Financial Disclosure with Costly Information Processing*

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Abstract

We analyze a model where some investors ("hedgers") are bad at information processing, while other ("speculators") trade purely to exploit their superior information processing ability. Disclosing information about asset fundamentals induces an externality: since speculators are known to understand its pricing implications, if they abstain fom trading hedgers will imitate their decision, depressing the asset price compared to its no-disclosure level. Trading transparency will reinforce this mechanism, by making speculators' trades more visible to hedgers. Hence asset sellers will oppose both disclosure of fundamentals and trading transparency. This policy is socially inefficient if speculators are a large fraction of market participants and hedgers' processing costs are low. But in these circumstances, forbidding hedgers' access to the market may dominate mandatory disclosure.

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1 Introduction

Can financial market transparency be detrimental to issuers? The most obvious answer would appear to be negative. Company disclosure should reduce adverse selection: hence issuers who disclose more information about asset fundamentals should be rewarded by investors via higher issue prices or more generous funding. The same should apply to the transparency of the trading process: when more is known about past trades, incoming orders and existing quotes, it is easier to gauge the presence and strategies of informed traders, hence adverse selection is reduced also on this account. These adverse selection costs should be priced into the initial price at which assets can be sold, so that either form of transparency should ultimately benefit issuers. This intuition has also motivated the provisions of Dodd–Frank Act that aim at increase market transparency and disclosure by issuers in off-exchange markets.

In this paper we show that this conclusion need not be true if (i) financial information is costly to process and (ii) not everyone is equally good at processing it. Under these assumptions, information disclosure might not always be beneficial, because providing more information to market participants (i) increases their information processing costs and (ii) increases the informational asymmetry between more sophisticated investors and less sophisticated ones, and therefore exarcebates adverse selection in the market.

More specifically, we present a simple search model with sequential trading where, upon receiving new fundamental information, investors must decide how much attention to pay to it in order to gauge its pricing implications, balancing the implied benefits for their trading decisions with the costs of increased attention. We show that, when investors differ in their processing ability, disclosure generates adverse selection: investors with limited processing ability will worry that, if the asset was not already bought by others, it might be because more sophisticated investors, who are better at understanding news' price implications, concluded that the asset is not worth buying. This depresses the price that unsophisticated investors are willing to offer to the seller; but then sophisticated investors, anticipating that the seller will have a hard time finding a buyer among the unsophisticated, will in turn offer a price below the no-disclosure level.

Hence, sellers may have a good reason to refrain from disclosure. However, they will have to balance this concern with an opposite one: releasing information also helps investors avoiding costly mistakes in their trades, and under this respect it stimulates their demand for the asset. Hence, in deciding about information disclosure, sellers face a trade-off: on the one hand, disclosure attracts speculators to the market, since it enables them to exploit their superior information-processing ability, and therefore triggers the pricing externality just described, to the detriment of issuers; on the other hand, disclosure encourages demand for the asset by hedgers, because it protects them from too large errors in trading.

The issuer's disclosure decision discussed so far concerns the amount and precision of information about assets' payoffs ("fundamental transparency") via listing prospectuses, presentation of accounting data, publication of credit ratings, etc. In balancing the pros and cons of this form of transparency, we show that issuers will also have to take into account the degree of transparency of the market where the asset will be traded ("trading transparency"), namely, how much investors know about recent trades or about the price at which a new order may execute. Trading transparency crucially affects the magnitude of the pricing externality triggered by fundamental disclosure, because it raises the unsophisticated investors' awareness of the trading behavior of sophisticated investors, and therefore encourages the former to mimic the trades of the latter more closely. In equilibrium, this increases the price concession that sophisticated investors can inflict on asset sellers, so that the latter will be averse to trading transparency. Hence, the interaction between fundamental and trading transparency makes them substitutes from the viewpoint of asset sellers: these will be more willing to disclose information about the asset's value if they can expect the trading process to be more opaque. In this case, the adverse selection caused by the disclosure of news is mitigated by the possibility that the order flow is not observed by investors. The interaction between these two forms of transparency may even affect the unsophisticated investors' willingness to trade: if trading transparency rises beyond a critical point, financial disclosure might induce them to withdraw from the market altogether, as they become too concerned that assets still available for sale may have been previously rejected by better informed investors.

Hence, our setting encompasses two notions of transparency that are generally analyzed separately by researchers in accounting and in market microstructure, even though they are naturally related: information about fundamentals affects security prices, but the transparency of the trading process determines how and when it is impounded in market prices. We show that each of these two forms of transparency amplifies the effects of the other on security prices. This is particularly important in view of the fact that the recent financial crisis has brought both of these notions of transparency under the spotlight. The opacity of the structure and payoffs of structured debt securities – a form of low fundamental transparency – is blamed as a reason for the persistent illiquidity of fixed income markets. But the crisis has also highlighted the growing importance of off-exchange trading, with many financial derivatives (such as mortgage-backed securities, collateralized debt obligations and credit default swaps) being traded in very opaque over-the-counter (OTC) markets – an instance of low trading transparency.

Our model provides a rationale for why issuers tend to oppose both forms of transparency: opacity improves the position of the seller and damages both sophisticated and unsophisticated investors, unlike in most market microstructure models where it tends to redistribute wealth from uninformed to informed investors. In our model, reducing information disclosure prevents sophisticated investors from exploiting their superior processing ability, and induces unsophisticated ones to make more trading mistakes, both because they have less fundamental information and because they cannot observe previous trades to update their beliefs about the asset's value.

Beside providing insights about the political economy of regulation in this area, our model can also be used to take a normative standpoint on a number of pressing policy questions: if the regulator wishes to maximize social welfare, how much information should be released when processing it is costly? Are seller's incentives to disclose information aligned with the regulator's objective? When should a regulator force disclosure? How does mandatory disclosure compare with a policy where only qualified investors are licensed to buy complex securities?

First, we show that in general there can be either over- or under-provision of information, depending on the size of processing costs and the seller's bargaining power. Surprisingly, there is a region in which the seller has a greater incentive to disclose than the regulator: this happens when enough unsophisticated investors participate to the market and the asset's expected value is low: sellers will spontaneously release more information when their assets are not much sought-after by investors. This is also more likely when the seller appropriates a high fraction of the expected gains from trade.

When instead there are enough sophisticated investors, so that issuers fear to unleash their superior processing ability, they inefficiently prefer not to disclose, so that regulatory intervention is required to mandate disclosure. This is likely to happen in markets for complex securities, such as those for asset-backed securities, where a high degree of sophistication is required to fully understand the structure of the assets and its implications in terms of risk, so that sophisticated investors are attracted to them. This is less likely to be the case for plain-vanilla assets such as treasuries or corporate bonds, where sophisticated investors cannot hope to exploit their superior processing ability.

Finally, we show that in markets where most investors feature a low degree of financial literacy, it may be optimal for the regulator to license market access only to the few sophisticated investors present, as this saves the processing costs that unsophisticated investors would otherwise pay. Thus, when information is difficult to digest, as in the case of complex securities, the planner should let issuers place assets only with the "smart money", rather than making it available to all comers.

