SHOULD WE REGULATE FINANCIAL INFORMATION?

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Abstract

Regulations that require asset issuers to disclose payoff-relevant information to potential buyers are often called “investor protection.” But even when they improve real economic efficiency, such regulations may still harm investors. By making payoffs less uncertain, information reduces risk and therefore reduces return. Similarly, real efficiency gains benefit only asset issuers, who can always choose to disclose. Providing information improves investors' welfare only when 1) issuers strategically manipulate the asset supply to obfuscate information, or 2) the information induces firms to take on riskier investments. Using a portfolio choice model with information markets, the paper explores which types of assets might warrant investor protection.

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Regulations that require asset issuers to disclose payoff-relevant information to potential buyers sound like obvious measures to increase investor welfare. This paper builds a model with an equilibrium asset market, a monopolist asset issuer, an information market and a real production sector to investigate whether such information regulations achieve that goal. We find that in many cases, requiring information disclosure harms investors. The reason is that asset returns compensate investors for risk. By making payoffs less uncertain, disclosure reduces risk and therefore reduces return. As high-risk, high-return investments disappear, investor welfare falls. Of course, information is still valuable to each individual investor. But acquiring information is like a prisoners' dilemma. Each investor is better off with the information, but collectively investors are better off if they remain uninformed. On the other side, providing information does improve investors’ welfare when asset issuers would otherwise distort the asset supply to hide information, or when disclosing information induces firms to undertake riskier investments. The paper explores when such outcomes are likely to arise.

Many recent financial reforms have sought to increase the transparency of financial products by requiring the seller to disclose additional information. Proponents of these reforms argue that giving buyers more information about the expected costs and benefits of a financial product increases their welfare, and allows the financial market to allocate capital more efficiently. Opponents point out that disclosure is costly for firms and that an active market for financial information and consulting services exists to provide this information in cases where it is efficient. Neither argument is correct. Our results explain why even when information can improve the allocation of capital, that does not translate into a rationale for mandatory disclosure. They also show that the existence of a competitive information market does not imply that disclosure is welfare-reducing. Instead, our analysis teaches us that the focus of the debate should be on whether disclosure prevents asset issuers with market power from manipulating asset markets and whether it encourages efficient risk-taking.

Because many new disclosure regulations pertain to new assets being sold, we model an asset issuer/entrepreneur who is endowed with shares in his firm and strategically chooses how many to sell to a continuum of investors at a market-clearing price. The assumption that issuers can strategically manipulate the asset supply makes the logic of our welfare results distinct from previous results based on risk-sharing inefficiencies. In our model, information can be produced at a cost. This cost can be borne by the issuer of a security, who discloses the information, free of charge, to all potential investors, or by independent analysts who can produce the information and sell it to each investor. After observing issuer or analyst reports, rational investors choose how much to
pay for the security. After all shares are sold at a market-clearing price, the payoff of the security is realized and agents get utility payoffs. On top of this foundation, we then add real investment spillovers, in an analytically tractable way. The policy we evaluate in the model is a mandatory disclosure regulation, which requires asset issuers to provide the information at their own cost.

Section 2 begins by considering the welfare effects of an exogenous change in the amount of symmetric information investors observe. Information affects asset prices in two ways: First, a surprisingly positive report will push the price of the asset up, while a surprisingly negative report will reduce the price. In expectation, reports are neutral and this effect washes out. The second effect is that information makes the asset’s payoff less uncertain. In doing so, it makes the asset less risky. Decreasing risk lowers the equilibrium return and systematically raises the asset’s average price. For welfare, this means that information reduces the asset’s risk, but also implies lower return. With exponential utility and normally distributed payoffs, the return effect always dominates.

There are circumstances in which mandatory disclosure improves investor welfare. Since mandatory disclosure shifts information costs from investors to asset issuers, one might think that disclosure would be most valuable to investors when this cost is large. Oddly, investors benefit from disclosure when the cost of information is low. If the information cost is high, few investors will buy the reports and there is little information asymmetry. With little asymmetry, the effect of disclosure is similar to the previous case where information is symmetric and more information reduces investor welfare. But when the analyst reports are cheap, many investors buy them. Any remaining uninformed investors face severe asymmetric information, which reduces risk-sharing.

Mandatory disclosure can also be beneficial because it remedies the distortions in the asset supply created by monopolist asset issuers. When issuers manipulate the asset supply to hide their information and increase their expected profit, forcing them to disclose information can reduce the size of the price distortion.

One potential objection to these results is that they come from a model with exponential utility, identical coefficients of absolute risk aversion for all investors and normally-distributed payoffs. Section 3.2 proves that our results persist for all investors when they have different levels of absolute risk aversion. Furthermore, section 3.3 shows numerically that the main results hold when preferences exhibit constant relative risk aversion (CRRA).

Another often-cited reason to regulate financial information provision is that better information in financial markets facilitates efficient real investments. Therefore, Section 4.2 explores the effect of disclosure in the presence of two spillovers from financial information to the real economy. In the first model, an issuer can choose how much real capital to invest in his firm at time 1. His payoff
depends on the price the asset sells for in the time-2 financial market. If financial asset prices are very sensitive to changes in the value of the capital stock (they are informationally efficient), then the issuer is incentivized to invest the optimal amount. We find that requiring disclosure improves the efficiency of capital allocation and maximizes output. But, surprisingly, the positive effect of information on the real economy does not benefit investors. Instead, all the efficiency gains accrue to the issuer. Investor returns are compensation for bearing risk. A project that is known by all to be more valuable will command a higher price. In equilibrium, it will have the same return as an equally risky, but lower-payoff project. If improving efficiency does not affect the risk of the project, then promoting efficient real investment may be a laudable goal, but it does not interact in any way with investor protection.

In the second production economy, information disclosure encourages the firm to invest more, which makes the firm payoff more risky. In this setting, more symmetric information can increase investor welfare, but only if it induces the firm to choose a more risky level of investment. Ironically, while mandatory disclosure is intended to reduce investor risk, it may be beneficial precisely in cases where it induces firms to compensate by increasing risk.

Together, these results reveal that mandatory disclosure is not warranted simply because investors are poorly-informed about a security. To the contrary, the case for regulating financial information, as an investor protection measure, hinges on establishing that either a) some investors have this information already, b) that asset issuers are strategically manipulating the price, or c) that providing the information would induce the firm to take more risk.

Ultimately, the desirability of mandatory disclosure depends on parameter values, which makes the optimal policy a quantitative question. Of course, quantifying a model based on sale of information is not an easy task. But one context where information is quantifiable is credit ratings. Section 5 uses data on ratings, prices, and performance of corporate bonds issued between 2004 and 2005 to estimate the model parameters and uses those estimates to compare the costs and benefits of ratings. The resulting numerical predictions tell us that rating costs are low, compared to the benefit of information, for the typical security. The costs are sufficiently low that without regulation, issuers would cease to provide ratings and all investors would buy analyst reports for themselves. Thus, requiring disclosure has no effect on the amount of information available about the average security. It would simply replace analyst markets with issuer disclosures. Shifting information costs to issuers benefits investors, but does not improve efficiency. It is a pure transfer.

The benefits of information disclosure mandates matter beyond finance. For instance, buying consumer goods or services with uncertain benefits is similar to investing in a risky asset. While
financial information helps to allocate real productive capital, consumer goods information encourages high-value goods to be supplied and low-value goods to be withdrawn. In both cases, mandatory information improves allocative efficiency. But this efficiency gain may not benefit consumers because, in equilibrium, the price of goods with less-uncertain quality is higher. One contribution of this paper is to assess regulation of financial market disclosure laws. But a second contribution is a framework that can be used to think through and to quantify these competing equilibrium effects in a broad array of markets.

**Related literature:** Our paper is closely related to a recent economics literature on the welfare consequences of information disclosure. In Medrano and Vives (2004), entrepreneurs are also risk-averse speculators who trade on private information. In Amador and Weill (2012, 2010) and Kondor (2011), providing financial information can be welfare-reducing. However, these papers do not model an information market and do not consider the same equilibrium effects as we do. Similarly, Gonzalo Llosa and Venkateswaran (2012) consider the efficiency of information acquisition decisions in a coordination game, but not in an equilibrium asset market. Gorton and Ordonez (2012) allow investors to acquire information that helps them distinguish firms with good collateral from those without. This type of information is specific to collateralized lending and is distinct from the information about asset payoffs that we consider.

Hirshleifer (1971) and Allen (1984) also argue that information acquisition is welfare-reducing because investors pay for it, because it does not create any social value, and because it prevents efficient risk-sharing. Our results go beyond Hirshleifer’s effect by exploring the effect of disclosure on strategic price manipulation and by showing that investor welfare falls even when the investors do not pay, even when informed asset trade results in more output, and even when providing information improves risk allocation. The commonly-invoked logic that information is bad because it prevents the efficient sharing of risk is not the basis for our results. In our production model, disclosing information shifts risk from risk-averse investors to risk-neutral issuers, and is therefore improving the risk allocation. Despite all this, information can still reduce investor welfare.

Our work also contributes to the literature that connects the real and financial sides of the economy. Most of these linkages work through the supply of credit to individuals or firms. In contrast, our model captures the idea that asset markets govern incentives: Market prices that aggregate more investor information provide better incentives for firms to invest in a more efficient manner. Like our model, Goldstein, Ozdenoren, and Yuan (2011), Ozdenoren and Yuan (2008), Albagli, Hellwig, and Tsyvinski (2009) and Angeletos, Lorenzoni, and Pavan (2010) all propose
mechanisms that capture an information externality. The information spillover is that asset prices aggregate information that firm managers can use to guide their real investment decisions. When financial investors can affect real investment, this creates complementarities in demand among investors and the potential for multiple equilibria. This effect is not possible in our model because real investment takes place first. More importantly, the type of information spillover our model describes is distinct. An important part of our contribution is a simple, tractable way to capture the idea that improving investors’ access to information incentivizes firms to allocate capital efficiently.

Literatures in finance and accounting consider how disclosures remedy managers’ incentive problems in principal-agent settings. But to examine market externalities and evaluate the merits of free-market efficiency claims requires a model with many agents interacting in a market. More closely related is work on costly information acquisition, such as Grossman and Stiglitz (1980), Verrecchia (1982), Peress (2010), and Fishman and Parker (2011). We extend this work by considering the trade-offs between issuer- and investor-purchased information and connecting the asset market to the real economy. If the issuer does not provide the signal, investors themselves can choose to purchase the information. We consider whether, in the absence of disclosure regulation, either issuer-provided or investor-purchased information markets will fill in the void. Furthermore, the model connects financial information choices to real investment choices, output and welfare.

Finally, this work is also related to a microeconomics literature on welfare and disclosure (e.g. Shavell (1994), Diamond (1985) and Jovanovic (1982)). Our model differs because it features a continuum of investors in a market that has an equilibrium price. Our results come primarily from equilibrium effects.

1 Model

**Asset issuer:** A risk-averse asset seller owns \((1 + \xi)\) shares of a divisible risky asset whose payoff is \(y \sim N(\bar{y}, \frac{1}{h_y})\). The endowment \((1 + \xi)\) is random and \(\xi \sim N(0, \frac{1}{h_\xi})\). Before selling, the issuer must decide whether to produce a report about the asset’s quality. Producing this report entails a cost \(C\). The report is a number \(z\) which is a noisy, unbiased signal about the risky asset’s payoff: \(z = y + \eta_z\), where \(\eta_z \sim N(0, \frac{1}{h_{\eta_z}})\). The seller will get to observe \(z\) in any case. But reporting \(z\) means that all investors will observe \(z\) as well. Denote the sale price of the asset by \(p\), the decision to produce a report by \(D = 1\) and the decision not to do so by \(D = 0\). The decision to report is made before knowing \(z\), \(y\) or \(\xi\).

After observing \(z\), \(\xi\) and rationally anticipating how the market price \(p\) depends on \(q_S\), the
issuer decides to retain $q_S$ shares of the risky asset. He sells the remaining $1 + \xi - q_S$ shares to investors. The issuer chooses $D$ and $q_S$ to maximize utility subject to the budget constraint:

$$U(W_S) = -E[exp\{-\rho S W_S\}] . \quad (1)$$

$$W_S = (1 + \xi - q_S)p + q_Sy - CD \quad (2)$$

A policy of mandated disclosure consists of mandating that the issuer choose $D = 1$.

**Investors and financial markets:** There is a continuum of ex-ante identical investors with measure $Q$. They have CARA expected utility\(^1\) with coefficient of risk aversion $\rho$:

$$EU = E[-e^{-\rho W}] , \quad (3)$$

where $W$ is their realized wealth. They have an initial endowment of wealth $w_0$. Investors can purchase fractional shares of the risky asset. They can also store their initial endowment with zero net return. Investor $i$’s realized wealth is therefore

$$W_i = w_0 + q_i(y - p) - d_i c. \quad (4)$$

where $q_i$ is the number of units of the project the investor buys.

Investors do not observe $y$ of $\xi$. If the issuer provides a report on the asset quality, then all investors observe $z$; otherwise none observe $z$. However, each investor $i$ can purchase a report from an analyst ($d_i = 1$) at a price $c$, or not ($d_i = 0$). The report is a noisy signal about what the issuer knows: $\theta = z + \eta_\theta$, where $\eta_\theta \sim N(0, 1/h_\theta)$ is independent of $y$ and $\eta_z$.

The price $p$ is determined in an auction. Each investor submits a bidding function $b_i(q)$ that specifies the maximum amount that he is willing to pay for a quantity $q$ of the risky asset as a function of his information. These bid functions determine the aggregate demand. The auctioneer specifies a market-clearing price $p$ that equates aggregate demand and supply, and each trader pays this price for each unit purchased (a Walrasian auction).

**Information markets:** The analyst can produce the signal $\theta$ at a fixed cost $C_A \geq C$ and distribute it at zero marginal cost. The fact that $\theta$ is a noisy signal of $z$ and that $C_A \geq C$ means

\(^1\)Since the model has a single asset, any risk is systematic and will be priced as such. More generally, since asset returns are correlated, the return has a systematic component, which justifies modeling investors in any given asset as risk-averse.
that the analyst’s technology for producing information is weakly worse than that of the issuer. They are the same in the limit case where $h_\theta \to \infty$ and $C_A = C$.

