 1.090$  (solid line) to  $D^b = 1.095$  (dotted line)) increases the size of the pure pooling equilibrium and decreases the size of the pure valuation region, and raises the size of the region where the pooling equilibrium coexists with the mixed 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.

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

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

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

where  $\tau\lambda D^g = \sigma(1-\lambda)D^b$  ensures revenue neutrality. Of course this policy is effective because private agents are assumed to be unable to commit to a similar insurance contract. And, 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.<sup>34</sup>

How do the optimality of these policies contrast with those if the information friction were of the type in Dang (2008) or Glode, Green, and Lowery (2012)? In both of these papers, outlawing valuation achieves the first best since 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, Green, and Lowery (2012), as agents in these models make the correct inference about whomever they are facing. Finally, in these papers committing to purchase at the uninformed 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.

## 7 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 buyer. We show the possibility of multiple equilibria with different levels of valuation and rank these equilibria by efficiency. Where equilibria without valuation exist, valuation is always socially inefficient, and where equilibria without valuation do not exist, valuation can still be less efficient than selling/funding without valuation. This result 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, while in the canonical model information tends to be under-produced and markets learn too late.

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<sup>34</sup>Although, if the tax and subsidy plan were explicitly 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.

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## Appendices

### A Proof of lemma 2

**Lemma 3** (*Funding with valuation, funding capacity, and share of good assets*)

*If  $h_i > 0$ , the sophisticated investor chooses  $f_i = P^g \lambda h_i$ , gets a share  $\lambda$  of good assets, only buys after valuation finds the asset to be good, and uses all its funding capacity.*

**Proof:** Valuation cannot be slack since it is costly ex ante. Thus sophisticated investors choose funds at least sufficient to buy all assets found to be good when using all their valuation capacity.

Suppose that a sophisticated investor bought more assets than its capacity to do valuation. In this case, any seller going to this investor would have a positive probability of selling without valuation at a price equal to its outside option. Thus this sophisticated investor, would be approached by sellers with previously-valued assets that they know to be bad as well as by sellers that do not know the quality of their assets. Thus the share of good assets would be the same as for unsophisticated investors, the market share of good assets. Since this sector is competitive, any purchases without valuation would not make profits. At the same time the existence of such purchases reduces the share of sellers with good assets that approach the sophisticated investor, so that a unit of valuation is less likely to uncover a good asset. Thus, buying only conditional on a good valuation, which would keep known-bad assets away, is more profitable.

A sophisticated investor with funds greater than its valuation capacity can not commit to value all assets before funding and not use these additional funds. If there is valuation in equilibrium, then the share of good assets in the market for funding without valuation is less than that in the population. Thus, if only unvalued assets approached the sophisticated investor, the investor would find it profitable to fund without valuation at a price equal to the expected value of the unvalued asset sold to the unsophisticated investors (or 1 if the unsophisticated investors are not in the market  $P < 1$ ). Thus,  $f_i > \lambda h_i$  cannot be an equilibrium if we are

to have sophisticated investors funding only after valuation. Therefore, sophisticated investors must choose funding capacity ( $f_i$ ) equal to population share of good assets ( $\lambda$ ) times their valuation capacity ( $h_i$ ) and only sellers with unvalued assets with probability  $\lambda$  of being good approach the sophisticated seller.

## B The unconstrained mixed equilibrium

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

$$J^S = 0 \quad (\text{B.1})$$

$$W^S = W^U > 0$$

As for the mixed equilibrium, this thus requires,  $H \leq \tilde{H}$  and  $P^g = P^U = P$ . Equation (B.1) implies  $P^g = \frac{D^g}{B} - \frac{D^b}{\lambda} = P^U(H)$  which, together with equation (7), implies that the level of valuation capacity that gives indifference is

$$H^* \equiv \frac{1}{\lambda} (1 - \lambda) \frac{D^g - D^b}{B} \quad (\text{B.2})$$

Thus, this equilibrium exists when

$$H^* \in \left( 0, \min \left[ \bar{\chi}, \tilde{H} \right] \right) \quad (\text{B.3})$$

or

$$\begin{aligned} c &> \lambda(1-\lambda) \frac{D^g - D^b}{B} \\ c &\leq \frac{1}{1-\lambda\lambda} \lambda(1-\lambda) \frac{D^g - D^b}{B} \\ c &< \lambda \left( \frac{D^g}{B} - 1 \right) \end{aligned}$$

The first inequality is a strict inequality version of the first condition for the pooling equilibrium (equation (9)) 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  $\frac{1}{1-\lambda_X}$ ) 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 (equation (10)).

It is straightforward to verify three properties. First, there is only one  $H^*$  is unique and thus that there is at most one unconstrained 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 unconstrained mixed equilibrium exists. And third, following the logic of the mixed equilibrium, wherever the unconstrained mixed equilibrium exists, it is less efficient than the pooling equilibrium.

## C Equilibrium with sequential search as in Zhu (2013)

The trading structure of Zhu (2013) 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 (2013), each seller has one unit of an indivisible asset she wishes to sell and approaches randomly chosen buyers sequentially. When a seller approaches a buyer, the buyer 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 buyer and get another quote. Or the seller can return to a previous buyer for another quote. Buyers do not observe negotiations elsewhere in the market. Thus buyers face “contact-order uncertainty – uncertainty regarding the order in which the competing buyers are visited by the seller.” Zhu (2013) analyzes a situation in which buyers have noisy signals of fundamental value and shows among other things that contact-order uncertainty leads to lower quotes due to adverse selection: any seller that a buyer observes may have been to previous buyers and been offered only low prices implying that their noisy signals of value were low. Thus a buyer – unsure whether it is seeing a seller who has been looked at by other buyers 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 OTC structure delivers the same equilibrium conditions as our model. 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.]