These insights build upon the difference between the information disclosed to the market and that digested by market participants. This difference naturally arises in many situations and has already drawn the attention of the regulator. In central banking, it is often argued that the quest for transparency about the transcripts of policy committee meetings must be balanced with the danger that the arguments behind policy decisions may be misinterpreted by some market participants.[1] In U.S. security regulation, there is some controversy about the effects of Regulation Fair Disclosure, which prohibits firms from disclosing information selectively to analysts and shareholders since 2000: according to Bushee et al. (2004), "Reg FD will result in firms disclosing less high-quality information for fear that [...] individual investors will misinterpret the information provided".[2] Our model does indeed predict that regulations imposing greater transparency may have have unintended consequences due to the countervailing reaction of issuers. For instance, imposing that securities currently traded on OTC markets be traded in centralized and transparent limit-order-book markets, may reduce issuers' incentives to disclose fundamental information. This is because increasing trading transparency allows unsophisticated investors to imitate the strategies of more sophisticated ones, and in our setting this induces the issuer to be less willing to disclose information about the securities traded.

The rest of the paper is organized as follows. Section 2 places the paper in the context of the literature. Section 3 presents the model, while Section 4 is devoted to the analysis and discussion of the main results. Section 5 investigates to the role of regulation. Section 6 concludes.

2 Related Literature

This paper is related to a growing literature on costly information processing by economic agents, started by Sims (2003) and Sims (2006) who argue that agents are unable to process all the available information, explaining in this way the observed inertial reaction

[1] See for example Woodford (2005). Winkler (2000) and Carpenter (2004) argue that the potential for misunderstanding by the market greatly affects the effectiveness of a central bank's policies and central banks are therefore naturally concerned about the risks involved in disclosing information.

[2] Bushee et al. (2004) find that firms which used closed conference calls for information disclosure prior to the adoption of Reg FD were significantly more reluctant to do so afterwards. In surveys of analysts conducted by the Association of Investment Management and Research, and the Security Industry Association, 57% and 72% of respondents respectively felt that less substantive information was disclosed by firms in the months following the adoption of Reg FD. Gomes et al. (2007) find a post Reg FD increase in the cost of capital for smaller firms and firms with a stronger need to communicate complex information as proxied by intangible assets.

to external information. Subsequent work by Peng and Xiong (2006), Van Nieuwerburgh and Veldkamp (2009) and Van Nieuwerburgh and Veldkamp (2010) have analyzed various information constraints in monetary policy as well as in portfolio choice problems.[3] Our model differs from these in many respects. Instead of assuming information capacity constraints, we propose a model of limited cognition where investors can increase the precision of the available information, but at a cost. Moreover, our focus is on the strategic interactions triggered by information disclosure and on its policy implications.

The assumption that information processing is costly squares with a large body of empirical evidence both in psychology, economics and accounting (Pashler and Johnston (1998), Yantis (1998)). Moreover, Libby et al. (2002) and Maines (1995) provide surveys of experimental research on financial information processing, whereas Daniel et al. (2002) survey the evidence consistent with limited attention affecting securities prices.[4] There is also evidence that limited attention affects portfolio choices: Christelis et al. (2010) investigate the relationship between household portfolio composition in 11 European countries and indicators of cognitive abilities drawn from the Survey of Health, Ageing and Retirement in Europe (SHARE), and find that the propensity to invest in stocks is strongly associated with cognitive abilities and is driven by information constraints, rather than by features of preferences or psychological traits.[5]

Several recent papers show that investors might overinvest in information acquisition. For instance, in Glode et al. (2011) traders inefficiently acquire information as more expertise improve their bargaining positions. In Bolton et al. (2011), too many workers choose to become financiers compared to the social optimum, due the negative externality that informed financiers have on the entrepreneurs' bargaining power. In these papers, the focus is on information acquisition. In contrast, our focus is on information processing by investors, and the effects that this has on the issuers' incentive to disclose it in the first place, leading to either over- or underprovision of information relative to the efficient level.

Several authors in the literature have proposed reasons why limiting disclosure may

[3] See also Hirshleifer and Teoh (2003) which analyze firms' choice between alternative methods for presenting information and the effects on market prices, when investors have limited attention.

[4] See Carlin (2009) for a model of strategic complexity, and Gennaioli and Shleifer (2010) and Gennaioli et al. (2011) for studies of different investors' behavioral limitations in processing information.

[5] Also the accounting literature recognizes a discrepancy between the information released to the market and the information digested by market participants: Barth et al. (2003) and Espahbodi et al. (2002), among others, distinguish between information disclosure and recognition, and observe that the latter has a larger empirical impact than the former, presumably a reflection of a better understanding of the disclosed information.

have an efficiency rationale, starting with the well-know argument by Hirshleifer (1971) that it may destroy insurance opportunities. The detrimental effect of information disclosure has been highlighted in settings where it can exacerbate externalities in the use of information by market participants, as in our setting: Morris and Shin (2011) analyze a coordination game among differentially informed traders with approximate common knowledge; **?**) analyzes a model of crises with strategic complementarity between investors, and shows that higher disclosure (e.g., a public signal about weak fundamentals) may backfire, aggravating the fragility of financial intermediaries. Also in our model the disclosure of information about fundamentals creates externalities and strategic behavior in trading, and these are exacerbated by transparency about the trading process; however, since the disclosure decision is entrusted to issuers, this may lead to a inefficiently low level of transparency.

Our result that issuers may be hurt by financial disclosure parallels Pagano and Volpin (2010), who show that when investors have different information processing costs, transparency exposes unsophisticated investors to a winners' curse at the issue stage: to avoid the implied underpricing, issuers will prefer opaqueness. But opting for an opaque primary market may lead to generate secondary market illiquidity, if the information not disclosed at the issue stage is later discovered by secondary market traders; if this illiquidity generates negative externalities, it may be socially efficient to mandate disclosure. Our present setting shares with Pagano and Volpin (2010) the idea that disclosure may amplify adverse selection if investors have different information processing costs, but it shows that issuers will not always opt for opaqueness, since they will trade off the costs of disclosure (arising from investors' information processing costs and the strategic interaction among them) against its benefits (arising from its contribution to avoiding mistaken portfolio choices). Moreover, differently from Pagano and Volpin (2010), in the current paper the level of disclosure chosen by issuers may either exceed or fall short from those chosen by a benevolent regulator, and is also affected by the degree of transparency of the trading process.[6]

Another paper in which issuers may choose an inefficiently low level of disclosure is that by Fishman and Hagerty (2003), who consider a setting where some customers fail to understand the meaning of the information disclosed by the seller, being able only to understand whether the seller discloses a signal or not. They show that if the fraction of these unsophisticated customers is too low, voluntary disclosure will not

[6] Recently, Dang et al. (2010) have also noted that opacity may be beneficial insofar as it reduces informational asymmetries, but they mainly concentrate on the security design implications of this insight.

occur, and mandatory disclosure benefits informed customers and harms the seller. This implies that disclosure should be mandatory in markets where information is difficult to understand. In our model we find very different results. The key modeling difference is that in our model unsophisticated investors must spend resources to understand the disclosed information, so that if they have high information-processing costs the regulator may prefer to save these costs by not mandating disclosure or , even better, by restricting investment in complex assets to sophisticated investors.