Analysts sell their services to individual investors at a price $c$. For now, we assume that the information is protected by intellectual property law and reselling it is forbidden. We revisit this assumption in the concluding remarks.

The analyst market is perfectly contestable, so that analysts earn zero profits. This implies that, if a measure $\lambda$ of investors chooses to purchase the analyst report, the price of the report must be $c = \frac{C_A}{\lambda}$.

The exact information market structure is not crucial. Veldkamp (2006) analyzes monopolistic competition and Cournot markets. Each one produces information prices that decrease in demand.

**Order of Events:**

1. The issuer decides whether or not he will pay to disclose information, before knowing $y$, $z$, $\theta$ or $\xi$.

2. (a) If the issuer discloses, all investors observe $z$. No investors observe $\theta$ because it contains no relevant information that is not already in $z$.

   (b) If the issuer does not disclose, the analyst decides whether to find out $\theta$ and sets the price $c$. Investors then simultaneously decide whether or not to buy the analyst’s report. Those who do, observe $\theta$. The issuer also observes $\theta$.

3. The issuer chooses a level of asset supply $1 + \xi - q_S$ that maximizes (1), given the equilibrium relationship between the asset price $p$ and asset supply. Investors submit menus of prices and quantities of assets they are willing to purchase at each price $b_i(q)$.

4. The asset auction determines a market-clearing price.

5. $y$ is realized and all payoffs are received.

**Equilibrium:** An equilibrium is a disclosure decision $D$ and asset supply $q_S$ by the issuer, a demand $d_i$ by each investor for analyst reports, a decision by the analyst about whether to produce a report and a price $c$ for the report, bidding functions $b_i(q)$ for each possible information set and an asset price $p(z, \theta, D, \{d_i\}, \xi)$ such that: issuers choose disclosure $D$ and supply $q_S$ to maximize

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2One way to ensure that the market is contestable is to force agents to choose prices in a first stage and choose entry in a second stage.
investors choose \( d_i \) and bidding functions to maximize (3) subject to (4); analysts make zero profits, and the asset market clears: \( \int_0^Q q_i \, \text{d}i = 1 + \xi - q_S \).

2 Equilibrium

We start by analyzing the properties of the second-period financial market equilibrium, for given information choices. Then, we consider the asset supply decision of the asset issuer and finally, the information choices.

Investors’ bidding: With CARA utility and Normal asset payoffs, investor \( i \)’s first order condition for portfolio choice is:

\[
q_i = \frac{h_i(\hat{y}_i - p)}{\rho} \tag{5}
\]

where \( \hat{y}_i \equiv E_i(y) \) and \( h_i \equiv Var_i(y)^{-1} \). The bidding function is the inverse of (5), i.e. \( b_i(q) = \hat{y}_i - q\rho h_i^{-1} \). The subscript \( i \) denotes the fact that the calculation is made under investor \( i \)'s information set. In the absence of disclosure, informed investors (i.e. those who buy the analyst’s report, denoted by subscript \( I \)) observe \( \theta \) and they observe (and learn from) the price \( p \). Uninformed investors (denoted by subscript \( U \)) only learn from the price \( p \). With disclosure, both types of investors observe \( z \) and the price contains no additional information.

Asset supply decision by the issuer: Both issuers and investors are solving a portfolio problem with CARA utility. However, the issuer is a monopolist and therefore does not take prices as given, like the investors do. The issuer understands that if \( \lambda \) investors choose to become informed, the equilibrium price will have to satisfy the market-clearing condition:

\[
1 + \xi - q_S = \lambda \frac{h_I[\hat{y}_I(p, \theta) - p]}{\rho} + (Q - \lambda) \frac{h_U[\hat{y}_U(p) - p]}{\rho} \tag{6}
\]

The issuer therefore chooses \( q_S \) and \( p \) to maximize (1) subject to (2) and (6). Due to the CARA-Normal structure, maximizing exponential utility is equivalent to maximizing the mean-variance objective \( E(W_S | z, \xi, \theta, p) - \frac{\rho_S}{2} Var(W_S | z, \xi, \theta, p) \). Substituting in the mean and the variance of \( y \) yields the problem

\[
\max_{q_S, p} (1 + \xi) p + q_S (\hat{y}_S - p) - \frac{\rho_S}{2} q_S h_S^{-1} \tag{7}
\]

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\( ^3 \)Implicit in the notation in (6) is the result that with normal distributions the precisions \( h_I \) and \( h_U \) do not depend on \( \theta \) or \( p \).
subject to (6), where by Bayes’ rule,

\[ \hat{y}_S = \frac{h_y \bar{y} + h_z z}{h_y + h_z} \]  

(8)

\[ h_S = h_y + h_z. \]  

(9)

The issuer can extract monopoly profits by restricting asset supply to keep the price high. This effect shows up as the negative relationship between \( q_S \) and \( p \) in (6). The issuer can also profit by manipulating the price to affect the beliefs of investors. That effect shows up through the terms \( \hat{y}_I (p, \theta) \) and \( \hat{y}_U (p) \). The disclosure environment will end up affecting both of these channels of monopoly power. First, under disclosure, prices contain no information that investors don’t already know and therefore \( \hat{y}_I \) and \( \hat{y}_U \) do not depend on \( p \), which removes the issuer’s incentive to manipulate investors’ inference. Second, under disclosure, \( h_i \) will be higher, which by (5) means that the slope of investors’ asset demand curves is less steep, reducing the incentive to restrict quantity to raise prices.

**Equilibrium prices:** Since the price equates asset demand and supply, and both depend on information in the price, there is a fixed point problem. We guess and verify (in the appendix) the following linear form for price:

\[ p = \alpha + \beta \theta + \delta z + \gamma \xi \]  

(10)

where \( \alpha, \beta, \delta \) and \( \gamma \) are taken as given by all investors and found by the method of undetermined coefficients. Since \( p \) is taken as given, all agents use the conjectured solution to invert the price and obtain an unbiased signal.

The average price is \( \alpha + \beta \bar{y} + \delta \bar{y} \), and it consists of the ex-ante expected payoff \( \bar{y} \) less a term that accounts for investors’ risk aversion \( \rho \) and the amount of information they have, which depends on the precision of the information and (under non-disclosure) the informativeness of prices and how many investors buy the report. The sensitivity of the price to the analyst report is given by \( \beta \). Under non-disclosure, \( \beta \) is greater when information is very precise relative to the prior and a large fraction of investors buy reports. The sensitivity of price to issuer information is \( \delta \), which also increases in signal precision and is highest when the issuer discloses. The sensitivity of the price to the noise in supply \( \xi \) is given by \( \gamma \). Prices will tend to be relatively sensitive to supply noise when investors are risk averse, when few have bought the analysts’ report or when the report is not very informative.
For the case where the issuer discloses the information (either by choice or due to the mandate), the price formula (10) still applies, but with different coefficients. In particular, since no investors would pay to observe a noisy signal about $z$ when the true $z$ is known, $\theta$ will remain unobserved and $\beta = 0$.

**Information choice when the issuer does not disclose:** In case the issuer does not provide the report, investors will simultaneously choose whether to buy it from the analyst. Since they are ex-ante identical, they will only make different choices when those choices yield identical expected utility. Appendix A.3 derives a set of equations that determine the equilibrium measure of informed investors. Equilibrium also implies that, if the issuer does not disclose, two things can happen. One possibility (for sufficiently low $C_A$) is that the analyst produces the signal and the the zero-profit condition holds: $c = \frac{C_A}{\lambda}$. The other possibility (for sufficiently high $C_A$) is that there is no $c$ that will make the analyst break even, so he does not produce the signal and the information market is not active.

**Voluntary disclosure by the issuer:** In those cases where, absent regulation, the issuer would voluntarily provide a report, disclosure mandates would be irrelevant. The issuer will voluntarily choose $D = 1$ only when the increase in expected utility from doing so outweighs the cost $C$. The costs and benefits of disclosure depend on what the issuer expects to happen in the information market under nondisclosure.

Suppose first that the issuer expects that the analyst will not produce the report so $\lambda = 0$. Then the costs and benefits of disclosure are as follows. First, disclosure increases the expected price of the asset because providing information decreases the amount of risk investors bear when they purchase it. Furthermore, more information reduces the sensitivity of the price to the liquidity shock $\xi$ and therefore makes the covariance between $p$ and $\xi$ less negative, i.e. it raises the price especially in the realizations of $\xi$ where the issuer is selling a large number of units. The issuer trades off these two benefits against two costs of disclosure. First, there is a direct monetary cost of disclosure, $C$. Second, disclosure makes the price more sensitive to realizations of $z$ and therefore increases the variance of the price, introducing extra risk into the issuer’s utility. The issuer’s willingness to disclose information will therefore depend on his risk aversion, the cost $C$, and the increase in expected price relative to the extra risk disclosure creates.

If the issuer expects that there will be an active information market, there are additional effects, since the issuer must compare the information that results from disclosure to the equilibrium
information that investors will acquire and not just to a market with uninformed investors.

**Proposition 1 (Disclosure by issuer)**

1. There exists a cutoff cost \( C^* \) such that the issuer will disclose his signal if and only if \( C < C^* \).

2. For any \( C > 0 \), the issuer will not disclose his signal for sufficiently high \( h_\theta \) and low \( C_A \).

Part 1 of Proposition 1 is straightforward. If the direct cost of disclosure is sufficiently high, the issuer will choose not to disclose the information. The expression for the cutoff \( C^* \) is derived in the appendix. Part 2 describes cases where, if the issuer does not disclose, the information market will provide information anyway. If \( C_A \) is sufficiently low, then the equilibrium price of the issuer’s report is sufficiently low that all investors buy it. If in addition \( h_\theta \) is high, then analyst’s report is almost identical to the signal the issuer would disclose. The issuer realizes that investors’ information sets will be very similar whether or not he discloses and he chooses not to disclose to save the direct disclosure cost.

One general implication of Proposition 1 is that there exist ranges of parameters such that the issuer will choose not to disclose information unless a mandate is in place, and hence a disclosure mandate will make a difference.

### 3 Welfare Effects of Information Regulation

We focus on whether a mandate to disclose information, i.e. a policy that mandates \( D = 1 \), benefits investors. A mandate also affects the asset issuer, but a simple revealed preference argument establishes that he is always weakly better off without the disclosure mandate. Without the mandate, he can always choose \( D = 1 \), with identical effects as if he were forced to do so. With the mandate, he cannot choose \( D = 0 \), which could be the preferred option for some parameter values.

We start by comparing a hypothetical market where investors have no access to any information (in the notation above, \( \lambda = 0 \)) to one where there is mandatory disclosure.

**Proposition 2 (Investors prefer information market collapse)** For \( \rho_S \) sufficiently high, investors have higher ex-ante expected utility when no information is provided than when disclosure is mandatory.

To see why investors prefer no information, imagine a scenario where, contrary to our framework with a strategic issuer, the noisy supply of the asset was independent of the asset’s payoff. Under
the CARA-Normal framework, conditional expected utility satisfies

\[ E_i[U] \propto -\exp \left\{ \frac{-1}{2} \frac{(E_i(y) - p)^2}{\text{Var}_i(y)} \right\}. \]  

(11)

(See Appendix A.3 for derivation.) Roughly speaking, expected returns enter quadratically in investors’ utility because the direct effect is compounded by them taking larger positions. The fact that variance enters (linearly) in the denominator of the fraction tells us that each investor individually would prefer more information. But when all investors acquire more information, the expected return falls. The unconditional expected return of the asset compensates the investor for bearing conditional variance. Overall, the effect of higher variance on utility through higher expected returns dominates the direct risk effect and expected utility is increasing in the conditional variance of the asset payoff. Investors benefit from access to a high-risk, high-return asset. They are indifferent between holding the last, marginal share of a risky asset, but earn a utility benefit from holding all the inframarginal shares. When firms disclose, it is as if the asset is replaced by a lower-risk, lower-return asset. Investors earn less of a utility benefit from holding this asset at the new, higher equilibrium price.

Acquiring information is like a prisoner’s dilemma. Each investor wants to observe more information. But investors would like to collectively commit to observe less. This is a stark result, meant to illustrate an effect that may otherwise be overlooked: Reducing the riskiness of an asset will reduce the equilibrium return, perhaps to the detriment of the party bearing the risk. However, there are certainly mitigating circumstances in which this conclusion is overturned. We next examine three reasons why disclosure may in fact help investors.

First, when issuers are not too risk averse (low \( \rho_S \)), proposition 2 may not hold and disclosure may increase investor utility. The reason is that with lower risk aversion, issuers will exploit their monopoly power and information can help to reduce the monopoly rent extraction. When they are very risk averse, issuers hold few shares in their firm and do not use asset supply as a strategic tool because it would entail bearing too much risk. When risk aversion falls, the issuers hold more shares in their firm, which restricts the supply available to investors and raises the average price of a share. In (6), we see this effect show up. Choosing a low \( q_S \) raises \( p \) all else equal. But notice that a one-unit increase in \( q_S \) reduces \( p(\lambda h_I + (Q - \lambda)h_U)/\rho \) by one unit. When investor uncertainty is lower (\( h_I \) and \( h_U \) higher) this requires a smaller change in price. More information here effectively reduces the slope of the asset demand curve, which reduces the cost of the monopoly distortion. In the limit, where uncertainty goes to zero and the asset becomes riskless, there is only
one arbitrage-free price and the monopolist has no power to affect the price.

The second reason disclosure may help investors is that it prevents information manipulation. When the issuer maximizes (7) subject to (6), the first-order condition with respect to \( p \) is

\[
(1 + \xi) - qS + \varphi \left[ \lambda \frac{h_I}{\rho} \left( \frac{\partial \hat{y}_I}{\partial p} - 1 \right) + (Q - \lambda) \frac{h_U}{\rho} \left( \frac{\partial \hat{y}_U}{\partial p} - 1 \right) \right] = 0
\] (12)

where \( \varphi \) is the Lagrange multiplier on (6). The two terms that reflect this ability to manipulate informed and uninformed investors’ beliefs are \( \frac{\partial \hat{y}_I}{\partial p} \) and \( \frac{\partial \hat{y}_U}{\partial p} \). With disclosure these terms become zero, removing this distortion.

