

A Note on Information Disclosure and Adverse Selection

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Abstract

We analyze public disclosure in a financial market with private information as in [Myers and Majluf \(1984\)](#). Firms need outside financing to invest in valuable projects, but they are privately informed about the quality of their assets. Adverse selection in credit markets can then lead to suboptimal investment. We characterize a set of policies that robustly increase investment.

JEL: E5, E6, G1, G2.

1 Set-up

The basic set-up is the same as in [Philippon and Skreta \(2012\)](#), and similar to [Faria-e-Castro et al. \(2015\)](#). There are three dates, $t = 0, 1, 2$, and three types of agents: a continuum of households, a continuum of firms (or “banks”), and a government. Banks have preexisting legacy assets, start with private information regarding the quality of these assets, and receive an investment opportunity at $t = 1$. The government can choose to disclose information at $t = 0$. All agents are risk-neutral, and the risk-free rate is normalized to zero.

Initial Assets. Banks start with legacy assets and no preexisting liabilities. The book value of legacy assets, A , is known, but the eventual payoff at time 2 is a random variable $a \in [0, A]$ since some assets may be impaired. Banks privately know their type θ , which determines the conditional distribution of the value of legacy assets, $f_a(a|\theta)$. We assume that types are discrete, $\theta \in \Theta = \{\theta_1, \dots, \theta_N\}$, and the prior over the different types is given by $\{\pi_k\}_{k=1}^N$.

Investment and Borrowing. Banks receive investment opportunities at time 1. Investment requires a fixed amount x and delivers a random payoff v at $t = 2$, with pdf $f_v(v)$. Banks start with no cash nor liquid assets, and can borrow from households at time 1 in a competitive market. After learning its type θ , a bank offers a contract to competitive investors that is characterized by a schedule of repayments y^l at $t = 2$.

Assumptions. We assume that investment opportunities are independent of the bank’s type, and so $f_v(v)$ does not depend on θ . We assume that v has support $[0, V]$ and expected value \bar{v} . We assume that new projects have positive net present value, $\bar{v} > x$. We also assume that contracts can be written only on the total income of the bank at time 2. The only observable income is thus $y \equiv a + v \cdot i$, the sum of the realizations of legacy assets and the investment opportunity, where $i = 1$ if the bank has invested and zero otherwise. Let f denote the distribution of income y , the convolution of f_a and f_v in the case the bank invests. Since f_a depends on the type θ , so does f . Letting Y denote the support of y , we assume that $f(y|\theta) > 0, \forall (y, \theta) \in Y \times \Theta$, and that f satisfies the strict monotone hazard property, that is, $f(y|\theta)/(1 - F(y|\theta))$ is decreasing in θ . Finally, we assume that the y^l schedule is nondecreasing in y , using the refinement in [Innes \(1990\)](#). Our assumption that only total income is observable prevents contracts from being written on the new investment. Following [Nachman and Noe \(1994\)](#), the optimal contract in this environment is debt.

2 Decentralized Equilibrium

In equilibrium, all banks offer the same debt contract. Bad types want to mimic good types, while the latter want to separate themselves. Let us consider the benchmark case of no information revelation, which we denote by \mathcal{S}_0 . This means that a single debt contract is traded, and there is a single interest rate. Let R_0 denote the total contractual repayment associated with this contract. The expected repayment for type θ can be written as

$$\rho(\theta, R_0) \equiv \int_{\mathcal{Y}} \min(y; R_0) f(y|\theta) dy$$

This function is increasing in both θ and R_0 . A bank invests if and only if the repayment is such that investment is worthwhile. A bank borrows to invest if and only if

$$\mathbb{E}[a|\theta] + \bar{v} - \rho(\theta, R_0) \geq \mathbb{E}[a|\theta],$$

or

$$\bar{v} \geq \rho(\theta, R_0).$$

Since the right-hand side is increasing in θ , we have that if any type n finds it optimal to invest, all types $k < n$ will also find it optimal to invest. Let N_0 be the best type that invests. Then, $\{1, \dots, N_0\}$ is the set of types that decide to invest. Types $k > N_0$ do not find it worthwhile to invest, and drop out of the credit market.