In practice, issuers may want to refrain from voluntarily disclosing information also for other reasons. First, disclosure may be deterred by the costs that firms must bear to transmit information credibly to investors (listing fees, auditing fees, regulation compliance costs, etc.). A second, less obvious cost arises from the non-exclusive nature of information disclosure: once a firm discloses information to investors, it also reveals it to its competitors, who may then exploit it to appropriate the firm's profit opportunities, as highlighted by **?**)and **?**). A third cost arises from the company's lower ability to evade or elude taxes: by providing more detailed accounting information to investors companies also reveal it to the tax authorities, and the implied additional tax burden may induce them limit their disclosure, as pointed out by **?**).

3 The Model

A seller is endowed with an indivisible asset that he wants to sell to investors, since he places no value on it. Trade occurs via a search market that randomly matches the seller with investors. Prior to trade, the seller can disclose a noisy signal about the value of the asset. To understand the pricing implications of this signal, potential buyers must devote some attention to analyze it. But investors face different costs in processing new information: for unsophisticated investors, understanding financial news is more costly that for professional ones who have greater expertise, better equipment and/or more time to devote to this task. Unsophisticated investors may wish to buy the asset only for non-informational reasons, for instance to hedge some other risk, and therefore we will refer to them as "hedgers". In contrast, sophisticated investors will be assumed to trade purely to exploit their superior information-processing ability, and accordingly will be labeled "speculators".

The value of the asset, v, can take one of two equally likely values $v \in \{v_b, v_g\}$ where $v_b < 0 < v_g$ and $v^e \equiv (v_g + v_b)/2$.[7] Each investor i has a reservation value $\omega_i > 0$ that

[7] This binary distribution is assumed just to simplify the exposition, but the results are qualitatively the same with a continuum of possible asset's values.

is independent from v. Therefore, the net value from purchasing the asset for investor i is $v - \omega_i$.

Once the seller is matched with a buyer, they negotiate a price and trade will occur whenever the buyer expects to gain a surplus: $\mathbb{E}(v - \omega_i \mid \Omega_i) > 0$, where Ω_i is the buyer i's information set. Let $\beta_i \in (0,1)$ be the probability the seller makes the offer. If an offer is rejected, the traders part and the seller continues searching; if the offer is accepted, exchange occurs. We adopt as bargaining protocol the generalized Nash solution under symmetric information.[8] Then, trade occurs at a price such that the seller captures a fraction β_i and the investor a fraction $1 - \beta_i$ of this expected surplus, where β_i measures the seller's bargaining power, which in turn may be taken to reflect the seller's impatience relative to that of buyers. Real-world examples of this setting are over-the-counter (OTC) markets and housing markets, where matching via search gives rise to a bilateral monopoly at the time of a transaction.[9]

The seller can disclose a signal $\sigma \in \{\sigma_b, \sigma_g\}$. If he does, before trading investor i must decide the level of attention $a \in (0,1)$ devoted to process this signal. We assume that the level of attention coincides with the probability that the investor correctly estimates the probability distribution of the asset's value: $\Pr(\sigma_i = v_i | v_i) = \frac{1+a}{2}$. So by investing more attention, investors reads the signal more accurately. However, greater precision comes at an increasing cost for the investor: the cost of information processing is $C_i(a, \theta)$, with $C_1(\cdot) > 0$ and $C_{11}(\cdot) > 0$, where the shift parameter θ_i measures the inefficiency of the investor in information processing – his degree of "financial illiteracy".[10] To simplify the analysis, we posit a quadratic cost function: $C_i(a, \theta) = \theta_i a^2/2$.

The choice of a captures the effort that investors may invest in understanding the information provided, for instance, in an asset's prospectus, in the earning announcements of a company or in disclosing data about a CDO's asset pool. The parameter θ measures how costly is for the investors to understand the sensitivity of the asset to factors like interest rates, commodity and housing price changes. It may also depend on the complexity of the asset: as shown by the recent financial crisis, understanding the pricing implications of a CDO's structure requires considerable skills and resources.

We assume that there are two types of investors, i.e. $i \in \{h, s\}$. A fraction μ of them are unsophisticated ("hedgers"), who face a cost $\theta_h = \theta > 0$ in information processing,

[8] See the end of this section for a discussion of this and of the other main assumptions.

[9] See Duffie et al. (2005) for a search-cum-bargaining model of trading in OTC markets.

[10] As Tirole (2009), we do not assume bounded rationality: in Tirole's framework information processing costs rationally lead to incomplete contracts, which impose costs on them; similarly, in our setting unsophisticated investors rationally decide how much information they wish to process, being aware that choosing a low level of attention may lead to mistakes in their trading strategies.

whereas the remaining $1-\mu$ are sophisticated "speculators" who face no such costs: $\theta_s = 0$.[11] It is worth mentioning also a different interpretation. We can assume that there is only one investor for each type i, and interpreting μ $(1-\mu)$ as the search frictions faced by hedgers (speculators). We impose the following restrictions on the parameters:

Assumption 1 $\omega_s \geq v^e > \omega_h > 0$

Assumption 1 states that the two types of investors also differ in their outside options. Hedgers have a comparatively low outside option, so that they view the asset as a good investment on average: $v^e > \omega_h > 0$. For instance, they are farmers who see the asset as a good hedge against their crops' price risk. In contrast, speculators are in the market only to exploit their information processing ability, because they do not have intrinsic need to invest in the asset: $\omega_s \geq v^e$. For example, they may be hedge funds or investment banks with strong quant teams.

Assumption 2 $(1-\beta_h)(\bar{v}_g - v_b) < 4\theta$

Under assumption 2 processing information is costly enough for the hedgers, which ensures that the attention allocation problem solved by the hedgers has a unique interior solution.

We also allow the two types of investors to differ in their bargaining power. The seller is able to capture a fraction β_h of the expected gains from trade when dealing with hedgers, but a lower fraction $\beta_s \leq \beta_h$ when dealing with speculators, because these may be better at shopping around for the best deals, or because they are repeat buyers who obtain price concessions as part of a stable trading relationship with the seller.

The timing of the game is the following:

1. The seller decides whether to disclose the signal or not, i.e. $d \in \{0, 1\}$.

2. An investor is randomly matched to the seller.

3. If $d = 1$, investors choose the attention level a and form their expectation of the asset value $\widehat{v}(a, \sigma)$. If $d = 0$, they go directly to the next stage.

4. The investor decides whether to trade or not.

5. If trading is profitable, buyer and seller bargain over the expected surplus.

[11] The model easily generalizes to the case where also speculators have positive information-processing costs or there are more than two types of investors.

6. If trade does not occur, another investor, upon observing the outcome of stage 4, is randomly matched to the seller and bargains with him over the expected surplus.

Note that at the final stage of the game we assume complete market transparency, since trades are observed by all market participants. However, one of the main results of the paper is obtained precisely by relaxing this assumption: in Section 4.4 we shall assume that trades can be imperfectly observed by other investors, so that we shall be able to explore how reducing market transparency affects the equilibrium outcome.