The third reason disclosure may benefit investors is that the alternative to disclosure may be asymmetric information, which is worse. If only some investors are willing to buy the analyst report, the informed and uninformed investors will hold different quantities of risky and riskless assets. But since all investors are identical ex-ante, holding different portfolios entails sharing risk inefficiently. Inefficient risk sharing reduces investor welfare. If this welfare effect is strong enough, investors prefer that a mandatory disclosure statute restore information symmetry.

**Proposition 3** *(Investors prefer mandatory disclosure when information is cheap and precise.)* There exists a cutoff \( C_A^* \) such that for every \( C_A < C_A^* \), there exists an \( h_\theta \) sufficiently high such that investor welfare is higher with mandatory disclosure.

The logic of this result is as follows: If the equilibrium is such that most investors will choose to buy the signal from the independent analyst, any given investor faces a choice between being less informed than most other traders or paying for the information. In any interior equilibrium, every investor must be indifferent between these two choices. In the limit, if everyone else is informed (\( \lambda = Q \)) and the analyst’s report is just as accurate as the issuer’s signal (\( h_\theta = \infty \)), an investor who pays for the information will have the same utility as in the mandatory disclosure case minus the cost of the report. In an equilibrium with \( \lambda \) close to \( Q \), each investor will be indifferent between bearing the cost of information or suffering from asymmetric information and would prefer mandatory disclosure, which both avoids the resulting information asymmetry among investors and shifts the cost of the report onto the issuer.

One might think that it is when information is very expensive that investors would prefer for asset issuers to pay for it and provide it to them for free. Instead, when information is expensive, investors know that few among them will buy analyst reports. There will be few informed investors to drive up asset prices and excess returns will be available. Instead, when information is cheap,
most investors will buy it. Anticipating this, the issuer will choose not to provide the report. In this scenario, investors would prefer that disclosure be provided for free.

Notice also that this effects is dominant only when \( h_\theta \) is high, i.e. when the information that the analyst would find is almost as good as that which the issuer would disclose. If the analyst’s report contains a lot of noise, it creates less asymmetry between informed and uninformed investors and the option of either paying or remaining uninformed is preferred to disclosure.

### 3.1 Highly Risk-Averse Issuers

We have characterized disclosure policies, portfolio choices, asset prices and investor welfare for the general case where an asset issuer has an arbitrary level of risk aversion. In order to enrich the model along other dimensions, from here on we restrict attention to a simple special case where the asset issuer is highly risk-averse: \( \rho_S \rightarrow \infty \). With high risk aversion, the issuer will retain almost no risky assets. Instead, he sells the entire endowment of risky assets \( 1 + \xi \). This simplifies the results because it makes the net supply of the asset uncorrelated with the asset’s quality. Specifically, the equilibrium price is \( p = \alpha + \beta \theta + \delta z + \gamma \xi \), where the coefficients simplify to

\[
\alpha = \frac{Q h_\theta \bar{y} - \rho}{\lambda h_\theta + (Q - \lambda) h_p} \tag{13}
\]

\[
\beta = \frac{\lambda h_\theta (Q - \lambda) h_p}{\lambda (h_y + h_\theta y) + (Q - \lambda) h_p} \tag{14}
\]

\[
\delta = 0 \tag{15}
\]

\[
\gamma = - \frac{\rho \lambda h_\theta (Q - \lambda) h_p}{\lambda (h_y + h_\theta y) (Q - \lambda) (h_y + h_p)} \tag{16}
\]

where \( h_{\theta y} = (h_{\xi}^{-1} + h_{\theta}^{-1})^{-1} \) is the precision of \( \theta \) as a signal for \( y \) (as opposed to its precision as a signal for \( z \), which is \( h_\theta \)) and \( h_p = \frac{\lambda^2 h_\xi^2 h_{\xi}}{\lambda^2 h_\theta h_{\xi} + \rho^2} \) is the precision of the price.

Since the asset supply is always \( 1 + \xi \), the issuer’s signal does not affect the asset supply other than through the analyst’s report. Since the signal does not enter the investors’ beliefs through any other channel, it cannot affect demand. Since \( z \) no longer affects either the supply or the demand of the asset, it does not affect the asset price and hence \( \delta = 0 \).

We continue with this simplifying assumption from here on, keeping in mind the lessons learned about how information disclosure helps to remedy inefficiencies associated with the strategic supply of an asset.
3.2 Heterogeneous Investors

The model so far assumes ex-ante identical investors. One potentially important dimension of heterogeneity is in risk aversion. Investors with different risk aversion would choose different investment portfolios and therefore have different valuation for information and might be affected differently by mandatory disclosure.

In order to examine this possibility, suppose that there is a function \( \rho_i \) that specifies the absolute risk aversion coefficient of investor \( i \) and assume without loss of generality that this function is increasing.\(^4\) The issuer and investors play the same game as in section 1. Equating supply and demand reveals that the equilibrium price will be linear, as in (10), with coefficients \( \delta = 0 \) and

\[
\begin{align*}
\alpha &= \frac{yh_y(\psi_L + \psi_H) - 1}{(h_y + h_\theta y)(\psi_L + (h_y + h_p)\psi_H)}
\end{align*}
\]

\[
\begin{align*}
\beta &= \frac{\psi_L h_\theta y + \psi_H h_p}{(h_y + h_\theta y)(\psi_L + (h_y + h_p)\psi_H)}
\end{align*}
\]

\[
\begin{align*}
\gamma &= -\frac{1}{\psi_L h_\theta y (h_y + h_\theta y)\psi_L + (h_y + h_p)\psi_H}
\end{align*}
\]

where \( \psi_L \equiv \int_0^{i^*} 1/\rho_i \, di \) is the total risk tolerance of informed agents, \( \psi_H \equiv \int_i^Q 1/\rho_i \, di \) is the total risk tolerance of uninformed agents, and \( i^* \) is the investor who is indifferent between buying and not buying the signal, who satisfies the indifference condition

\[
\rho_{i^*} = \frac{1}{2c} \log \left( \frac{h_y + h_\theta y}{h_y + h_p} \right).
\]

Finally, the equilibrium asset price is a signal about firm value, with precision

\[
h_p = \frac{\psi_L^2 h_\theta y h_\zeta}{\psi_L^2 h_\theta y h_\zeta + 1}.
\]

Investors with lower absolute risk aversion take larger positions in the risky asset and therefore have a higher willingness to pay for a given piece of information. In equilibrium, there is a cutoff investor \( i^* \) such that investors with lower risk aversion than \( i^* \) buy the analyst report and those with higher risk aversion choose to remain uninformed. In principle, this could mean that some investors benefit from mandatory disclosure rules while others are hurt by them. Nevertheless, the results below show that the main welfare results for the homogeneous-investor case carry over to

\(^4\)One could in principle link the coefficient of absolute risk aversion to each investor’s wealth by postulating a relationship between wealth and absolute risk aversion, as in Makarov and Schornick (2010).
this more general case.

**Proposition 4 (Investor welfare with heterogeneity)**

1. All investors have higher expected utility with no information than with mandatory disclosure.

2. There exists a cutoff \( C_A^* \) such that for every \( C_A < C_A^* \), there exists an \( h_\theta \) sufficiently high such that all investors' welfare is higher with mandatory disclosure.

Part 1 of Proposition 4 generalizes Proposition 2 for the case with heterogeneous risk aversion and part 2 generalizes Proposition 3.

Together, these results show that the welfare results do not depend on the assumption of homogeneous investors. All investors, irrespective of their risk aversion, benefit when the lack of information gives them access to a higher risk, higher return asset. Also, all investors benefit from mandatory disclosure when it is the only way to avoid a choice between paying a cost or being at an informational disadvantage. This case is still likely to arise when the cost of producing information is relatively small and in an intermediate range of information precision.

### 3.3 Wealth-Dependent Preferences

Increasing the information available to investors reduces the amount of risk investors bear but lowers expected returns, so its effects on investors’ welfare depends on which effect dominates. Propositions 2 and 4 show that in the CARA-Normal framework the change in expected returns always dominates, so investors prefer not to have information. Is this result a consequence of the special properties of the CARA-Normal model or does it hold more generally for preferences with wealth effects?

In a limit of perfect information, it’s clear that no matter their preferences investors are better off with no information. If the asset’s payoff is perfectly known, then there is no risk and competition will drive excess returns to zero. Investors will achieve the same payoffs that are also attainable by choosing zero investment in the world of no information. By revealed preference, the fact that they strictly prefer a positive position in the asset when there is no information means they must be better off.

Away from this trivial limit, the issue is less obvious. Indeed, in a dynamic setting with learning, Veronesi (2000) has shown that dynamic hedging effects can result in excess returns that are increasing in the amount of information available to investors. Unfortunately, no analytical formulas for characterizing the equilibrium, let alone calculating welfare, are known for general
<table>
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<td>relative risk aversion</td>
<td>$\sigma$</td>
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</tr>
<tr>
<td>initial wealth</td>
<td>$w_0$</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1: Parameter Values for model with CRRA preferences

preferences. However, it is possible to solve the model numerically and, at least within a range of parameters, ask whether it is still the case that investors prefer no information.

We make two modifications to the model in Section 3.1. First, we assume that investors’ preferences take the CRRA form $E\left[ W^{1-\sigma} \right]$ (following Bernardo and Judd (2000), Peress (2004) and Sockin and Xiong (2014)). Second, to avoid the possibility of negative consumption, we assume that the payoff of the asset follows a lognormal, rather than normal, distribution, i.e. we assume $\log(y) \sim N(\bar{y}, \frac{1}{h_y})$, the report is $z = \log(y) + \eta_z$ and the rest of the model is unchanged.

For each combination of parameters, we solve for the equilibrium in the two polar cases of disclosure or non disclosure and no information market.\(^5\) In each case we find investors’ expected utility and re-express it as certainty-equivalent increase in consumption as a fraction of the expected payoff of the asset, which is normalized to 1. Table 1 shows the baseline parameters, which produce the same payoff variance, excess returns and signal informativeness that we find in the calibration in section 5.

Figure 1 shows how welfare in each information environment changes with parameters. The first panel varies the precision of information $h_z$; the second varies the riskiness of the asset $h_y^{-1}$ (holding $h_z$ constant); the third varies the risk aversion coefficient $\sigma$ and the last varies the supply noise $h_\zeta$. For every combination of parameters that we have examined, investors are better off with no information, lending support to the conclusions drawn from the CARA-Normal model.

4 Financial Information and Real Economic Efficiency

Studying the asset market in isolation teaches us why investors may prefer no information, to full information, to severe asymmetric information. But would these results change if financial

\(^5\) Numerically solving the model for the cases of either no information or all informed investors is relatively straightforward. In both cases, investors do not learn from the price. Thus, the equilibrium can be solved separately for each realization of the signal and asset supply.
Figure 1: With CRRA preferences, welfare for investors is always higher with no information than with disclosure

information has spillovers into the real economy?

We consider two types of spillovers. First, more information creates better incentives for asset issuers (who are also entrepreneurs) to invest a socially optimal amount. Information regulation here has social value, but does not benefit investors, except when the alternative is asymmetric information, just as before. The second spillover is that disclosure reduces the cost of capital and induces issuers to take more risk.\footnote{Oddly, more symmetric information given to all investors can only increase investor welfare when it encourages firms to take more risk.}

As we enrich the model to allow for real investment decisions, we simplify the model in other respects to keep it transparent. In this section only, we assume that the issuer is risk-neutral but must sell $1 + \xi$ units of the project due to a liquidity shock, so his portfolio choice is the same as in the case where he is highly risk-averse. Investors are still risk averse as in the baseline model. We also focus on the case where $h_\theta = \infty$ (so $\theta = z$ and $h_{\theta y} = h_z$) and $C_A = C$, so the analyst’s information technology is as good as the issuer’s.

\footnote{This cost of capital effect is also present in the accounting literature. See e.g., Easley and O’Hara (2004) and Hughes, Liu, and Liu (2007).}
4.1 Production Model 1: Information Improves Real Efficiency

To see how real economic spillovers change the results, we build on the previous model by adding an initial period where an issuer builds up his firm. We let $N$ represent the total number of shares of the project and assume a liquidity shock forces the issuer to sell $1 + \xi$ shares.

Suppose that instead of having an exogenous payoff $y$, the dividend per share from the asset depends on the issuer’s investment according to

$$y = f(k) + u$$  \hfill (17)

where $k \geq 0$ is real capital investment and $f$ is a concave function with $f'(0) > 1$ and $u \sim N(0, \frac{1}{\eta_y})$. The issuer chooses $D$ first, and then $k$ to maximize:

$$\mathbb{E}[p(1 + \xi) + y(N - 1 - \xi)| k, D] - k - CD$$  \hfill (18)

The choice of $k$ is not observable by investors. The game progresses as follows. First, the issuer chooses $D$ and $k$. Then the game progresses as in section 3.1.

Finally, $y$ is realized and payoffs are received. Since the decision $D$ is observable but $k$ is not, it is necessary to specify both the issuer’s investment $k(D)$ for each disclosure decision $D$ (including off-equilibrium) and investors’ beliefs about $k$ depending on $D$, which we denote by $k^*(D)$. Note that the issuer chooses his disclosure first, so that there is no signalling value to the choice of $D$ and no strategic disclosure. The realistic counterpart to this assumption is that firms have long-standing disclosure policies. They disclose at regular intervals and rarely change that policy, even if they would prefer not to disclose bad news. This leads to the following equilibrium definition.

**Equilibrium:** An equilibrium consists of a disclosure decision $D$ and then an investment decision $k(D)$ by the issuer; a demand $d_i$ by each investor for analyst reports, a decision by the analyst about whether to produce a report and a price $c$ for the report, bidding functions $b_i(q)$ for each possible information set and an asset price $p(\theta, D, \{d_i\}, \xi)$ such that: issuers choose disclosure $D$ to maximize (18) and choose $k(D)$ to maximize (18), taking $D$ as given but conditioning on the signal $z$; investors choose $d_i$ and bidding functions to maximize (3) subject to (4); analysts make zero profits; the asset market clears: $\int_0^Q q_i d_i = 1 + \xi$, and investors’ belief about investment is correct: $k^*(D) = k(D)$. 