The decentralized equilibrium is characterized by a threshold type N_0 and a repayment R_0 such that

1. The break-even condition for creditors is satisfied,

$$\sum_{k=1}^{N_0} \pi_k [\rho(\theta_k; R_0) - x] \geq 0$$

2. The threshold type satisfies

$$N_0 = \arg \max_n \{\theta_n : \rho(\theta_n; R_0) \leq \bar{v}\}$$

Adverse selection models of this type can have multiple equilibria that can be Pareto-ranked. Whenever this happens, we simply select the best equilibrium.¹ Total investment in the decentralized equilibrium is equal to

¹This is without loss of generality since the government can costlessly implement the best equilibrium with a lending program. See [Faria-e-Castro et al. \(2015\)](#) for a more detailed discussion.

$x \times \mathcal{I}_0$, where \mathcal{I}_0 denotes the total number of banks who invest, and is given by

$$\mathcal{I}_0 = \sum_{k=1}^{N_0} \pi_k.$$

3 Disclosure Policies

We now consider the role of different disclosure policies \mathcal{S} . A disclosure policy is characterized by a set of signals $s \in \{1, \dots, N\}$, and probabilities $\{\pi_{n,s}\}_{[1:N]^2}$, where

$$\pi_{n,s} = \Pr(S = s | \theta = \theta_n)$$

that is, $\pi_{n,s}$ is the probability of the signal realization being equal to s given that the type is n . All types receive exactly one signal, so

$$\sum_{s=1}^N \pi_{n,s} = 1, \quad \forall n \in \{1, \dots, N\}.$$

Agents use Bayes' Law to compute the probability that a bank receiving signal s is of type n

$$\hat{\pi}_{s,n} = \Pr(\theta = \theta_n | S = s) = \frac{\Pr(s|n) \times \Pr(n)}{\Pr(s)} = \frac{\pi_{n,s} \pi_n}{\sum_{k=1}^N \pi_{k,s} \pi_k}.$$

3.1 Equilibrium with Disclosure

All banks that receive the same signal s are pooled into a class, for which the equilibrium conditions that we described above apply. Each class s is characterized by a threshold type N_s and a repayment R_s such that

$$\sum_{k=1}^{N_s} \hat{\pi}_{s,k} [\rho(\theta_k; R_s) - x] \geq 0$$

$$\rho(\theta_{N_s}; R_s) \leq \bar{v}$$

The total number of banks investing given disclosure policy \mathcal{S} is given by

$$\mathcal{I}_{\mathcal{S}} = \sum_{s=1}^N \underbrace{\left(\sum_{n=1}^{N_s} \hat{\pi}_{s,n} \right)}_{\text{Investment in } s} \times \underbrace{\left(\sum_{k=1}^N \pi_{k,s} \pi_k \right)}_{\text{Size of } s}$$

3.2 Decreasing Type 1-Error Policies

We focus on sequences of disclosure policies that satisfy the “decreasing type-1 error” property, defined as follows.

Definition 1. *A sequence of disclosure policies $\{\pi_{n,s}^{(t)}\}_{t=0}^{\infty}$ satisfies the “decreasing type-1 error” property (DT1) if it starts from $\pi_{n,N}^{(0)} = 1$ for all n , there are only two possible signals per type, $\pi_{n,s}^{(t)} = 0$ unless $s \in \{n, N\}$, truthful revelation is monotonic*

$$\pi_{n,n}^{(t+1)} \geq \pi_{n,n}^{(t)}$$

and the posteriors within the pooling class are ranked by reverse hazard rate dominance

$$\{\hat{\pi}_{N,k}^{(t+1)}\}_k \succeq^{RHRD} \{\hat{\pi}_{N,k}^{(t)}\}_k.$$

Under disclosure policies that satisfy (DT1), there are two types of banks. Some are partially revealed for what they are, while others are pooled at the high signal N . The key property is that the quality of the pool that receives the high signal is monotonically increasing in t , in the precise sense of reverse hazard rate ordering, which means that, for every n ,

$$\frac{\hat{\pi}_{N,n}^{(t+1)}}{\sum_{k=1}^n \hat{\pi}_{N,k}^{(t+1)}} \geq \frac{\hat{\pi}_{N,n}^{(t)}}{\sum_{k=1}^n \hat{\pi}_{N,k}^{(t)}}$$

We argue that this captures the idea of decreasing type-1 errors because either a type is truthfully revealed (in which case both type 1 and 2 errors are zero), or the risk of being pooled with worse types decreases with t . Technically, it will imply first-order stochastic dominance on the conditional distribution of banks below any investment cutoff, which is the key property to ensure that investment increases with t . We consider sequences indexed by t because we want to think of a planner choosing how much to disclose by choosing a particular t , which indexes the “amount” of disclosure. We normalize these policies such that $t = 0$ is no disclosure, and all banks receive the highest signal regardless of their type. Finally notice that for simplicity we have considered only one pooling group, namely the one with signal N , but it is easy to extend our definition to several pooling groups.