3.1 Discussion

At this point it is worth discussing some of the assumptions of the model.

First, we assume that investors choose their attention level after being matched with the seller: for instance, they analyze a security's prospectus only upon finding a security available for purchase. The alternative would be to assume that buyers investigate the information in advance, before being matched with the seller. However, this alternative would entail greater costs for investors, because they would bear information-processing costs even for securities that they would not eventually buy: hence, if they are given the choice, they would opt for the sequence assumed in the model's time line.

Second, one might wonder whether the seller might avoid the externality arising from the speculator's behavior by committing to trade only with unsophisticated investors. However, this overlooks the fact that the externality arises from the seller simply receiving an offer from a speculator, rather than trading with him: even if the seller commits to refrain from trading with speculators, he cannot avoid receiving offers from them, and this is sufficient to induce learning by hedgers and hence generate the externality present in the model.

Finally, we assume that bargaining occurs under symmetric information, but we can argue that this is without loss of generality. Suppose, in fact, that the seller is matched with a speculator. Since the seller does not know the value of the asset, while the speculator in equilibrium perfectly infer it from the disclosed signal, there exists asymmetric information between them. However, since there are no gains from trade in the event that the speculators observes a negative signal about the asset's value, the seller knows that if the speculator is willing to buy, it means that the asset's value is v_g. This is the same reason that motivates the adoption of the Nash Bargaining solution also in Duffie et al. (2005). Moreover, as will become clearer in the next section, the seller will always trade with the speculator if he has observed a positive signal.

Instead, when the seller is matched with a hedger, the latter has a posterior belief about the asset's value. However, the seller knows the parameters of the hedger's attention allocation problem, therefore he is able to infer the attention chosen by the hedger. Moreover, in equilibrium the seller expects the hedger to buy the asset only if a positive signal about the asset's value has been released. This means that the gains from trade between seller and hedger are indeed common knowledge, hence the Nash bargaining solution can be applied.

We do not allow the seller to possess private information about the asset's value, because then a multiplicity of equilibria would arise, due to the possibility for the seller to signal his information at the bargaining stage of the game, and this would prevent us from drawing clear policy implications. Moreover, our focus is on the heterogeneous information among investors that endogenously arise in equilibrium, not on how asymmetric information affects trade.

4 Equilibrium

We solve the game backwards to identify the subgame perfect equilibrium of the game, that is, the strategy profile (d, a_s, a_h, p_s, p_h) such that: (i) the disclosure policy d maximizes the seller's expected profits; (ii) the choice of attention a_i maximizes the expected gains from trade of the typical buyer i; (iii) the prices p_s and p_h offered to the seller by speculators and hedgers respectively, solve the bargaining problem specified above. Specifically, each type of investor will offer a different price depending on the disclosure regime and possibly on whether he is matched with the seller at stage 5 (when he is the first bidder) or at stage 6 (when he bids after another investor chose not to buy). Each of the following sections addresses one of these decision problems.

4.1 The Bargaining Stage

Let p_i be the price offered by investor i and $\bar{\omega}_i$ the seller's outside option when he is dealing with investor i. Note that the latter is endogenously determined by the investors' equilibrium behavior.

The price offered by hedgers when they meet the seller solves the following program:

$$p_h \in \arg\max \left(p_h - \bar{\omega}_h\right)^{\beta_h} \left(\widehat{v}\left(a, \sigma\right) - \omega_h - p_h\right)^{1-\beta_h}, \tag{1}$$

where

$$\bar{\omega}_h = \begin{cases} \beta_s \frac{1+a}{2} (v_g - \omega_s) & \text{if } \sigma = \sigma_g, \\ \beta_s \frac{(1-a)}{2} (v_g - \omega_s) & \text{if } \sigma = \sigma_b \end{cases} \tag{2}$$

is the price that hedgers expect a speculator to offer if their trade does not go through. Only v_g appears in this expression because the speculator would buy the asset only in the good state: in the bad state the asset is worthless to him. Therefore, this price is the seller's outside option in bargaining with a hedger. Since in equilibrium hedgers only know the signal σ, but not the actual realization of v, their forecast of the price that speculators would offer depends on the signal that they receive and on its precision.

The asset's expected value for investors, as a function of the signal σ, is

$$\widehat{v}(a,\sigma) \equiv \mathbb{E}[v|\sigma] = \begin{cases} \frac{1+a}{2} v_g + \frac{1-a}{2} v_b & \text{if } \sigma = \sigma_g, \\ \frac{1-a}{2} v_g + \frac{1+a}{2} v_b & \text{if } \sigma = \sigma_b. \end{cases}$$

The weight assigned to the signal σ disclosed by the seller is an increasing function of the attention a that hedgers devote to the signal: in the limiting case $a = 0$, their estimate of the asset value would be the unconditional average v^e, whereas in the opposite polar case $a = 1$, their estimate would become as precise as that of the speculators. In what follows, we conjecture that speculators, who face no information-processing costs, will choose $a_s^* = 1$, whereas hedgers' optimal choice will choose a lower attention level, namely $a_h^* \in [0, 1)$.[12] Thus in equilibrium speculators know the value of the asset, while hedgers hold a belief $\widehat{v}$ whose precision depends on the attention they devote to the available information.

Symmetrically, the price offered by speculators solves the following bargaining problem:

$$p_s \in \arg\max (p_s - \bar{\omega}_s)^{\beta_s} (v - \omega_s - p_s)^{1-\beta_s}, \tag{3}$$

where $\bar{\omega}_s$ is the price that will be offered by hedgers if speculators do not buy the asset. Upon observing that speculators did not buy, hedgers will revise their estimate of the asset's value down to v_b. Since this value falls short of their reservation value (as $v_b < 0 < \omega_s$), they will be themselves unwilling to buy the asset, so that in this case the seller's outside option is zero: $\bar{\omega}_s = 0$. This information externality in turn weakens the seller's bargaining position when dealing with speculators, lowering his outside option compared to the case where the speculators' trading decision is not observed by hedgers (so that the latters' estimate is $\widehat{v}(a, \sigma) > v_b$). As a result, the speculators can buy the asset more cheaply. In other words, even when $\beta_h = \beta_s$, the speculators' superior

[12] In the next section we solve the attention allocation problem and show that this conjecture is correct.

processing ability allows them to capture a higher fraction of the trading surplus due to the effect that their trading decision has on the hedgers' valuation.

The inference that hedgers make from speculators' decisions in our model is reminiscent of results in the literature on herding (Scharfstein and Stein (1990) and Banerjee (1992)). However, in our model hedgers always benefit from observing speculators' decisions, because there is no loss of valuable private information.