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**Real investment decision:** Since the issuer’s portfolio decisions are the same as in the high risk aversion case, the equilibrium price formulas (13)-(16) still apply, replacing $\bar{y}$ with $f(k^*)$. Replacing the equilibrium price $p = \alpha + \beta \theta + \gamma \xi$ into the issuer’s objective function in (18) and noting that the informed investor’s signal is $\theta = z = f(k) + u + \eta_z$, the issuer solves

$$\max_k E \left[ (\alpha + \gamma \xi + \beta (f(k) + u + \eta_z)) (1 + \xi) + (f(k) + u)(N - 1 - \xi) \right] - k$$

Note that, because investment is unobserved, the issuer cannot affect beliefs about $k^*(D)$ through the investment decision. The reason for the issuer to undertake investment is to affect the analyst report (or, under disclosure, the direct report) and therefore to indirectly affect the selling price.

The first order condition for investment is

$$f'(k) = \frac{1}{\beta + N - 1} \quad (19)$$

The value of $\beta$ depends on whether the issuer has disclosed and, if he has not, on how many investors have purchased analyst reports. Since $\beta < 1$, investment always falls below its first-best level, which is defined by $f'(k) = \frac{1}{N}$. Furthermore, since $\beta$ is increasing in $\lambda$, investment will be higher when more investors are informed. Therefore whenever the equilibrium value of $\lambda$ in an investor-driven market is less than $Q$, investment will be higher under disclosure.

Information is socially valuable in this model because when investors are informed, they bid more for firms that have invested more. Since the owners of the high-investment firms gain more from selling higher-priced shares, this gives issuers an incentive to invest. The inefficiency here comes from the fact that investment is unobserved. Providing investors with noisy signals about the firm’s value helps to remedy this friction. Thus it promotes a level of investment that is closer to the efficient level.

**Issuer disclosure decision:** The addition of a production economy makes it more advantageous for the issuer to disclose information. This makes asymmetric information problems between investors, resulting from only some of them purchasing the signal in the information market, less likely to arise. Let $p_1$ be the price of an asset when investment $k^*(1)$ is undertaken and all investors observe the analysts’ report. Let $p_0$ be the price of the asset when investment $k^*(0)$ is undertaken and there is an active market for analyst reports. Then, the issuer will disclose iff expected payoffs net of the information cost $C$ exceed expected payoffs without information:
\[ E[p_1] + \text{cov}[p_1, \xi] + f(k^*(1))(N - 1) - k^*(1) - C > E[p_0] + \text{cov}[p_0, \xi] + f(k^*(0))(N - 1) - k^*(0). \]

**Proposition 5 (Disclosure by issuer with production)**

1. If

\[ N[f(k^*(1)) - k^*(1) - (f(k^*(0)) - k^*(0))] + \frac{\rho}{Q} \frac{h_z(1 + \frac{1}{h_z})}{h_y (h_z + h_y)} > C, \tag{20} \]

then either the issuer will disclose, or at least some investors will buy a report.

2. If condition (20) does not hold, the issuer will not disclose.

As before, providing investors with information reduces the risk they have to bear, which increases average prices. The new effect is the additional term \( N[f(k^*(1)) - k^*(1) - (f(k^*(0)) - k^*(0))] \) which reflects the investment efficiency gains from disclosure. Notice that the issuer captures the entire efficiency gain, either directly on the part he keeps (\( N - 1 \) shares on average) or through the increase in the average price on the one unit he sells on average. Hence the set of parameters for which the issuer will choose to disclose voluntarily (\( D = 1 \)), making regulation irrelevant, is larger than in the economy with no production. Although policy makers cite efficiency gains as a rationale for mandatory disclosure laws, ironically, adding real efficiency gains weakens the case for disclosure as an investor protection measure.

### 4.2 Welfare in Production Model 1

**Effect on output:** One possible objective a government might have is to simply maximize the production of real goods. This is obviously a simplification, but it makes for a good starting point. The relevant question becomes: Which disclosure policies maximize output \( f(k) \)?

The primary friction in the model is that investors’ imperfect information about capital investment decisions of the firm reduces the issuer’s return to investing in capital. In other words, if investors don’t know that the issuer invested more, the issuer won’t be compensated for that investment when he sells his firm. Efficiency requires that the marginal return to investment be equal to its unit marginal cost: \( f'(k) = \frac{1}{N} \). Therefore if we somehow manage to ensure that the private return to a marginal unit of investment is equal to its social return, which is achieved if \( \frac{\partial E[p(k)]}{k} = f'(k) \), then investment will be efficient. With imperfect information, the left side is typically smaller than the right because prices can only respond to changes in \( k \) to the extent that investors know \( k \). The following analysis shows that mandatory information provision to financial markets helps to remedy this friction because it makes \( p \) more responsive to \( k \).
Since the production function is concave, a higher $f(k)$ corresponds to a lower marginal product of capital $f'(k)$. The issuer’s first-order condition tells him to set $f'(k) = 1/\left[\beta + N - 1\right]$. The pricing coefficient $\beta$ (equation 16) is increasing in the measure of informed investors $\lambda$ because $h_z \geq h_p$, i.e. prices cannot reveal more information that what is contained in the signals they are revealing.

If disclosure is mandated by the government, then $\lambda = Q$. This maximizes $\beta$, minimizes $f'(k)$ and thus maximizes $f(k)$ over all feasible values $\lambda \in [0, Q]$. Thus, mandating disclosure provides the maximum possible information, which maximizes output of real economic goods. Since information facilitates the efficient allocation of capital, mandatory information disclosure maximizes gross output.

**Effect on output net of costs:** One obvious objection to the analysis in the previous subsection is that it does not take into account the cost of information production. Another possible objective is to maximize $Nf(k) - k - \delta C$, where $\delta = 1$ if any agent (issuer or investor) discovers information and $\delta = 0$ otherwise.

If equilibrium is such that $D = 0$ but $\lambda \in (0, Q)$, then it is immediate that mandatory disclosure maximizes net output, since the cost will be paid regardless and $\lambda = Q$ will bring investment closest to efficient levels. If equilibrium is such that $D = 1$, then mandatory disclosure is irrelevant. Finally, if equilibrium is such that the information is not produced at all, then in equilibrium $k = 0$ and mandatory disclosure maximizes net output whenever $Nf(k^*(1)) - k^*(1) - C > Nf(k^*(0)) - k^*(0)$. We know that $f'(k^*(1)) > \frac{1}{N}$, so that anything that increases $k^*(1)$ also increases $Nf(k^*(1)) - k^*(1)$ and therefore makes the inequality more likely to hold. A higher ratio of the signal precision to prior precision ($h_z/h_y$) makes $k^*(1)$ higher, making it more likely that the high-information level of capital is the one that maximizes output net of investment and information costs.

**Investor welfare:** Next, we show that the same two investor welfare results from the model without production still hold in the model with production.

**Proposition 6 (Investor welfare in the economy with production)** a) Investors have higher ex-ante expected utility when no information is provided $\lambda = 0$ than when disclosure is mandatory. b) There exists a cutoff $C^*$ such that for every $C < C^*$ investor welfare is higher with mandatory disclosure.

What the production economy changes is that now disclosure raises the expected value of the asset. Recall that investors benefit from access to a high-risk, high-return asset. They do not
benefit from high-expected-value assets because these assets have a high price to compensate for their high value. Return is offered for bearing risk, not for buying valuable assets. This can be seen from the equilibrium price equation, which shows that increases in $\bar{y}$ translate one-for-one into increases in the price, and therefore have no effect on expected returns or on investor welfare. In other words, any efficiency gains from improved incentives to invest are captured 100% by the issuer of the asset. Therefore all the results regarding how mandatory disclosure affects investor welfare carry through directly.

Of course, this is a stylized model. One could build a model where the presence of the production economy affected investor welfare. But the key to building such a model would be that the production economy must change the risk investors bear. Expected increases in efficiency result in more valuable assets, and higher prices for those assets. When the payoff and the price increase together, the return on the asset doesn’t change. In an equilibrium model with a constant price of risk, anything that doesn’t change risk cannot change returns.

4.3 Production Model 2: Information Increases Firm Risk

The key feature of the production model that prevented disclosure from having an effect on investor welfare was that the issuer’s investment choice only shifted the mean of the firm value and did not affect its variance. If information disclosure causes issuers to choose a riskier production technology, then we can reverse the previous result. While investor welfare may improve, it is because the disclosure results in investors holding assets with more uncertain payoffs. This is the opposite of the usual justification for disclosure mandates.

To show how disclosure can affect risk-taking, we alter the production function so that the stochastic shock is multiplicative, rather than additive. Suppose the dividend from the asset depends on the issuer’s investment according to

$$y = (1 + u)f(k)$$  \hspace{1cm} (21)

where $k \geq 0$ is real capital investment and $f$ is a concave function with $f'(0) > 1$ and $u \sim N(0, \frac{1}{h_y})$.

As before, the issuer chooses $D$ first, and then $k$ to maximize $E[y | k, D] - k - CD$. The definition of equilibrium is identical to the previous case.

The expected payoff of the asset is the same function of equilibrium investment as before: $E[y] = f(k^*)$. But now, the variance of payoffs is no longer a fixed parameter: $Var[y] = f(k)^2 / h_y$. The different payoff variance changes the price formula because $h_y$ must be replaced everywhere
by $h_y/f(k^*)^2$. Note that the actual level of capital investment cannot affect the price of the asset because this investment is not observed by those who purchase the asset. Instead, what affects the asset price is beliefs about $k$. Since this is a noisy rational expectations model, those beliefs about $k$ correspond to the optimal $k^*$. But the fact that the issuer cannot affect beliefs about the riskiness of the asset is important because in his optimization problem, this issuer still takes the price coefficients $\alpha$, $\beta$ and $\gamma$ as given. Thus, the first order condition for capital investment is the same as before (19), albeit with a different equilibrium level of $\beta$.

Recall that investor expected utility is proportional to $(E[y] - p)^2/Var[y]$. The asset pricing formulas (13)-(16) tell us that if $\lambda = Q$, then $E[y|p] - p = \rho Var[y|\theta]/Q$. Therefore, expected utility is proportional to $(\rho(1+\xi)/Q)^2 Var[y|\theta]$. By Bayes’ law, we know that $Var[y|\theta] = f(k^*)^2(h_y + h_z)^{-1}$. Thus, expected utility is clearly increasing in firm production $f(k)$, but decreasing in signal precision $h_z$.

What this tells us is that, if agents start with symmetric information, then requiring a firm to disclose has a direct effect and an indirect effect. The direct effect is to reduce investor utility by increasing $h_z$ and decreasing the expected asset return. The indirect effect increases utility by inducing the firm to increase production. The net effect depends on how sensitive production is to investor information, which in turn depends on the shape of the production function. Define the inverse of the marginal product function as $g(x) : x \rightarrow g : f'(g) = x$. Then disclosure increases welfare iff $2f(k^*)^{-3}f'(k^*)g'(1+h_y/h_z)(h_y/h_z)^2 < -1$. As long as firm production is sufficiently sensitive to disclosure, then the positive welfare benefits of more production can outweigh the negative effects of lower returns identified in the previous cases and disclosure can help improve investor welfare.

5 Extension to Non-Normal Payoffs and Application to Corporate Bonds

Assuming that the asset’s payoff is normally distributed is admittedly restrictive, as there are settings where this is likely to be a poor approximation to reality. In this section we examine numerically whether our main results extend to a case where payoffs instead follow a binary distribution, as in Breon-Drish (2012). We then calibrate the model parameters using data from corporate bonds markets and credit ratings.

The model has the same assumptions as before (focusing on the case where $h_\theta = \infty$ so $z = \theta$.
and \( C_A = C \), with the following three changes:

1. The asset’s payoff \( y \) has a binary, rather than a normal distribution. It takes the values 0 or 1. The unconditional probability of each outcome is governed by the parameter \( \bar{y} \equiv \Pr [y = 1] \).

2. The signal \( z = \theta \) is informative about a variable \( \theta_0 \), which is in turn informative about the asset’s payoff. The distribution of \( y \) conditional on \( \theta_0 \) is \( \Pr (y = 1|\theta_0; h_0) = e^{\theta_0} \frac{1}{1 + e^{\theta_0}} \), where \( h_0 \) is a parameter that governs the variance of the \( \theta_0 \) distribution. \(^7\) The unconditional probability of \( y = 1 \) is \( \bar{y} \). The signal \( z = \theta \) is a noisy observation of \( \theta_0 \):

\[
    z = \theta = \theta_0 + \eta_z
\]

where \( \eta_z \sim N \left( 0, \frac{1}{h_z} \right) \).

3. Investors can observe an additional, public signal \( \omega = \theta_0 + \nu \) where \( \nu \sim N \left( 0, \frac{1}{h_\omega} \right) \), at no cost. This additional signal allows the model to explain the high information content of bond prices. In a model where the only exogenous source of information is the costly signals, the equilibrium price cannot be more informative than the signal itself. The fact that true bond prices are more informative than credit ratings tells us that they must contain additional information, beyond what is in credit ratings (the costly signal). Therefore, adding public signals to the model allows us to compare the data and model in a meaningful way.

5.1 Equilibrium with binary payoffs

Each investor \( i \) chooses a quantity of risky assets \( q \) to maximize expected utility:

\[
    \max_q \left[ -e^{-\rho q (1-p) - c} \Pr (y = 1|\mathcal{I}_i) + e^{-\rho (0-p) - c} \Pr (y = 0|\mathcal{I}_i) \right]
\]

where \( \mathcal{I}_i \) denotes \( i \)'s information set. The first-order condition is

\[
    q_i (\mathcal{I}_i) = \frac{1}{\rho} \left[ \log \left( \frac{\Pr (y = 1|\mathcal{I}_i)}{\Pr (y = 0|\mathcal{I}_i)} \right) - \log \left( \frac{p}{1 - p} \right) \right]
\]

\(^7\)This conditional probability results from a \( \theta_0 \) whose unconditional distribution is “tilted Normal”: \( f (\theta_0) = (1 + e^{\theta_0}) (1 - \bar{y}) \phi \left( h_0^{1/2} \left( \theta_0 - \log \left( \frac{\bar{y}}{1 - \bar{y}} \right) - \frac{1}{2h_0} \right) \right) \), where \( \phi(\cdot) \) is a standard normal probability density function and \( h_0 \) is a parameter. See Breon-Drish (2012) for details.
Applying Bayes’ Rule, the log ratio of informed investors’ posteriors about \( y \) are given by

\[
\log \left( \frac{\Pr (y = 1 | \theta, \omega)}{\Pr (y = 0 | \theta, \omega)} \right) = \kappa_I^\theta \theta + \kappa_I^\omega \omega + (1 - \kappa_I^\theta - \kappa_I^\omega) \log \left( \frac{\bar{y}}{1 - \bar{y}} \right)
\]  

(23)

where \( \kappa_I^\theta \equiv \frac{h_z}{h_z + h_0 + h_\omega} \) and \( \kappa_I^\omega \equiv \frac{h_\omega}{h_z + h_0 + h_\omega} \).