This class of disclosure policies nests some interesting particular cases, such as the one that follows

Definition 2. *A sequence of disclosure policies $\{\pi_{n,s}^{(t)}\}_{t=0}^{\infty}$ satisfies “disclosure from the bottom” (DB) if $\pi_{n,N}^{(0)} = 1$*

and

$$\begin{aligned}\pi_{n,n}^{(t+1)} &\geq \pi_{n,n}^{(t)} \\ \pi_{n,N}^{(t+1)} &= 1 \quad \text{if } \pi_{n-1,n-1}^{t+1} < 1\end{aligned}$$

Disclosure from the bottom involves completely disclosing worse types first: all banks are given the highest possible signal, and the worst type is gradually revealed. Only once the worst type is fully revealed can the second-worst type be revealed, and so on. We show that this is a special case of (DT1) policies in the following result.

Proposition 1. *If a sequence of disclosure policies satisfies (DB), it also satisfies (DT1).*

Proof. We show that (DB) implies likelihood ratio dominance. This is enough, since it implies reverse hazard rate dominance. We want to show that the $t+1$ distribution of posteriors among the high signal class dominates the t distribution in terms of likelihood ratios.

$$\hat{\pi}_{N,\cdot}^{(t+1)} \succeq^{LRD} \hat{\pi}_{N,\cdot}^{(t)}$$

To show this, take a disclosure policy satisfying (DB) for an arbitrary t , and let $z_t \in \{1, \dots, N\}$ denote the worst type that is partially revealed under this t . That is, $\pi_{k,N}^{(t)} = 0$ for $k < z_t$, and $\pi_{k,N}^{(t)} = 1$ for $k > z_t$. Let $\{\hat{\pi}_{N,k}^{(t)}\}_{k=z_t}^N$ be the posterior that is induced by the disclosure policy t . Without loss of generality, we can describe the $(t+1)$ policy as

$$\begin{aligned}\hat{\pi}_{N,z_t}^{(t+1)} &= \frac{(1-\alpha)\hat{\pi}_{N,z_t}^{(t)}}{1-\alpha\hat{\pi}_{N,z_t}^{(t)}} \\ \hat{\pi}_{N,k}^{(t+1)} &= \frac{\hat{\pi}_{N,k}^{(t)}}{1-\alpha\hat{\pi}_{N,z_t}^{(t)}} \quad \text{for } k > z_t\end{aligned}$$

where $\pi_{z_t,N}^{(t+1)} = (1-\alpha)\pi_{z_t,N}^{(t)}$ or

$$1-\alpha = \frac{1-\pi_{z_t,z_t}^{(t+1)}}{1-\pi_{z_t,z_t}^{(t)}}$$

which implies that $\alpha \in [0, 1]$. The disclosure policy at $t+1$ consists of updating the disclosure policy at t by

reducing the mass of banks of type z_t that are given the signal N by a fraction α . Notice then, that

$$\frac{\hat{\pi}_{N,k}^{(t+1)}}{\hat{\pi}_{N,k}^{(t)}} = \begin{cases} \frac{1-\alpha}{1-\alpha\hat{\pi}_{N,z_t}^{(t)}} & \text{if } k = z_t \\ \frac{1}{1-\alpha\hat{\pi}_{N,z_t}^{(t)}} & \text{if } k > z_t \end{cases}$$

That is, $\frac{\hat{\pi}_{N,k}^{(t+1)}}{\hat{\pi}_{N,k}^{(t)}}$ is an increasing function of k for any $\alpha \in [0, 1]$. This is equivalent to $\hat{\pi}_{N,\cdot}^{t+1}$ stochastically dominating $\hat{\pi}_{N,\cdot}^t$, according to the likelihood ratio order. This, in turn, implies reverse hazard rate dominance, thus establishing our claim. The case for which $z_{t+1} > z_t$ is proved analogously. \square

3.3 Investment and DT1 Policies

We now present our main result: investment is increasing in t for any sequence of disclosure policies satisfying DT1.