In contrast, speculators do not learn from hedgers: since in equilibrium they have better information, they do not make any inference regarding the asset's value if they observe the hedgers not buying it. So observing past trades is irrelevant for them. By solving problems (1) and (3), we obtain:

Proposition 1 *If the seller is initially matched with a speculator, trade will occur if and only upon observing v_g. Otherwise, in subsequent matches hedgers will refuse buying the asset. If the seller is initially matched with a hedger and trade does not occur, in the subsequent matches the seller will deal with speculators. The prices offered by the two types of investors are*

$$p_h = \beta_h \left(\widehat{v}\left(a, \sigma_g\right) - \omega_h \right) + \left(1 - \beta_h\right) \beta_s \left(v_g - \omega_s\right) \frac{1 + a_h}{2} \text{ and } p_s = \beta_s \left(v_g - \omega_s\right).$$

The proposition indicates that in equilibrium the seller never deal with the same type of investor twice. Irrespective on whether the initial match is with a speculator or with a hedger, if the sale does not go through no other investor of the same type will buy the asset, because they are all identical. Specifically, if a first hedger does not buy the asset, other hedgers will believe that he observed σ_b, which will discourage them from buying the asset as well. Then, the only option for the seller is to deal with a speculator. Similarly, if a first speculator does not buy the asset, neither other speculators will. But in this case even hedgers will refuse buying the asset, due to the negative inference that they will make about the asset's value.

Since in equilibrium hedgers only buy (immediately) upon receiving good news, the price that they offer equals their expected surplus conditional on good news. The first term is the fraction of the unconditional expected surplus that the seller is able to capture as result of bargaining with the hedgers. The second term, which is increasing in the hedgers' level of attention a_h, captures the fact that they also have to compensate the seller for his outside option, that is, the price the speculators would offer. In contrast, the price offered by speculators is only affected by their bargaining power – indeed they grab a share $1 - \beta_s$ of the surplus conditional upon good news. This is because when she bargains with a speculator, the seller's outside option is zero: unless she sells to him, the asset will go unsold because hedgers will also refuse to buy.

It is important to realize that the price concession that speculators obtain as a result of hedgers imitating their behavior arises from the hedgers' awareness of the speculators' superior information processing ability, which exposes hedgers to adverse selection. But this adverse selection effect is made possible by the public announcement made by the seller at the initial stage, since without such announcement speculators would lack the very opportunity to exploit their information processing advantage.

Indeed, if there is no signal disclosure ($d = 0$), speculators do not participate to the market, because once they are matched to the seller their expected gains from trade are negative: $v^e - \omega_s < 0$. That is, it pays for them to be in the market only for information reasons. In this case, absent both the signal and the adverse selection problem, the price offered by hedgers will simply be the unconditional expectation of their gains from trade:

$$p_h^{ND} = v^e - \omega_h.$$

Since the seller can always costlessly wait to be matched with a different hedger, he can capture the entire surplus.

4.2 Attention Allocation

So far we have taken investors' choice of attention as given. In this section we characterize their attention allocation as a function of their processing ability. Investors process the signal σ to guard against two possible types of errors. First, they might buy the asset when its value is lower than the outside option: if so, by investing attention a they save the cost $v_b - \omega_i$. Second, they may miss on buying the asset when it is worth doing so, that is, when its value exceeds their outside option ω_i: in this case, not buying implies forgoing the trading surplus $v_g - \omega_i$.

In principle there are four different outcomes: the hedger may (i) never purchase the asset, (ii) always buy it, irrespective of the signal realization; alternatively, he can choose to buy the asset (iii) only when the signal is σ_g or (iv) only when the signal is σ_b. Proposition 2 characterizes the optimal attention allocation choice and shows that hedgers find it profitable to buy if and only if the realized signal is σ_g, that is, if the seller discloses "good news".

Since investors choose a_i to maximize their expected utility, we can write the attention allocation problem as follows:

$$\max_{a_i \in [0,1]} (1-\beta_i)\left(\frac{1+a_i}{2}v_g + \frac{1-a_i}{2}v_b - \omega_i - \bar{\omega}_i(a_i)\right) - \theta_i \frac{a_i^2}{2}, \text{ for } i \in \{h, s\} \tag{4}$$

where we bring out that the seller's outside option is function of the attention choice. The solution to problem (4) is characterized as follows:

Proposition 2 *Speculators choose an optimal attention allocation level of* $a_s^* = 1$. *Hedgers' optimal attention choice is instead given by*

$$a_h^* = \frac{(1-\beta_h)}{4\theta}\Sigma$$

where $\Sigma = v_g - \beta_s(v_g - \omega_s) - v_b$. *It is decreasing in their financial illiteracy* θ, *and in the seller's bargaining power* β_i *while it increases in the asset's volatility* $\bar{v}_g - v_b$ *and in the speculators' outside option* ω_s.

The first part of the result captures the speculators' optimal choice of attention, which confirms our conjecture: as they face no processing costs, they will choose the maximum level of attention, and therefore extract the true value of the asset from the information released by the seller.

The second part characterizes the choice of attention by hedgers, for whom instead processing the signal is costly. First, unsurprisingly their optimal choice is an interior solution given assumption 2. Moreover, when a larger fraction of the gains from trade are extracted by the seller (i.e. high β_h), investors spend fewer resources in analyzing the available information. Intuitively, investors expect to capture a smaller fraction of gains from trade, which reduces their incentives to invest in processing information. Moreover, the optimal choice a_h^* is increasing in the range of values that the asset can take Σ, because a larger spread increases the magnitude of the two types of errors that the hedger must guard from.

It is also intuitive that a_h^* is decreasing in the investor's financial illiteracy θ, because the greater the cost of analyzing the signal σ, the less worthwhile it is to investigate it. Alternatively, one can interpret θ as a measure of the informational opacity or complexity of the asset: under this interpretation, the equilibrium attention level a_h^* is decreasing in the complexity of the asset: while it might be relatively costless to understand the pricing implications of information about a bond (a low-θ asset), this is much more challenging for an asset-backed security (a high-θ asset).

The comparative static results on β_s and ω_s are less immediate, and follow from the sequential bargaining structure of our model. Hedgers will choose a lower attention level when the seller has high bargaining power β_s vis-à-vis the speculators or when the latter are more aggressive in buying because their outside option ω_s is low. In both cases, the information rents that the seller must pay to speculators are lower, so that he is less eager to sell to hedgers; this reduces the hedgers' trading surplus, and therefore also their incentive to exert costly attention a_h^*.

4.3 Disclosure Policy

To investigate the seller's incentives to disclose the signal σ, we must compare the seller's expected profits in the two different disclosure regimes, based on the analysis in the previous sections. When no information is revealed to investors, the seller's expected profits are simply

$$\mathbb{E}\left[\pi^{ND}\right] = p_h^{ND} = v^e - \omega_h,$$

because, as previously shown, speculators do not participate to the market when $d = 0$.

Under disclosure, instead, the seller meets a hedger with probability μ, so that his expected profits are $\mathbb{E}\left[\pi_h^D\right]$,whereas with probability $1-\mu$ he encounters a speculator and his expected profits are $\mathbb{E}\left[\pi_s^D\right]$. Hence his expected profits are

$$\mathbb{E}\left[\pi^D\right] = \mu\mathbb{E}\left[\pi_h^D\right] + (1-\mu)\,\mathbb{E}\left[\pi_s^D\right].$$

Let us consider each of these two scenarios. If the seller meets a hedger his expected profits are

$$\mathbb{E}\left[\pi_h^D\right] = \frac{p_h}{2} + \frac{1-a_h^*}{4}\left(v_g - \omega_s\right)\beta_s$$

where p_h is the price that the seller expects to receive, as defined by Proposition 1. With probability $\left(1+a_h^*\right)/2$ the value of the asset is v_g and the hedger observes a congruent signal σ_g, the probability a_h^* being defined by Proposition 2. In this case, the hedger finds it profitable to trade and will bargain for the asset. With probability $\left(1-a_h^*\right)/4$ instead, the asset's value is v_g but the signal received by hedgers is σ_b, which induces them not to trade. This implies that the asset will be offered to the speculators.