Since all informed investors have the same information set and all uninformed investors have the same information set, risky asset demand \( q_i \) takes on only two possible values. For informed investors, let \( q_i = q^I (\theta, \omega, p) \) and for uninformed investors, let \( q_i = q^U (\omega, p) \). If a measure \( \lambda \) of investors are informed, the market clearing condition is

\[
\lambda q^I (\theta, \omega, p) + (Q - \lambda) q^U (\omega, p) = 1 + \xi
\]

(24)

Replacing (23) and (22) in (24) tell us that a known function of price \( \theta_U \) is a noisy signal about \( \theta \) that takes the following form: \( \theta_U = \theta + \rho / (\lambda \kappa_U^\theta) \xi \), where \( \xi \) is the normally-distributed asset supply shock, and \( \kappa_U^\theta = j / (j + h_0 + h_\omega) \), where \( j^{-1} = h_z^{-1} + h_\xi^{-1} \rho (1 + h_z^{-1} h_0) / \lambda \).

Applying Bayes’ Rule, the log ratio of uninformed investors’ posteriors is

\[
\log \left( \frac{\Pr (y = 1 | p, \omega)}{\Pr (y = 0 | p, \omega)} \right) = \kappa_U^\theta \theta + \kappa_U^\omega \omega + (1 - \kappa_U^\theta - \kappa_U^\omega) \log \left( \frac{\bar{y}}{1 - \bar{y}} \right)
\]  

(25)

where \( \kappa_U^\omega = h_\omega / (j + h_0 + h_\omega) \). Substituting (23) and (25) into (22) to get \( q^U \) and \( q^I \) and then substituting those in the market clearing condition (24) reveals the following expression for the equilibrium price:

\[
p = \frac{\exp A + B \theta + C \omega + D \xi}{1 + \exp A + B \theta + C \omega + D \xi}
\]

(26)

The coefficients \( A, B, C \) and \( D \) are defined in Appendix A.10.

After substituting this price back into the objective function, the next step is to compute the expected utility achieved by informed and uninformed investors for each realization of \( \theta, \omega \) and \( \xi \), and then integrate over the distribution of all three random variables to compute ex-ante utility. There is no closed form solution because expected utility depends on asset demands, which contain terms like \( p / (1 - p) \), where \( p \) is a random variable at time 1. Computing expectations of ratios of such random variables is not tractable. However, it is possible to compute expected utility numerically. Then, we solve for a \( \lambda \) that equates utilities of informed and uninformed investors when setting the cost of ratings \( c \) to satisfy the zero-profit condition \( c = C / \lambda \), if such a \( \lambda \) exists, or by setting \( \lambda = 0 \) or \( \lambda = Q \) if it does not.

26
5.2 Calibration for corporate bonds and credit ratings

For numerical analysis, focusing on corporate bonds and credit ratings has advantages. There is a clear sense of what the information in credit ratings is and there exist measures of how much it costs to produce. Furthermore, current regulation on credit ratings is somewhat akin to a mandatory disclosure system, in that many types of investors can only invest in rated assets and therefore issuers must pay for a rating if they wish to sell their securities to these investors. Finally, the assumption of a binary distribution for payoffs is arguably a plausible representation of the payoff profile of bonds, with $y = 0$ representing default. Of course, the recovery rate on bonds that default is not zero, so the mapping is not perfect.

**Data description:** Our data comes from Datastream and includes all corporate bonds issued in 2004 and 2005, with maturities of not more than 30 years, whose prices are tracked by Datastream. In total, this amounts to 770 different bonds. The bond ratings are the Standard and Poor’s rating at the time of issuance. For each bond, we know its face value, the price $\tilde{p}_0$ at the time when it was issued, the rating at the time of issue and the market price $\tilde{p}_1$ one year later.

Since bonds are heterogeneous in their contract terms (e.g. coupon rate), we normalize them in the following way. Let $z$ be the present value of all the promised payments of a bond (coupons plus face value at redemption) discounted at the risk-free rate. We express all values per unit of $z$, letting $p_0 \equiv \tilde{p}_0/z$ and $p_1 \equiv \tilde{p}_1/z$. Furthermore, we adjust $p_1$ for changes in the risk-free rate, which would affect bond prices for reasons that are outside our model.

**Calibration targets:** We assume that the data has been generated by the model under the current regime of issuer-provided ratings, which implies $\lambda = Q$. For each bond, we assume that the observed $p_0$ arises from equation (26). We then assume that in the interval between the observation of $p_0$ and the observation of $p_1$, the value of $\theta_0$ has been revealed and there are no more supply shocks, so that

$$\log \left( \frac{p_1}{1 - p_1} \right) = \theta_0 - \frac{\rho}{Q} \tag{27}$$

We need to find values for the following parameters: $\bar{y}$, $h_0$, $h_z$, $h_\omega$, $h_\xi$ and $\frac{\rho}{Q}$ ($\rho$ and $Q$ are not separately identified). We choose these values to match the following empirical moments.

1. Average bond payoffs. The first parameter to set is $\bar{y}$. Ideally, this could be done by tracking all the bonds to maturity or default and set $\bar{y}$ to match observed default rates. Unfortunately,
Table 2: Parameter Values

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Pr[y = 1]$</td>
<td>$\hat{y}$</td>
<td>0.95</td>
<td>default probability is $\frac{1}{2}$ of yields</td>
</tr>
<tr>
<td>governs pdf of $\theta_0$</td>
<td>$h_0$</td>
<td>1.34</td>
<td>mean (0.89) and variance (0.0078) of $p_1$</td>
</tr>
<tr>
<td>risk aversion</td>
<td>$\rho$</td>
<td>0.88</td>
<td>informativeness of ratings ($R^2 = 0.47$)</td>
</tr>
<tr>
<td>costly signal precision</td>
<td>$h_z$</td>
<td>1.65</td>
<td>informativeness ($R^2 = 0.56$)</td>
</tr>
<tr>
<td>free signal precision</td>
<td>$h_w$</td>
<td>1.41</td>
<td>and variance (0.0068) of $p_0$</td>
</tr>
<tr>
<td>asset supply precision</td>
<td>$h_\xi$</td>
<td>8.25</td>
<td></td>
</tr>
<tr>
<td>signal cost</td>
<td>$C$</td>
<td>$2.97 \times 10^{-4}$</td>
<td>Treacy and Carey (2000)</td>
</tr>
</tbody>
</table>

Data limitations prevent this. Instead, we rely on findings by Giesecke, Longstaff, Schaefer, and Strebulaev (2011) who report that on average bond yields can be decomposed roughly equally between a default probability and a risk premium. Denoting the average bond yield by $\bar{r}$, this implies $1 - \bar{y} = \bar{r}/2$. Since for any bond the yield is simply $p_0 = 1/(1 + r)$, we set the value of $\bar{y}$ to

$$\bar{y} = 1 - \frac{1}{2} E \left[ \frac{1 - p_0}{p_0} \right]$$

2. Mean and variance of $p_1$. By equation (27), the model says that $p_1$ depends on $\theta_0$ and on $\frac{\rho}{Q}$. Using that $\bar{y}$ is already established from the previous step, we choose values of $\frac{\rho}{Q}$ and $h_0$ such that the mean and variance of $p_1$ implied by the model match the ones we find in the data. $\frac{\rho}{Q}$ affects only the mean but $h_0$ affects both the mean and the variance, so these two parameters need to be set jointly.

3. Informativeness of ratings. In the model, $\theta$ is a noisy signal of $\theta_0$, which then translates directly into $p_1$ through equation (27). Therefore the covariance between $\theta$ and $p_0$ (or, equivalently, the $R^2$ of a regression of $p_1$ on $\theta$) depends on the precision of the signal, $h_z$. We set $h_z$ to a value such that the $R^2$ implied by the model matches that of a regression of $p_1$ on dummies for each possible ratings level.

4. Variance and informativeness of prices at issuance. By equation (26), prices are sensitive to both the $\theta$ signal (credit ratings) and the $\omega$ public signal, as well as to the supply shock $\xi$. Both signals are informative about $\theta_0$ so they should correlate with $p_1$, while supply shocks introduce pure noise. Therefore the informativeness of $p_0$ about $p_1$ depends on the total noise-to-signal ratio, while the variance of $p_0$ depends on the variances of both signals and noise. We set values of $h_w$ and $h_\xi$ such that the $R^2$ of a regression of $p_1$ on $p_0$ and the variance
of $p_0$ implied by the model match those we find in the data.

5. Cost of ratings. The one other parameter we need to calibrate is the fixed cost of information discovery. Treacy and Carey (2000) report that the average cost of rating an asset is 0.0325% of the value of the issue, so we set $C$ equal to 0.0325% times the average $p_0$ of 0.91.

Table 2 summarizes our parameter estimates. It reveals that the precisions of prior beliefs $h_0$, public information $h_\omega$ and credit ratings $h_z$ are roughly equal.

**Numerical results:** Figure 2 shows the measure of investors $\lambda$ that choose to become informed as a function of the cost of producing information $C$, assuming the issuer has chosen not to obtain and disclose ratings voluntarily. For low values of $C$, all investors choose to become informed. According to our estimates, this would be the case for any $C < 3.19 \times 10^{-3}$, so even if the cost of ratings were 10 times higher than our estimate, the model still predicts that all investors would choose to buy ratings if the issuer does not disclose them. Knowing this, the optimal strategy for the asset issuer is not to obtain a rating, since investors will buy it anyway. Thus, with or without mandatory disclosure, all investors are informed. A disclosure mandate simply transfers the amount of the ratings fee $c$ from investors to issuers. These findings suggest that policies of mandatory disclosure policies benefit investors, at the expense of asset issuers. But they also tell us that these measures are not likely to affect market information or liquidity.

For values of $C$ between $3.19 \times 10^{-3}$ and $3.22 \times 10^{-3}$, not all investors obtain ratings but a market for ratings is still viable. Since not all investors buy the rating, the zero profit condition implies that $c > C$. For $C > 3.22 \times 10^{-3}$, no investor-pay market for ratings can exist.

Our main results regarding investor’s welfare from the case where payoffs are Normally distributed (Proposition 2 and Proposition 3) can be verified numerically in our calibrated exam-
ple. Table 3 shows investors’ ex-ante utility under three possibilities, expressed in consumption-equivalent terms as in section 3.3. The first is when no information production takes place (perhaps because $C$ is prohibitively high); the second is when information is voluntarily disclosed by the issuer; the third is when information production is possible but it has not been provided by the issuer so investors buy it themselves, as will be true in equilibrium in our calibrated example. As seen from the table, investors prefer no information to free information (Proposition 2) but, because information is cheap, a system of non-mandatory disclosure leaves them the option of either paying for information or being asymmetrically less informed than other investors, which yields even lower utility (Proposition 3).

<table>
<thead>
<tr>
<th></th>
<th>No information</th>
<th>Issuer-Provided</th>
<th>Investor-Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0457</td>
<td>0.0446</td>
<td>0.0443</td>
</tr>
</tbody>
</table>

Table 3: Welfare Comparison. Investors’ Ex-Ante Utility

Numerical exploration reveals that this welfare ranking still holds for other values of the parameters. Figure 3 shows the comparison of ex-ante utility in different regimes for different parameter values. Panel (i) shows the comparison for our estimated parameter values; panel (ii) shows an economy with three times the default rate of the baseline ($\bar{y} = 0.84$); panel (iii) shows an economy with signals that are three times as informative ($h_z = 5.17$) as our baseline and panel (iv) shows an economy with a risk aversion coefficient three times as high ($\rho_Q = 2.65$) as our baseline. In all cases, the pattern is the same. No information is better for investors than issuer-provided information, but issuer provided information is better than an investor-pay market if the investor-pay market would result in high $\lambda$.

6 Conclusions

The paper investigated the welfare consequences of mandatory financial disclosures. It characterizes the types of assets for which a free market for information will provide reports to investors. Information could be produced and disclosed by an issuer who wants to make his project less risky and therefore more valuable to investors, so that it fetches a higher price at auction. Alternatively, analyst reports could be purchased by investors who want to know how much of the risky asset to buy.

When the private market provides information to most investors, mandatory disclosure will simply transfer information costs from investors to issuers. But in some instances, the private market
does not provide information. In these cases, issuers are always better off without the disclosure mandate. Surprisingly, investors are often better off without the mandate as well. Investors’ welfare is often highest when no information about the asset payoff is available to anyone. Where investors benefit from information regulations are instances where asset issuers are exploiting their monopoly power and manipulating the asset price, or cases where the alternative is that investors end up with asymmetric information.

There are many limitations to interpreting these welfare results. This model included only two salient potential benefits of financial information: facilitating the allocation of productive capital and preventing the inefficient risk-sharing that comes with asymmetrically informed investors. These benefits must be weighed against the cost of information discovery and the loss of investors surplus when an asset becomes less risky. But there are other possible benefits of disclosure, such as the ability to limit risk-taking by banks or portfolio managers or the ability to assess the risk of large pools of assets. There are also other possible problems with disclosures such as manipulation of reports, the possibility that firm disclosures crowd out some richer more nuanced sources of information, or outright fraud. None of these are incorporated in the model. Yet, the ability of disclosures to ameliorate asymmetric information problems and to improve the efficiency of asset prices are certainly two of the most widely-acknowledged benefits.
A maintained assumption in the model is that, unlike partial revelation through prices, direct leakage of information, for instance by investors who bought the analyst report sharing it with those who have not, can be effectively prevented by intellectual property laws. However, this might be hard to enforce due to technologies that make it easy to disseminate information. If information leakage cannot be prevented, analysts might not be able to sell enough copies of the information at a high enough price to pay for the fixed cost of information discovery. This would render the investor-pay market unviable through a far more direct channel than the model examines.