Proposition 2. *If a disclosure policy \mathcal{S}_t satisfies DT1, total investment \mathcal{I}_t is increasing in t .*

Proof. Take an arbitrary t . For this disclosure policy, types are either revealed, or pooled with the highest signal. Let N_t be the threshold type that invests in the pool of banks with the high signal. Then, we know that all types $n \leq N_t$ will fully invest (since they are either revealed or invest under pooling), while only types $n > N_t$ that are revealed invest. Total investment is then equal to

$$\mathcal{I}_t = \sum_{k=1}^{N_t} \pi_k + \sum_{k=N_t+1}^N \pi_{k,k}^{(t)} \pi_k$$

The additional investment generated by \mathcal{I}_{t+1} can be written as

$$\mathcal{I}_{t+1} - \mathcal{I}_t = \left[\sum_{k=1}^{N_{t+1}} \pi_k - \sum_{k=1}^{N_t} \pi_k \right] + \left[\sum_{k=N_{t+1}+1}^N \pi_{k,k}^{(t+1)} \pi_k - \sum_{k=N_t+1}^N \pi_{k,k}^{(t)} \pi_k \right]$$

If $N_{t+1} \geq N_t$, then we can write the above term as

$$\mathcal{I}_{t+1} - \mathcal{I}_t = \sum_{k=N_t+1}^{N_{t+1}} \pi_k (1 - \pi_{k,k}^{(t)}) + \sum_{k=N_t+1}^N \pi_k \left(\pi_{k,k}^{(t+1)} - \pi_{k,k}^{(t)} \right) \geq 0$$

Since $\pi_{k,k}^{(t)} \leq 1, \forall k, t$, and $\pi_{k,k}^{(t+1)} \geq \pi_{k,k}^{(t)}$, it is enough to show that N_t is increasing in t to prove our claim.

To see this, note that we can write the conditions that characterize the pooling equilibrium as

$$\sum_{k=1}^{N_t} \hat{\pi}_{N,k}^{(t)} [\rho(\theta_k; R_t) - x] \geq 0$$

$$\rho(\theta_{N_t}; R_t) \leq \bar{v}$$

where

$$\hat{\pi}_{N,n}^{(t)} = \frac{\pi_{n,N}^{(t)} \pi_n}{\sum_{k=1}^N \pi_{k,N}^{(t)} \pi_k}$$

If we show that N_t is an equilibrium with disclosure policy $t + 1$, we are done. The reason is that for any equilibrium with threshold N_s , $N'_s < N_s$ is also an equilibrium. Our selection device consists of selecting the largest N_s that satisfies the equilibrium conditions. If we show that N_t is an equilibrium under policy $(t + 1)$, we are showing that the equilibrium set is at least as good: the selected equilibrium will then either be the same, or better than N_t .

We proceed then to show that (N_t, R_t) is an equilibrium under $(t + 1)$. Under these conditions, the following participation condition

$$\rho(\theta_{N_t}; R_t) \leq \bar{v}$$

is trivially satisfied. We need then to show that the break-even condition

$$\sum_{k=1}^{N_t} \hat{\pi}_{N,k}^{(t+1)} [\rho(\theta_k; R_t) - x] \geq 0$$

is also satisfied. To see that this is the case, note that under disclosure (t) , we can write

$$\sum_{k=1}^{N_t} \hat{\pi}_{N,k}^{(t)} [\rho(\theta_k; R_t) - x] \geq 0$$

$$\Leftrightarrow \frac{1}{\sum_{k=1}^{N_t} \hat{\pi}_{N,k}^{(t)}} \sum_{k=1}^{N_t} \hat{\pi}_{N,k}^{(t)} [\rho(\theta_k; R_t) - x] \geq 0$$

$$\Leftrightarrow \mathbb{E}_{(t)}[\rho(\theta_k; R_t) - x | k \leq N_t] \geq 0$$

Since ρ is an increasing function of θ , reverse hazard rate dominance implies that

$$\mathbb{E}_{(t+1)}[\rho(\theta_k; R_t) - x | k \leq N_t] \geq \mathbb{E}_{(t)}[\rho(\theta_k; R_t) - x | k \leq N_t]$$

and so (N_t, R_t) must also be an equilibrium under $(t + 1)$. This implies that $N_{t+1} \geq N_t$, and thus investment is always weakly greater under $(t + 1)$ than under (t) :

$$\mathcal{I}_{t+1} \geq \mathcal{I}_t.$$

□

References

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