If the seller meets a speculator, his expected profits are instead

$$\mathbb{E}\left[\pi_s^D\right] = \frac{p_s}{2} = \frac{\beta_s\left(v_g - \omega_s\right)}{2}. \tag{5}$$

In this case, with probability $1/2$ the signal reveals to the speculators that the asset's value is higher than their outside option, so that they will bargain offering the price

p_s. But with probability 1/2 the asset's value turns out to be v_b, which induces both speculators and hedgers not to trade, which in the hedgers' case is due to their negative inference from observing speculators not buying the asset.

The key reason why the seller may want not to disclose the signal is that under disclosure the interaction between the two types of investors creates an adverse selection problem that depresses the price offered to the seller. Indeed $1-\mu$ naturally captures the likelihood that disclosing information will generate this information externality among investors, damaging the seller.[13] This brings us to the first main positive result of the paper:

Proposition 3 *The seller's willingness to disclose the signal σ is increasing in the proportion μ of hedgers, in their outside option ω_h and in the asset's volatility $\bar{v}_g - v_b$; while it is decreasing in the hedgers' financial illiteracy θ.*

This result shows that opacity can pay for the seller, but not always does. As shown by Figure 1, the seller prefers to disclose information when the security's volatility is high (for given expected value $\bar{v}^e$), because otherwise the asset would not be attractive enough to induce hedgers to offer a high price.

The figure also shows that if there are few speculators (high μ) in the market, the seller will be more willing to disclose information, because he is less likely to pay adverse selection rents to speculators. Thus, from the seller's viewpoint, disclosing information generates a trade-off: on the one hand, it encourages hedgers to offer a higher price than they would otherwise, because it helps them avoiding too large errors in trading; on the other hand, it leads to the possibility of selling to a speculator, who will appropriate a higher fraction of the expected surplus not only because he has more bargaining power but especially because he can exploit his superior processing ability and the pricing externality that this advantage entails.

The processing cost θ affects the seller's incentives to disclose only through its effect on the optimal attention allocation a_h^*. A higher degree of financial illiteracy decreases the hedgers' processing ability, which in turn decreases the seller's incentives to disclose. Intuitively, the higher the hedgers' outside option ω_h, the lower are the expected gains from trade in the case of no-disclosure, which in turn make the seller more willing to let speculators participate to the market, because he expects a higher profit by selling

[13] Since high-frequency trading, in which computers initiate orders based on information that is received electronically, before human traders are capable of processing the information they observe, accounts for 73% of all US equity trading volume, it is worth mentioning a different interpretation for $1-\mu$. It might also capture the speed of speculators, that is, how fast they can enter their trading orders.

the asset to them. The comparative statics with respect to the seller's bargaining power are instead less clear cut. On the one hand, an increase in β_s increases the seller's incentive to disclose because (1) the fraction captured by the seller when trading with the speculators is higher; (2) the seller expects hedgers to offer a better price, since p_h is increasing in β_s. On the other hand, a higher seller's bargaining power with the speculators also reduces the level of hedger's sophistication a_h^*, which in turn decreases the incentives to disclose the new piece of information.

5 Trading Transparency

Trading transparency refers to the public and timely transmission of information on past trades, including volume and price.[14] We can capture this notion of transparency assuming that only a fraction γ of hedgers observe the previous order flow. Then, if speculators are considered the ones that are better at processing information – the case for investors with high visibility such as Warren Buffett or George Soros– the small investors are going to find their decisions more informative about the asset's value and then they will try to imitate their trading strategies more closely, but they are able to do so only with probability γ.

Market opacity has two main effects. First, it affects the price that speculators offer to buy the asset. Second, it might induce the hedger to leave the market due to an endogenous lemons problem.

Let us first analyze the model for a given hedger's price-strategy. Notice that, in an opaque market, the seller might still have a positive expected revenue even when he is rejected by a speculator. That is, the speculator needs to offer a higher price to compensate the seller for an outside option that is now higher than in the full-transparency case ($\gamma = 1$). In particular, the price that speculators would offer to the seller is now a decreasing function of market transparency:

$$\begin{aligned} p_s^O(\gamma) &= \beta_s (v_g - \omega_s) + (1-\beta_s)(1-\gamma)\frac{1+a_h}{2} p_h^O \\ &= p_s^T + (1-\beta_s)(1-\gamma)\frac{1+a_h}{2} p_h^O. \end{aligned}$$

where the superscript stands for market opaqueness, $\gamma < 1$, and transparency $\gamma = 1$.

[14] For empirical studies on the effect of post-trade transparency on market quality see Naik et al. (1994), Gemmill (1996), Board and Sutcliffe (1995), and Saporta et al. (1999) which analyze the effects of delayed trade reporting on the London Stock Exchange, whereas Porter and Weaver (1998) examine delayed reporting on the Nasdaq Stock Market.

When hedgers do not observe the speculators' trade, which happens with probability $1-\gamma$, they might be willing to offer a positive price because they do not fully discount for the possibility of buying a low quality asset. Notice that, for any given p_h^O, this price will be lower as γ increases, and we have that $p_s^O(1) = p_s^T$. Hence, market opacity can increase the expected revenue for the seller.

This is driven by how the pricing externality introduced in the previous section is affected by the degree of market transparency γ: in a more transparent market, the speculator's trading strategy has a stronger impact on asset's prices due to the inference made by the hedger.

However, since in our model buyers are unsophisticated but not *naive,* they might not be willing to offer a positive price p_h^O to buy the asset. In fact, when the market is opaque ($\gamma < 1$), a Bayesian buyer will infer that there is a positive probability that the asset has been rejected by a speculator. This means that market opaqueness creates asymmetric information between seller and investors. The seller who has been previously matched with a speculator, has now learnt that the asset's value is v_b, but now, in contrast to the previous section, there is asymmetric information between seller and buyer. Indeed, the seller might be of two types: the lemon type, who has private information about the asset, and the uninformed one who has not been previously matched with anyone.

Following the bargaining literature under asymmetric information (Ausubel et al. (2002), and references therein), we assume that the hedger can make a take-it-or-leave-it offer to the seller. As shown by Samuelson (1984), for an economic exchange to be possible, a necessary and sufficient condition is that the buyer can make a profitable first-and-final offer. Then, in contrast with the baseline case of the previous section, once asymmetric information between seller and investors is endogenously introduced by market opacity, we need to modify the bargaining protocol. Therefore, we shall find the price p_h^O that the hedger is willing to offer as a function of his beliefs about the asset's value, taking into account that he will not be able to perfectly infer it from the speculator's trading strategy.