The degree to which information leakage is an insurmountable concern is a matter of debate. For the case of credit ratings, ratings agencies did mainly follow an investor-pay model until around the mid-twentieth century, and historical accounts differ on the relative roles played by regulation and technological progress (in particular, photocopying machines) in driving the shift towards an issuer-pay market (White, 2010). For other types of information such as equity analysis, the issue is even less clear. Analysts can try to take measures to prevent easy retransmission of information, such as delivering their reports in non-recorded oral communications, but whether these attempts are successful remains an open question.

If the threat of information leakage undermines the investor pay market, asset issuers would still prefer no regulation because then they can choose to disclose or not. Investors’ opposition to a disclosure mandate would now be unambiguous: Unregulated information markets would never result in asymmetric information. Therefore, if the mandate has any effect at all, it is to prevent there being no information available. But investors prefer this outcome because more information reduces the expected return on the assets they buy.
References


A Mathematical Appendix

A.1 Financial market equilibrium without disclosure

Throughout, denote an informed investor by the subscript $I$ and an uninformed investor by the subscript $U$. In this first section, we use the market clearing condition $\lambda q_U + (Q - \lambda) q_S = 1 + \xi - q_S$ to determine the equilibrium price. We begin by explaining how each group of agents uses prices as a signal and deriving posterior beliefs in the case where the issuer’s signal is not disclosed. Recall that the price conjecture is $p = \alpha + \beta \theta + \delta z + \gamma \xi$.

Uninformed investor beliefs: These agents do not know the value of $\theta$ and thus their price signal is

$$s_U := \frac{p - \alpha}{\beta + \delta}$$ (28)

Note that $s_U = (\beta \theta + \delta z + \gamma \xi)/\beta + \delta$. Since $\theta = z + \eta_\theta$ and $z = y + \eta_z$, we can rewrite this price signal as $s_U = y + \eta_z + (\beta \eta_\theta + \gamma \xi)/(\beta + \delta)$. The variance of the signal noise $\text{var}[s_U - y]$ is

$$h_{U,p}^{-1} = h_y^{-1} + \left(\frac{\beta}{\beta + \delta}\right)^2 h_{\theta}^{-1} + \left(\frac{\gamma}{\beta + \delta}\right)^2 h_{\xi}^{-1}. \tag{29}$$

Using Bayes’ rule, the posterior for these investors is $y|p \sim \mathcal{N}(\hat{y}_U, \hat{h}_U^{-1})$, where

$$\hat{y}_U := \frac{\bar{y} h_U + s_U h_{U,p}}{h_y + h_{U,p}} \tag{30}$$

$$h_U := \frac{h_y + h_{U,p}}{h_{U,p}} \tag{31}$$

Using (5) and the above posteriors, we then get that the optimal amount of assets for the uninformed investors is

$$q_U = \frac{\hat{y}_U - p}{\rho h_{U,p}} \tag{32}$$

Informed investor beliefs: These agents know the value of $\theta$ and thus can condition on it when making decisions. In particular, their price signal is $(p - \alpha - \beta \theta)/\delta$ (37). Substituting in (10) for $p$, this signal becomes $s_I = z + \xi \gamma/\delta$. So, this investor has two signals about $z$, one from price and the other is the signal $\theta$. The price signal has variance of the signal precision that is $h_{\xi} \delta^2/\gamma^2$, while $\theta$ has signal precision $h_{\theta}$. Thus, the posterior belief about $z$ has mean

$$s_I = \frac{h_\theta \theta + h_\xi \frac{\delta^2}{\gamma^2} \frac{\rho - \alpha - \beta \theta}{\delta}}{h_\theta + h_\xi \delta^2/\gamma^2} \tag{33}$$

The precision of $s_I$ as a signal about $y$ is $h_{\theta y}^{-1} = \frac{1}{h_\theta + h_\xi} + \frac{1}{h_y}$. Using Bayes’ rule, the posterior for these investors is $y|p, \theta \sim \mathcal{N}(\hat{y}_I, \hat{h}_I^{-1})$, where

$$\hat{y}_I = \frac{h_\theta \bar{y} + h_{\theta y} s_I}{h_y + h_{\theta y}} \tag{34}$$

$$\hat{h}_I = \frac{h_y + h_{\theta y}}{h_{\theta y}} \tag{35}$$

Using (5) and the above posteriors, we then get that the optimal amount of assets for the informed investors is

$$q_I = \frac{\hat{y}_I - p}{\rho h_{\theta y}} \tag{36}$$

Issuer beliefs and portfolio problem: The issuer maximizes (7) subject to (6) given beliefs (8) and (9). The first-order conditions in $q_S$ and $p$ of this concave optimization problem are (12) and

$$(\hat{y}_S - p) - \rho_S q_S h_{S}^{-1} + \varphi = 0 \tag{37}$$

and $\varphi$ is the Lagrange multiplier on (6). We can rearrange (12) to solve for $\varphi$ and substitute that solution into (37) to get

$$\hat{y}_S - p - \rho_S q_S h_{S}^{-1} + \frac{(1 + \xi) - q_S}{\lambda \frac{\rho_S}{\rho} \left(1 - \frac{\rho_S q_S}{\rho_p}\right) + (Q - \lambda) \frac{h_{U,p}}{\rho} \left(1 - \frac{\rho_S q_S}{\rho_p}\right)} = 0$$

35
Rearranging this equation to solve for $q_S$ yields

$$q_S = \frac{(\hat{y}_S - p) + \lambda \frac{h_y}{\rho} \left(1 - \frac{h_y}{\rho \theta p} \right) + (Q - \lambda) \frac{h_U}{\rho} \left(1 - \frac{h_U}{\rho \theta p} \right)}{\rho_S h_S^{\frac{1}{q}} + \frac{1}{\lambda} \frac{h_y - h_{\beta} q}{\rho h_{\beta} p} + (Q - \lambda) \frac{h_U}{\rho} \left(1 - \frac{h_U}{\rho \theta p} \right)}$$

(38)

and $1 + \xi - q_S$ is the optimal supply of assets. Notice that the supply is linear in price $p$, the supply shock $\xi$ and the posterior belief of the issuer $\hat{y}_S$. That is significant because it will ensure that the equilibrium price is linear as well.

Differentiating (30) and (35) reveals that $\partial \hat{y}_l / \partial p = h_{\theta p} / (\delta (h_{\theta} + h_{\beta p}) (h_{\theta} + h_{p}))$ and that $\partial \hat{y}_U / \partial p = h_U / (h_{\theta} + h_{U \theta} (\beta + \delta))$. Substituting this derivatives into (38) gives us optimal asset holdings of the asset issuer:

$$\frac{(\hat{y}_S - p) + \lambda \frac{h_y}{\rho} \left(1 - \frac{h_y}{\rho \theta p} \right) + (Q - \lambda) \frac{h_U}{\rho} \left(1 - \frac{h_U}{\rho \theta p} \right)}{\rho_S h_S^{\frac{1}{q}} + \frac{1}{\lambda} \frac{h_y - h_{\beta} q}{\rho h_{\beta} p} + (Q - \lambda) \frac{h_U}{\rho} \left(1 - \frac{h_U}{\rho \theta p} \right)}$$

(39)

**Imposing market clearing:** To confirm the price conjecture, we substitute optimal portfolios and optimal supply (39) inside the market clearing condition and solve for prices to get the coefficients $\alpha$, $\beta$, $\delta$ and $\gamma$. The market clears if $\lambda q_{l,t} + (Q - \lambda) q_{l,u} = 1 + \xi - q_S$, where $\lambda \in [0, Q]$ is the equilibrium fraction of informed investors in the economy.

Substituting in for $q_S$ from (39) and then substituting out the posterior means $\hat{y}_S$, $\hat{y}_l$ and $\hat{y}_u$ and rearranging:

$$1 + \xi = q_S + \frac{\lambda}{\rho \theta} \hat{y}_l - p + (Q - \lambda) \frac{\hat{y}_U - p}{\rho h_{\beta} p}$$

(40)

Rearranging to solve out for $p$ yields:

$$p = \frac{1}{\Delta} \left( \frac{h_{\beta} \hat{y}_l + h_{\beta} q}{\rho h_{\beta} p} + \frac{\lambda}{\rho} \left(h_{\beta} - h_{\beta p} \frac{h_{\theta} + h_{\beta} q}{\rho \theta p} \right) + \frac{Q - \lambda}{\rho} \left(h_{\beta} - h_{\beta p} \frac{1}{\rho \theta p} \right) \right) + \frac{\lambda}{\rho \theta} \left(h_{\beta} \hat{y}_l + h_{\beta} q - h_{\beta} \frac{h_{\theta} + h_{\beta} q}{\rho \theta p} \right) + Q - \lambda \left(h_{\beta} \hat{y}_U - h_{\beta} \frac{1}{\rho \theta p} \right) - 1 - \xi$$

(41)

where

$$\Delta = \frac{1}{\rho h_S^{\frac{1}{q}}} + \frac{1}{\lambda} \frac{h_{\beta} \hat{y}_l + h_{\beta} q}{\rho h_{\beta} p} + \frac{Q - \lambda}{\rho} \left(h_{\beta} - h_{\beta p} \frac{1}{\rho \theta p} \right)$$

(42)
This confirms the linear price conjecture. Matching coefficients yields the following solution:

\[
\alpha = \frac{1}{\Delta} \left[ \frac{h_y \tilde{y} + \frac{1}{\rho} \left( h_U - h_{U_p} \frac{1}{2} \right) h_y \tilde{y} + \frac{Q}{\rho} h_s}{h_U - h_{U_p} \frac{1}{2}} + \frac{Q}{\rho} \left( h_y \tilde{y} - h_{U_p} \frac{\alpha}{\beta + \delta} \right) - 1 \right]
\]

\[
\beta = \frac{1}{\Delta} \left[ \frac{\lambda h_{U_p} h_a - h_{U_p} \frac{\beta}{2}}{h_{U_p} + h_p} \right]
\]

\[
\delta = \frac{1}{\Delta} \left[ \frac{h_z}{\rho h_{U_p} \frac{1}{2} + h_p + h_z} \right]
\]

\[
\gamma = \frac{1}{\Delta} \left[ \frac{\frac{Q}{\rho} \left( h_U - h_{U_p} \frac{1}{2} \right) h_s + \frac{2 h_s}{h_U - h_{U_p} \frac{1}{2}}}{h_U - h_{U_p} \frac{1}{2} + h_s} \right]
\]

where the precisions \( h_S, h_I, h_U, \) and \( h_{U_p} \) are given by (9), (35), (31), and (29), \( h_{U_p}^{-1} = \frac{1}{h_{U_p}} + \frac{1}{h_a} \), and \( h_p = h_0 \delta^2 / \gamma^2 \).

**Special case with no informed investors:** Substituting in \( \lambda = 0 \) into the solution above and simplifying yields the following price coefficients:

\[
\alpha = \frac{1}{\Delta} \left[ \frac{h_U - h_{U_p} \frac{1}{2}}{h_U - h_{U_p} \frac{1}{2}} h_y \tilde{y} + \frac{Q}{\rho} h_s}{h_U - h_{U_p} \frac{1}{2}} + \frac{Q}{\rho} \left( h_y \tilde{y} - h_{U_p} \frac{\alpha}{\beta + \delta} \right) - 1 \right]
\]

\[
\beta = 0
\]

\[
\delta = \frac{1}{\Delta} \left[ \frac{h_z}{\rho h_U \frac{1}{2} + h_s} \right]
\]

\[
\gamma = -\frac{1}{\Delta} \left[ \frac{\frac{Q}{\rho} \left( h_U - h_{U_p} \frac{1}{2} \right) h_s + \frac{2 h_s}{h_U - h_{U_p} \frac{1}{2}}}{h_U - h_{U_p} \frac{1}{2} + h_s} \right]
\]

with

\[
\Delta = \left[ \frac{\frac{Q}{\rho} \left( h_U - h_{U_p} \frac{1}{2} \right) h_s + \frac{2 h_s}{h_U - h_{U_p} \frac{1}{2}}}{h_U - h_{U_p} \frac{1}{2} + h_s} \right] \frac{Q}{\rho} \left( h_U - h_{U_p} \frac{1}{2} \right)
\]

The precisions \( h_s \) and \( h_U \) are still given by (9) and (31), but \( h_p \) and \( h_{U_p} \) can be simplified to \( h_p = \left( \frac{h_s}{h_U} \right)^2 h_\xi \) and \( h_{U_p} = h_{U_p}^{-1} + \left( \frac{h_s}{h_U} \right)^2 h_\xi^{-1} \).

**A.2 Equilibrium when the issuer’s signal \( z \) is disclosed**

All agents will now be able to condition on the observation of the issuer’s signal. Since they observe \( z \) and \( \theta \) has no additional relevant information because it is just a noisy signal of \( z \), no investors pay to see \( \theta \) and all investors have the same information set:

\[
\tilde{y} = \frac{h_y \tilde{y} + h_z z}{h_y + h_z}, \quad h = \frac{h_y h_y + h_z}{h_y + h_z}
\]

We have the same linear price guess as before, but with different coefficients. Because there are only informed investors, the market clearing condition takes the simpler form \( 1 + \xi = q_s + \frac{Q}{\rho h_s} \). Substituting in beliefs above
and rearranging yields new price coefficients $\beta = 0$ and $\alpha = h_y h_S \left( \frac{\rho S}{\rho S \rho + 2} \right)$

$$\alpha = h_y h_S \left( \frac{\rho S}{\rho S \rho + 2} \right) \tag{50}$$

$$\delta = \frac{h_z}{h_I} \tag{51}$$

$$\gamma = -\frac{\rho S h_I Q}{\rho S + 2} \tag{52}$$

### A.3 Equilibrium measure of informed investors

In this section, we focus on the case where the issuer does not disclose his signal. Recall the utility function:

$$EU = -E \left[ \exp \{-\rho W\} \right]$$

where

$$W_i = (w_0 - cd) + q_i [y - p]$$

At the time when an investor $i$ observes price and any signals and chooses his portfolio $q_i$, expected utility conditional on his information set is

$$EU_i = -\exp \left\{ -\rho \left[ E_i (W_i) - \frac{E_i (W_i)}{2} \right] \right\} \tag{53}$$

Use that $q_i = \frac{E_i (y) - p}{\rho \text{Var}_i (y)}$ so that

$$W_i = w_0 - cd + \frac{E_i (y) - p}{\rho \text{Var}_i (y)} [y - p]$$

and therefore

$$E_i (W_i) = (w_0 - cd) + \frac{[E_i (y) - p]^2}{\rho \text{Var}_i (y)} \tag{54}$$

and

$$\text{Var}_i (W_i) = \frac{[E_i (y) - p]^2}{\rho^2 \text{Var}_i (y)} \tag{55}$$

Replacing (54) and (55) in (53):

$$EU_i = -\exp (-\rho (w_0 - cd)) \exp \left\{ -\frac{1}{2} \left[ \frac{E_i (y) - p}{\text{Var}_i (y)} \right]^2 \right\} \tag{56}$$

The next step is to compute ex-ante expected utility. This is not conditioning on $\theta$ or $p$ and treats $E_i (y) - p$ as a random variable.

The information set of an informed investor includes $\theta$ and $p$. Let

$$\Sigma_I \equiv \text{Var} [E (y|\theta, p) - p] \tag{57}$$

$$Z_I \equiv \frac{E (y|\theta, p) - p}{\sqrt{\Sigma_I}} \tag{58}$$

Replacing (57) and (58) into (56):

$$EU_I = -\exp (-\rho (w_0 - c)) \exp \left\{ -\frac{\Sigma_I}{2 \text{Var} (y|\theta, p) Z_I^2} \right\} \tag{59}$$

Conditional on $p$, $Z_I$ follows a Normal distribution with mean $A_I = \frac{E (y|\theta, p) - p}{\sqrt{\Sigma_I}}$ and standard deviation 1. Using that, by the law of total variance

$$\text{Var} (y|p) = \Sigma_I + \text{Var} (y|\theta, p)$$

and the MGF of a noncentral $\chi^2$ distribution to take conditional expectations of (59), we conclude that

$$E [U_I|p] = -\exp (-\rho (w_0 - c)) \sqrt{\frac{\text{Var} (y|\theta, p)}{\text{Var} (y|p)}} \exp \left( -\frac{(E (y|p) - p)^2}{2 \text{Var} (y|p)} \right) \tag{60}$$
For the uninformed investor, equation (56) directly implies

$$E [U_1 | p] = - \exp (-\rho w_0) \exp \left( - \frac{(E (y | p) - p)^2}{2 \text{Var} (y | p)} \right)$$

(61)

To compare the conditional expected utilities of informed and uninformed investors, use (60) and (61) to conclude that

$$E [V_I | p] - E [V_U | p] = \left[ \exp (pc) \sqrt{\frac{\text{Var} (y | \theta, p)}{\text{Var} (y | p)}} - 1 \right] E [V_U | p]$$

Taking expectations over $p$, ex-ante indifference requires:

$$\exp (pc) \sqrt{\frac{\text{Var} (y | \theta, p)}{\text{Var} (y | p)}} = 1$$

(62)

where $\text{Var} (y | \theta, p) = h_y^{-1}$ and is given by (35) and $\text{Var} (y | p) = h_y^{-1}$ and is given by (31). The $\lambda$ that solves (62) is the equilibrium fraction of informed investors, as long as that solution lies between 0 and $Q$.

A.4 Proof of proposition 1

Part 1.

The issuer’s mean-variance expected utility, conditional on his signal, the realized price and asset supply is:

$$EU = -E_0 \left[ \exp \left( - (1 + \xi) p - q_S \hat{y} - p + \frac{\rho}{2} \hat{\theta} h_y^{-1} \right) \right]$$

where we have excluded the disclosure cost. Define $\hat{y} \equiv y - p - E[\hat{y} - p]$ and $\hat{z} \equiv z - y$, so that $[\xi, \hat{y}, \hat{z}]$ is a vector of mean-zero random variables. Note that this implies $p = -\hat{y} + \hat{z} - E[\hat{y} - p]$. Using the relationships $p = a + \beta \theta + \delta z + \gamma \xi$, $q_S = a + b \hat{y} + c \xi$, where $a$, $b$ and $c$ come from matching coefficients in (38) and $\hat{y} = \hat{y} + \frac{h}{h_y + h_z} \hat{z}$ from (8), we can write the expected utility above in matrix form as

$$EU = -E_0 \left[ \exp \left( [\xi, \hat{y}, \hat{z}] F [\xi, \hat{y}, \hat{z}] + G' [\xi, \hat{y}, \hat{z}] + H \right) \right]$$

(63)

where $F$ and $G$ are $3 \times 3$ and $3 \times 1$, respectively, defined by

$$F = \begin{bmatrix}
\frac{\xi^2}{2h_y} & 0 & 0 \\
1 - c + \frac{\mu_2}{h_y} & \frac{\mu_2}{h_y} & -b \\
\frac{\mu_2}{h_y + h_z} & 0 & 0
\end{bmatrix}$$

$$G = \begin{bmatrix}
(1 - c)E[\hat{y} - p] - \hat{y} + \frac{\mu_2}{h_y} \\
1 - a + \frac{\mu_2}{h_y} \\
\frac{h_y}{h_y + h_z}
\end{bmatrix}$$

and $H$ is a scalar: $H \equiv E[\hat{y} - p] - \hat{y} + \frac{\mu_2}{2h_y}$. The variance covariance matrix of our three mean-zero random variables is

$$\text{Var} \left[ \begin{bmatrix} \xi & \hat{y} & \hat{z} \end{bmatrix} \right] = \begin{bmatrix}
h_{\xi}^{-1} & -h_{\xi}^{-1} & 0 \\
-h_{\xi}^{-1} & h_{\hat{y}}^{-1} & \frac{1}{h_y + h_z} - \frac{\beta + \delta}{h_z^{-1}} \\
0 & \frac{1}{h_y + h_z} - \frac{\beta + \delta}{h_z^{-1}} & h_z^{-1}
\end{bmatrix} \equiv \Sigma$$

To derive a sufficient condition for the issuer to prefer disclosure, it suffices to compare expected utility under the same portfolio rule, $q_S$. If the issuer prefers disclosure, given the same portfolio rule as he would choose under no disclosure, then he must also prefer disclosure under the optimal portfolio rule. This implies that we can hold the coefficients $a$, $b$ and $c$ constant and just consider the effect of disclosure on the equilibrium pricing coefficients $\alpha$, $\beta$, $\gamma$, $\mu_2$.
\[ EU^D - EU^{ND} = \left( \frac{1 - 2\Sigma^{ND} F}{I - 2\Sigma^{D} F} \right)^{1/2} \exp \left( \frac{1}{2} \left( G^{D^*} \left( I - 2\Sigma^{D} F \right)^{-1} \Sigma^{D} G^{D} - G^{ND^*} \left( I - 2\Sigma^{ND} F \right)^{-1} \Sigma^{ND} G^{ND} \right) \right) + E \left[ p^{ND} - \left( p^D \right) \right] \]

where we have used the general result that, for any normally distributed random vector \( x \sim N(0, \Sigma) \), it holds that \( E[\exp(x'Fx + G'x + H)] = |I - 2\Sigma F|^{-1/2} \exp(\frac{1}{2}G'(I - 2\Sigma F)^{-1}\Sigma G + H) \) for \( F, G \) and \( H \) being matrices of coefficients. Including the disclosure cost means multiplying \( EU^D \) by \( \exp(\rho C) \). Therefore, the issuer will choose to disclose if, and only if,

\[ \frac{EU^D \exp(\rho C)}{EU^{ND}} < 1 \]

Taking logs in the above expression, we conclude that the issuer will disclose if \( C \leq C^* \), where

\[ C^* = \ln \left( \left| \frac{1 - 2\Sigma^{D} F}{I - 2\Sigma^{D} F} \right| \right) - \ln \left( \left| \frac{1 - 2\Sigma^{ND} F}{I - 2\Sigma^{ND} F} \right| \right) + G^{ND^*} \left( I - 2\Sigma^{ND} F \right)^{-1} \Sigma^{ND} G^{ND} - G^{D^*} \left( I - 2\Sigma^{D} F \right)^{-1} \Sigma^{D} G^{D} + E \left[ p^{ND} - \left( p^D \right) \right] \]

**Part 2.**

When the fixed cost of information for the analyst is \( C_A = 0 \), then the equilibrium price of the analyst’s report is \( c = 0 \). All agents become informed because \( \text{var}(y|\theta, p) \leq \text{var}(y|p) \) implies that informed utility in (60) is always at least as high as uninformed utility (61) for \( c = 0 \). From the equilibrium pricing equation (52), we see that even when all investors are informed, \( \gamma \neq 0 \) and thus prices are not perfectly informative. So an investor who chooses not to become informed will have a strictly higher conditional variance \( \Sigma_{I|} > \Sigma_{ij} \). From the formula for expected utility (56), we know that higher conditional variance will mean that this uninformed investor has strictly lower utility from their portfolio (not including the difference in information costs): \( EU_I > EU_{IJ} \).

Thus, by continuity, there is a region of \( C_A > 0 \) sufficiently close to zero such that being informed still delivers strictly higher utility: \( EU_I - c > EU_{IJ} \) when (from the analyst’s zero-profit condition under the assumption that \( \lambda = Q \)), \( c = \frac{C_A}{Q} \). For this region of \( C_A > 0 \), every investor therefore chooses to remain informed: \( \lambda = Q \).

If in addition, investors signal perfectly precise (\( h_0 = \infty \)) about the issuer signal \( z \), then \( \theta = z \), and the equilibrium outcomes with no disclosure and with disclosure are identical. By continuity, for \( h_0 \) sufficiently large, the equilibrium outcomes are arbitrarily close under disclosure and non-disclosure, and non-disclosure lets the issuer save the disclosure cost \( C \), so that is his optimal decision.

**A.5 Welfare of investors - proof of proposition 2**

Expected utility conditional on any information set is given by (56). Let

\[ A_i \equiv E \left[ E_i(y) - p \right] \]
\[ \Sigma_i \equiv \text{Var} \left[ E_i(y) - p \right] \]
\[ Z_i \equiv \frac{E_i(y) - p}{\sqrt{\Sigma_i}} \]

Ex-ante, \( Z_i \sim N \left( \frac{A_i}{\sqrt{\Sigma_i}}, 1 \right) \). Rewrite (56) as

\[ EU_i = -\exp(-\rho(w_0 - cd)) \exp \left\{ -\frac{1}{2} \frac{1}{\text{Var}_i(y)} \Sigma_i Z_i^2 \right\} \]

Using the formula for the moment-generating function of a chi-square distribution, the ex-ante expected utility is

\[ EU = E(EU_i) = -\exp(-\rho(w_0 - cd)) \frac{\exp \left\{ -\frac{A_i^2}{2\text{Var}_i(y)} \right\}}{\sqrt{1 + \frac{1}{\text{Var}_i(y)} \Sigma_i}} \]
or, re-normalizing:

\[ V_i \equiv -2 \log \left[ \frac{-EU}{\exp(-p\omega_i)} \right] = \frac{A_i^2}{\var V_{\alpha i}(y) + \var \Sigma_i} + \log (\var V_{\alpha i}(y) + \var \Sigma_i) - \log (\var V_{\alpha i}(y)) - 2p cd \] (64)

1. **Full disclosure case** If the issuer discloses, no investors also acquire \( \theta \), therefore the ex-ante expected profit per share comes from substituting in the linear equation for \( p \) (10) and the price coefficients \( \delta \) and \( \alpha \). Let the subscript \( D \) denote the moments with disclosure. From simply applying Bayes’ law, we get \( \var D(y) = 1/(h_y + h_z) \).

\[
A_D = \mathbb{E}[\mathbb{E}(y|z) - p] = \mathbb{E}\left[ \frac{h_y \tilde{y} + h_z z}{h_y + h_z} - (\alpha + \delta z + \gamma \xi) \right]
\]
\[
= \mathbb{E}\left[ \frac{h_y}{h_y + h_z} \tilde{y} - \alpha + \left( \frac{h_z}{h_y + h_z} - \delta \right) z - \gamma \xi \right]
\]
\[
= \mathbb{E}\left[ \tilde{y} (1 - \delta) - \alpha \right]
\]
\[
= \mathbb{E}\left[ \left( \frac{Q}{\rho} + \frac{2}{\rho S} \right)^{-1} \right]
\]

The ex-ante variance of the expected profit per share, after conditioning on price and signal information is:

\[
\var_D = \left( \frac{h_z}{h_y + h_z} - \delta \right)^2 (h_y^{-1} + h_z^{-1}) + \gamma^2 h^{-1}
\]
\[
= \left( \frac{h_z}{h_y + h_z} - \frac{h_z}{h_y} \right)^2 (h_y^{-1} + h_z^{-1}) + \left( \frac{\rho S}{\rho S + 2} \frac{h_z}{h_y} \right)^2 h^{-1}
\]
\[
= h_y^{-2} \left( \frac{Q}{\rho} + \frac{2}{\rho S} \right)^{-2} h_z^{-1}
\]

The next step is to take the limits of these means and variances as the issuer’s risk aversion grows large \( (\rho S \to \infty) \).

\[
\lim_{\rho S \to \infty} A_D = \frac{1}{h_y} \left( \frac{\rho}{Q} \right) = \frac{1}{h_y + h_z} \left( \frac{\rho}{Q} \right)
\]
\[
\lim_{\rho S \to \infty} \var_D = \left( \frac{\rho}{h_y Q} \right)^2 h_y^{-1} = \left( \frac{\rho}{h_y + h_z} Q \right)^2 h_z^{-1}
\]

Note that \( \var D(y) \) has no \( \rho S \) terms in it and is therefore unchanged in the limit.