To solve for the equilibrium, notice that when making his offer, a buyer needs to take into account whether his price induces the seller with no information about his asset to accept the offer or not. For a buyer to induce a seller to accept his take-it-or-leave-it offer, he needs to offer a price that compensates the seller for his outside option, or $p_h^O > \beta_s(v_g - \omega_s)/2$. Since the seller who knows that he is holding a bad asset does not derive any utility from it, we know that he will accept any buyer's offer. Hence, for the buyer, the probability of being the first one to be matched with the seller is given by

$$\widetilde{\mu}(p) = \begin{cases} \frac{\mu}{\mu+(1-\mu)/2} \text{ if } p_h^O \geq \beta_s (v_g - \omega_s)/2 \\ 0 \text{ if } p_h^O < \beta_s (v_g - \omega_s)/2 \end{cases}$$

This formulates the basic adverse selection problem. If the buyer offers a price that is too low, uninformed sellers will reject the offer and he will then acquire a low quality asset for sure. Any offer by the buyer will thus be given by $p_h^O = \beta_s (v_g - \omega_s)/2$, because any price higher than this will just transfer resources to the seller. This has two implications. First, it means that the seller of a low-quality asset is able to extract rents from the hedger, who pays a positive price for a worthless asset. Second, the seller who does not possess any private information might be precluded from trading his security with the hedger, if he is not willing to offer the price p_h^O.

For the further analysis, it is convenient to define the buyer's expected surplus from buying the asset:

$$\Gamma(\mu) = \widetilde{\mu}(p)\,\widehat{v} + (1 - \widetilde{\mu}(p))\,v_b - \omega_h - p_h^O$$

Then, we can show the first main result of this section:

Proposition 4 *When the market is opaque, i.e. $\gamma < 1$, if $\mu \geq \bar{\mu}$ the hedger offers the price p_h^O and the seller accepts it. Instead if $\mu < \bar{\mu}$, the hedger does not trade. The threshold $\bar{\mu}$ is defined by $\Gamma(\bar{\mu}) = 0$.*

When the hedgers' belief $\widetilde{\mu}(p)$ about the asset's value is too low, there cannot be any trading by hedgers in equilibrium – a situation that we call *market freeze.* Intuitively, a small μ – namely, greater search frictions for hedgers – reduces the probability of being matched with a hedger in the first place, so that a hedger will be very pessimistic about the value of the asset.

Recall that if information is disclosed by the seller, speculators will not find it worthwhile to trade, and therefore only hedgers will be present in the market: hence $\mu = 1$ and the market will never freeze. This result is interesting because it shows that not disclosing information might prevent the market from freezing.

Since γ turns out to capture the strength of the negative externality between speculators and hedgers, we can now characterize how the seller's incentives to disclose the signal σ are affected by the degree of market transparency.

Proposition 5 *The seller's incentives to disclose are decreasing in the degree of market transparency γ. However, when $\mu < \bar{\mu}$, the seller has a lower incentive to release*

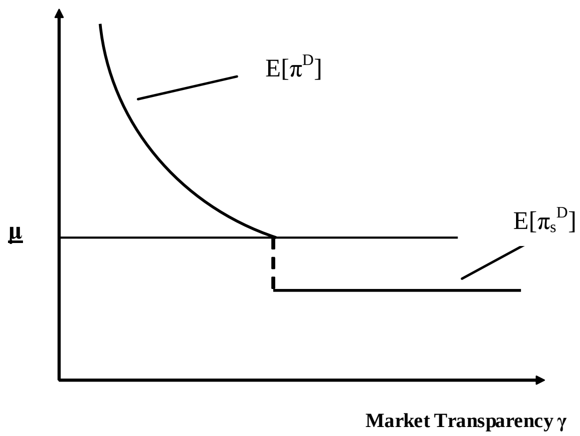

Figure 1: Expected profits from disclosing information as a function of market transparency γ.

information in an opaque market, i.e. $\gamma = 0$*, than when market is fully transparent, i.e.* $\gamma = 1$.

Proposition 5 shows that the seller considers financial disclosure and market transparency substitutes. That is, he will always disclose more information in an opaque market than in a more transparent one, because the pricing externality generated by the release of information, that is difficult to process for unsophisticated investors, is mitigated by the difficulties encounter by these investors to infer the asset's value from the strategies of the most sophisticated ones. Figure 2 displays the expected profits as a function of market transparency γ. It shows that these are always strictly decreasing as long as the hedger is willing to offer the price p_h^O to buy the asset, whereas they jump downward and stay flat when trading frictions with the hedger are particularly important, i.e. $\mu < \bar{\mu}$.

The second point made in proposition 5, compares the extreme case of fully transparent market, characterized in the previous proposition and the case a fully opaque one. It shows that the seller can benefit from releasing information in a fully transparent market if the trading frictions for hedgers are sufficiently high. In fact, trading opacity leads the hedgers to doubt about the value of the asset, which in turns reduces the price they are willing to offer. Hence, when hedgers' trading frictions are important, disclosing hurt the seller more in a opaque market than in a transparent one.

We can now discuss our results in the light of the existing literature on market transparency. In contrast to the existing theoretical literature on transparency (see

Glosten and Milgrom (1985), Kyle (1985), Pagano and Roell (1996), Chowhdry and Nanda (1991), Madhavan (1995) and Madhavan (1996) among others) in which opacity tends to redistribute wealth from uninformed to informed investors, here instead it damages both and improves the position of the seller.[15] The speculators are not able to fully exploit their superior processing ability, and the hedgers lose the possibility to employ the previous order flow to update their beliefs about the asset's value.

Moreover, in our model the speculators would like to make their trading strategy as visible as possible. This means that we should expect informed traders to place their trade in non-anonymous public market such as dealer markets. This implication runs contrary to the traditional market microstructure view, where such markets should be preferred by the uninformed investors. Our model then provides another reason why dealer markets might be preferred by investors: unsophisticated investors are able to imitate the trading strategies of the most sophisticated investors while sophisticated investors can maximize their influence and close the deal at a better price.

Admati and Pfleiderer (1991) investigates a phenomenon called "sunshine trading", that is, the possibility that some traders pre-announce their orders to identify their trades as informationless. Our model predicts that, if allowed, speculators would pre-announce their trades, but for exactly the opposite reason, that is, to be recognized as the most sophisticated investors and to generate the information externality that lowers the price in their favor.

Consistent with this result is the empirical evidence in Reiss and Werner (2005). They analyze data from the London Stock Exchange to examine how trader anonymity affect dealers' decisions about where to place interdealer trades. Contrary to intuition, they show that informed interdealer trades tend to migrate to the direct and non-anonymous public market.

This is also consistent with the evidence in Bloomfield and O'Hara (1999). They use laboratory experiments to determine the effects of trade disclosure on market efficiency. They find that trade transparency increases the informational efficiency of transaction prices. This is exactly what our model predicts, in fact, a more transparent market as captured by a higher γ, allows the hedgers to infer the value of the asset.[16] Finally, Foucault et al. (2007) using data from Euronext (the French Stock Exchange) find that uninformed dealers are more aggressive when using anonymous systems, which is reflected in our model by a higher price that the hedgers are willing to offer when $\gamma = 0$.