2. **No signals case** If the issuer does not supply the rating and in equilibrium \( \lambda = 0 \), there is still some updating: The investors still infer information from the price because the issuer’s asset supply depends on the value of \( z \). The price coefficients in this case are given by (46) - (49). We start by calculating the prior expected profit \( A_U = \mathbb{E}[y - p] \). \n
\[ A_U = \mathbb{E}[y - \alpha + \beta \theta - \delta z - \gamma \xi] \]

Using the fact that \( \beta = 0 \), \( E[\xi] = 0 \), and that \( E[y] = E[z] = \tilde{y} \), we get

\[ A_U = \tilde{y} (1 - \delta) - \alpha \] (65)

Next, we compute \( \var U = \mathbb{V}ar[E[y|p] - p] \). Since \( \beta = 0 \), we can use (30) for the conditional expectation and write this as

\[
\var U = \left( \frac{1}{\delta} \frac{h_u p}{h_u + h_u p} - 1 \right)^2 (\delta^2 (h_y^{-1} + h_z^{-1}) + \gamma^2 h_z^{-1})
\] (66)

Finally, we note that \( \var U(y) = h_u^{-1} \), where \( h_U \) is given by (31).
The next step is to take the limits of $A_U$ and $\Sigma_U$ as the issuer’s risk aversion grows large ($\rho_S \to \infty$). Since they depend on pricing coefficients, we first need to know the limits of the pricing coefficients as $\rho_S \to \infty$. One term that shows up in many of these coefficient expressions is $(1/\delta)h_{Up}$. From (48), we see that as $\rho_S \to \infty$, $\delta \to 0$. However, even though $\delta \to 0$, $(1/\delta)h_{Up}$ also converges to 0. To see why, note that from (29), the variance can be written as $h_{Up} = \delta^2/(\delta^2 h_z^{-1} + \gamma^2 h_{\xi}^{-1})$. Thus, $1/\delta h_{Up} \to 0$. As $\rho_S \to \infty$, $h_{Up} \to 0$. Using this result, we find that the limits of the pricing coefficients are

\[
\lim_{\rho_S \to \infty}\alpha = \frac{1}{\Delta} \left[ \frac{Q}{\rho} (h_y \bar{y}) - 1 \right] = \bar{y} - \frac{\rho}{Qh_y}
\]

\[
\lim_{\rho_S \to \infty}\delta = \lim_{\rho_S \to \infty} \frac{1}{\Delta} \left[ \frac{h_z (h_U - h_{Up} \frac{1}{\delta})}{\rho_S (h_U - h_{Up} \frac{1}{\delta}) + \xi h_S} \right] = 0
\]

\[
\lim_{\rho_S \to \infty}\gamma = \lim_{\rho_S \to \infty} - \frac{1}{\Delta} \left[ \frac{\frac{Q}{\rho} (h_U - h_{Up} \frac{1}{\delta})}{\rho_S (h_U - h_{Up} \frac{1}{\delta}) + h_S} + \frac{Q}{\rho} Qh_y \right] = - \frac{\rho}{Qh_y}
\]

Some of these results use $\lim_{\rho_S \to \infty} \Delta = \frac{Q}{\rho} h_y$. Substituting these limiting coefficients back into the expected utility terms (65) and (67), we get

\[
\lim_{\rho_S \to \infty} A_U = \frac{\rho}{Qh_y}
\]

\[
\lim_{\rho_S \to \infty} \Sigma_U = \left( \frac{\rho}{Qh_y} \right)^2 h_{\xi}^{-1}
\]

\[
\lim_{\rho_S \to \infty} Var_U(y) = \frac{1}{h_y}
\]

Finally, we substitute the limiting values of $A_D$, $A_U$, $\Sigma_D$, $\Sigma_U$ and $var(y)$ into the expected utility formula and compare utilities. We will sign the difference of transformed utilities $V_D - V_U > 0$. To do this, we break this difference into two pieces and sign each one separately.

**First term** Define

\[
X_1 = \frac{A_U^D}{Var_D(y) + \Sigma_D} - \frac{A_U^U}{Var_U(y) + \Sigma_U}
\]

$\Delta_1 < 0$ iff

\[
\frac{1}{h_y + h_z} < \frac{1}{\frac{1}{h_y} + \left( \frac{\rho}{Qh_y} \right)^2 h_{\xi}^{-1}}
\]

where the second line follows from rearranging and simplifying terms. Since $h_z$ is an inverse variance, it is always $h_z > 0$ and thus the expression always holds.

**Second Term** Define

\[
X_2 = \log \left( 1 + \frac{\Sigma_D}{Var_D(y)} \right) - \log \left( 1 + \frac{\Sigma_U}{Var_U(y)} \right)
\]
\( \Delta_2 \) is negative if \((1 + \frac{\Sigma_D}{Var_D(y)}/(1 + \frac{\Sigma_U}{Var_U(y)}) < 1 \), which implies \( \Sigma_D/Var_D(y) < \Sigma_U/Var_U(y) \). Substituting in the expressions above for \( \Sigma_D, \Sigma_U \) and \( Var_D(y) \), \( Var_U(y) \), we get

\[
\left( \frac{\rho}{(h_y + h_z)Q} \right)^2 h^{-1}_\xi < \left( \frac{\rho}{\sigma_y} \right)^2 h^{-1}_\xi
\]

where the second line follows from rearranging and simplifying terms. Since \( h_z \) is an inverse variance, it is always \( h_z > 0 \) and thus the expression always holds.

This proves that for sufficiently high \( \rho_S \), \( X_1 + X_2 < 0 \). This means that investors always prefer no information to disclosure.

### A.6 Proof of proposition 3

As shown in the proof of proposition 1, for sufficiently low \( C_A \) all investors will choose to be informed and for sufficiently high \( h_\theta \) allocations are arbitrarily close to those under disclosure. But, using the zero-profit condition for the analyst, each investor will pay \( \frac{C_A}{Q} \), which they would not have to pay under disclosure. Therefore investors have higher utility under disclosure. Because utility is continuous in \( C_A \), there is a region of \( C_A < C_A^* \) such that utility with disclosure does not exceed utility without disclosure.

### A.7 Proof of proposition 4

Welfare for any given investor is given by

\[
V_i = 2\rho_i w_0 - 2\rho_i cd + \frac{A_i^2}{Var_i(y)} + \Sigma_i + \log \left( 1 + \frac{\Sigma_i}{Var_i(y)} \right)
\]  

where

\[ A_i \equiv E [E_i(y) - p] \]

\[ \Sigma_i \equiv Var [E_i(y) - p] \]

1. When the issuer discloses, we have

\[
A_I = \frac{1}{(h_y + h_\theta) \psi} \]

\[
\Sigma_I = \left[ \frac{1}{(h_y + h_\theta) \psi} \right]^2 \frac{1}{h_\xi}
\]

\[
Var_I(y) = \frac{1}{h_y + h_\theta}
\]

where

\[ \psi \equiv \int_0^Q \frac{1}{\rho_i} di \]

When there is no information, we have

\[
A_0 = \frac{1}{h_y \psi} \]

\[
\Sigma_0 = \left[ \frac{1}{h_y \psi} \right]^2 \frac{1}{h_\xi}
\]

\[
Var_0(y) = \frac{1}{h_y}
\]

so replacing (74)-(79) into (73) and rearranging yields \( V_0 > V_I \).

2. This follows from the fact that for a sufficiently small \( C \), the equilibrium value of \( i^* \) will be \( Q \) and from continuity.
A.8 Proof of proposition 5

Proof.
1. Suppose to the contrary that the issuer does not provide information, and investors do not buy it either. Using the fact that \( \text{cov}(p, \xi) = \frac{\rho}{h_z} \) and formulas (13) - (16) (replacing \( \bar{y} \) with \( f(k) \)), expected profits for the non-disclosing issuer will be:

\[
\Pi^0 = f(k^*(0)) - \frac{\rho}{Qh_y} - \frac{\rho}{Qh_zh_y} - k^*(0)
\]

If instead the issuer paid the cost of disclosure, expected profits would be:

\[
\Pi^1 = f(k^*(1)) - \frac{\rho}{Q(h_z + h_y)} - \frac{\rho}{Qh_z(h_y + h_z)} - k^*(1) - C
\]

Rearranging the inequality \( \Pi^1 - \Pi^0 > 0 \) yields condition (20). If the condition holds, it contradicts the assumption that the issuer does not provide information.

2. If condition (20) does not hold, then \( \Pi^1 \leq \Pi^0 \), so an issuer will not disclose if he expects investors not to buy the report either. But the average price, which is equal to \( E(p) = \alpha + \beta f(k) \), satisfies

\[
\frac{\partial E(p)}{\partial \lambda} = \frac{h_z - h_p + (Q - \lambda) \frac{\partial h_p}{\partial \lambda}}{(Qh_u + \lambda h_z + (Q - \lambda)h_p^2) \rho} > 0
\]

because \( \frac{\partial h_p}{\partial \lambda} > 0 \) and \( h_z > h_p \). Therefore if the issuer expects some positive \( \lambda \) the profits from not disclosing are even higher that if he expects \( \lambda = 0 \). This implies that the issuer will not provide a rating regardless of what he expects investors to do.

A.9 Proof of proposition 6

Proof. From the proof of proposition 2, we know that ex-ante expected utility is (64), where \( A_i \equiv E[X_i(y) - p] \), and \( \Sigma_i \equiv \text{Var}[X_i(y) - p] \).

1. In case the issuer supplies the rating, then, using the equilibrium price coefficients (13)-(16) the ex-ante expected return and variance are: \( E_i(y) - p = \rho(N - 1)/Q (h_y + h_z) \) and \( \text{Var}_i(y) = 1/(h_y + h_z) \), where the \( I \) subscript denotes that the investor is informed. In this case, all investors are informed because the signal is disclosed. Therefore

\[
\Sigma_i = \left[ \frac{\rho}{Q(h_y + h_z)} \right]^2 \frac{1}{h_z} \quad A_i = \frac{1}{Q} \frac{\rho}{h_y + h_z}
\]

2. In case the issuer does not supply the rating and \( \lambda \in (0, Q) \), there are two expected utilities to consider, that of the informed agent and that of the uninformed. But in an interior equilibrium, the two must be equal. So, it suffices to look only at the expected utility of the uninformed agent. Using (13-16):

\[
E_U(y) - p = \frac{h_y\bar{y} + h_p \left( \bar{y} - \frac{\alpha - \beta}{\gamma} \right)}{h_y + h_p} - p
\]

\[
= \bar{y} - \alpha + \left( \frac{h_p}{h_y + h_p} - \gamma \right) (\theta - \bar{y}) + \left( \frac{h_p}{h_y + h_p} - \gamma \right) \frac{\beta}{\gamma} \xi
\]

and \( \text{Var}_U(y) = 1/(h_y + h_p) \) so

\[
A_U = \frac{\rho}{(h_y + h_z)\lambda + (h_y + h_p)} (Q - \lambda)
\]

\[
\Sigma_U = \left[ \left( \frac{\rho}{\lambda h_z} \right)^2 \frac{1}{h_z} + \left( \frac{1}{h_y} + \frac{1}{h_z} \right) \right] \left[ \frac{h_p}{h_y + h_p} - \frac{\lambda h_z + (Q - \lambda)h_p}{h_y + h_z} \lambda (h_y + h_z) + (Q - \lambda) (h_y + h_p) \right]^2
\]

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3. In case the issuer does not supply the rating but in equilibrium \( \lambda = 0 \), utility can be found by setting \( h_z = 0 \) in (80) and (81):

\[
\Sigma_0 = \left[ \frac{\rho}{Q h_y} \right]^2 \frac{1}{h_{\xi}} \quad (84)
\]

\[
A_0 = \frac{1}{Q} \frac{\rho}{h_y} \quad (85)
\]

4. Finally, for the case where the issuer does not provide a rating but in equilibrium \( \lambda = Q \), utility for each is as in the issuer-provided rating, subtracting the fixed cost \( c = \frac{C}{Q} \), so that \( V_Q = V_I - 2\rho \frac{C}{Q} \).

Replacing (84), (85), (80) and (81) respectively into (64)

\[
V_0 - V_I = \rho^2 h_{\xi} \left[ 1 - \frac{1}{Q^2 h_y h_{\xi} + \rho^2} - \frac{1}{Q^2 (h_y + h_z) h_{\xi} + \rho^2} \right] + \log \left( 1 + \frac{1}{h_y + h_{\xi}} \left( \frac{\rho}{Q} \right)^2 \frac{1}{h_{\xi}} \right) > 0
\]

that is positive because \( h_z > 0 \). This proves part a) of the Proposition. Part b) follows by the same reasoning that leads to Proposition 3.

**A.10 Price function coefficients with binary payoffs**

The coefficients in equation (26) are:

\[
A = \left( \frac{Q - \lambda}{Q} \left( 1 - \kappa_0^U - \kappa_0^I \right) + \frac{\lambda}{Q} \left( 1 - \kappa_0^U - \kappa_0^I \right) \right) \log \left( \frac{\bar{y}}{1 - \bar{y}} \right) - \frac{\rho}{Q}
\]

\[
B = \frac{Q - \lambda}{Q} \kappa_0^U + \frac{\lambda}{Q} \kappa_0^I
\]

\[
C = \frac{Q - \lambda}{Q} \kappa_0^I + \frac{\lambda}{Q} \kappa_0^U
\]

\[
D = \left( \frac{Q - \lambda}{\lambda} \kappa_0^U + 1 \right) \frac{\rho}{Q}
\]

**B Model Calibration**

**Adjusting for fluctuations in the risk-free rate:** We compute the spread as follows: By definition, the yield of the bond at the issue date, \( r_0 \), satisfies

\[
p_0 = \sum_{t=0}^{T} \frac{c_t}{(1 + r_0)^t}
\]

where \( c_t \) is the bond’s \( t \)-dated coupon (or coupon-plus-principal). The spread on the bond is

\[
s_0 = r_0 - r_0^T
\]

(where \( r_0^T \) is the \( T \)-maturity risk-free rate as of \( t = 0 \)). At \( t = 1 \), instead of looking directly at the price of the bond, we look at a corrected price defined by

\[
\tilde{p}_1 = \sum_{t=0}^{T} \frac{c_t}{(1 + r_0 + s_1)^t}
\]

where \( s_1 \) is the spread calculated on the basis of the \( t = 1 \) price. If \( r_0^T = r_1^T \), the corrected price coincides with the pure price, but if risk-free interest rates have changed in the meantime, the corrected price filters out the effect.

**Normalizing by the promised value:** In order to account for the different contractual terms of different bonds, we normalize the price of bonds by the contractually-promised net present value \( y^p \), defined by

\[
y^p = \sum_{t=0}^{T} \frac{c_t}{(1 + r_0)^t}
\]

For bonds with low probability of default (for instance, highly rated bonds), their price as a proportion of the contractually promised net present value \( (p/y^p) \) will be close to one. In our data, the average \( p/y^p \) is 0.91.