[15] Note that this result differ also from the insights of the existing models of the primary market, where opacity damages the seller (see for example Rock (1986))

[16] See also Biais et al. (2005) for a survey on some of these issues

6 Regulation

Up to now we have analyzed the seller's incentives to disclose the signal, but what a regulator should do? The recent financial crisis has highlighted the drawbacks of a very opaque market, as those for asset-backed securities, from which the crisis originated. In the words of Lloyd Blankfein, CEO of Goldman Sachs, one of the key lessons of the crisis is that the financial industry "let the growth in new instruments outstrip the operational capacity to manage them". This has induced some to advocate for more transparency in this markets, while others have proposed to restrict the access to this market only to the most sophisticated investors.

In our model we can analyze all these possibilities, in fact, the policy maker has mainly three policy instruments $\{d, \gamma, \mu\}$. He can (1) mandate disclosure (choosing d), (2) affect the degree of trading transparency (changing γ) and (3) restrict market participation (affecting μ).

6.1 Mandating Disclosure

In this section we analyze under which conditions the regulator should force disclosure. We assume that the regulator aims to maximize the sum of market participants' payoffs:

$$S = \pi + u,$$

where u is the investors' utility.[17]

We compute the expected gains from trade when new information is made available to the market and when this is not the case. The social welfare when no information is disclosed is simply given by

$$\mathbb{E}\left[S^{ND}\right] = v^e - \omega_h$$

The expected social surplus in the case of disclosure is instead given by

$$\mathbb{E}\left[S^{D}\right] = \mu \mathbb{E}\left[S_h^D\right] + (1-\mu)\,\mathbb{E}\left[S_s^D\right]$$

that is, the expected value generated by a transaction with one of the two type of investors. The expected gains from trade when the seller meets a hedger are

[17] For expositional simplicity, we assume that the planner maximize the sum of utilities of the seller and investors with equal weights.

$$\mathbb{E}\left[S_h^D\right] = \left(\frac{1+a_h^*}{4}\left(v_g - \omega_h\right) + \frac{1-a_h^*}{4}\left(v_b - \omega_h\right) + \frac{1-a_h^*}{4}\left(v_g - \omega_s\right)\right) - \frac{\theta a_h^{*2}}{2}, \qquad (6)$$

where the first term captures the surplus in the case in which the asset's value is v_g and the realized signal is σ_g, when the hedgers buy the asset and the realized surplus is positive. With probability $\frac{1-a}{4}$ instead the asset's value is v_b but the hedgers are willing to purchase the asset because the realized signal is σ_g. The realized surplus in this case is negative. Finally, the third term captures the possibility that hedgers do not buy the asset even if it was actually worth buying, and then the asset is allocated to the speculators, whereas the processing costs are captured by the last term.

To gain some more intuition we can rewrite (6) as follows:

$$\mathbb{E}\left[S_h^D\right] = \underbrace{\frac{(v_g - \omega_h)}{2}}_{\text{trading gains}} - \underbrace{\frac{1-a_h^*}{4}\left(\omega_s - v_b\right)}_{\text{errors}} - \underbrace{\frac{\theta a_h^{*2}}{4}}_{\text{processing costs}}.$$

In fact, if the asset's value is v_g disclosing the signal σ allows for the possibility of selling the asset and realize the maximum surplus $v_g - \omega_h$. However, disclosing has also a direct cost captured by the costly effort exerted by hedgers. Finally, when hedgers can purchase the asset, this choice may also happen to be wrong, due to the noise that remains after they have processed the information about the asset. Hence, with probability $(1-a)/4$ the realized surplus will be negative. As the recent financial crisis shows, some real investment decisions such as the building of entire new residential areas might be linked to the issuance and pricing of financial products. This suggests that a regulator cares about the correctness of the investors' beliefs about asset values, because on those depend other relevant decisions.

The expected gains from trade when the seller deals with a speculator are instead given by

$$\mathbb{E}\left[S_s^D\right] = \frac{v_g - \omega_s}{2}.$$

Recall that the main cost of disclosing evidence for the seller comes from the possibility of non-trading and from the drop in price due to the information externality among investors. This means that he is more willing to disclose when there are fewer speculators in the market (high μ). For the regulator, instead, the main costs come from the processing costs paid by the hedgers, and the possibility of trading even when there are no gains from trade. This means that he will be more willing to force disclosure when there more sophisticated investors (low μ).

Proposition 6 *The regulator mandates disclosure if the fraction of speculators* $1-\mu$ *and their trading errors* $\omega_h - v_b$ *are high, and the difference between the outside options of speculatirs and hedgers* $\omega_s - \omega_h$ *is low. Both under- and over-provision of information might occur in equilibrium, depending on the seller's bargaining power* β_i *and on the hedgers' financial illiteracy* θ*.*

The regulator's objective function differs from the seller's expected profits computed in the previous section for three reasons. First, the planner does not take into account distributional issues driven by the bargaining protocol, so that the parties' bargaining power does not affect the expected gains from trade. Second, the planner takes into account that disclosing information induces the hedgers to investigate it, which is costly. Third, the regulator does not consider the externality generated by the speculators' superior processing ability and its effect on the seller's profits. This is due to the fact that the endogenously generated adverse selection only affects the distribution of the surplus from trade, not its level. These differences generates the discrepancy between the privately and the socially optimal disclosure policy.

The fact that the over- or under-provision of information depends on information processing costs and the seller's bargaining power is explained as follows: On one hand, the social planner takes into account the total gains from trade rather than the fraction accruing to issuers: on this account, its incentives to disclose exceed those of the seller. On the other hand, the seller does not internalize the cost of processing information, which are instead taken into account by the regulator. Interestingly, there is a region in which the seller has a *higher* incentive to disclose than the regulator. Intuitively, this happens when enough hedgers participate to the market and the asset's volatility is low, where the seller will disclose the signal σ even if it would be socially efficient to withhold it. This is even more likely when the seller appropriates a high fraction of the expected gains from trade (high β_i). It is also more likely if a high level of financial literacy is required (high θ), so that disclosure would imply large information-processing costs for hedgers.

Conversely, in a market with many speculators waiting for the information to be released, the seller will fear to unleash their superior processing ability, and will not disclose even though it would be socially efficient to do so. This is likely to happen in very specialized markets, such as the ones for asset-backed securities, where the degree of financial sophistication required to fully understand the structure of the assets and its implications in terms of risks is higher so that it is more likely that speculators participate. Hence, in this market the regulator should intervene forcing sellers to release as much information as possible. This is probably not the case for markets where treasuries and simple corporate bonds are traded, because speculators do not expect to fully exploit their superior processing ability in those markets.

There are regions of the parameter space where the seller's incentives to disclose are perfectly aligned with regulator's. When the likelihood of selling to a hedger as well as the asset's volatility is low enough, then no disclosure is privately and socially optimal. The seller has no incentive to disclose because the extra gains from trade he could obtain by disclosing σ are very small when the asset's volatility is low; whereas the regulator prefers saving on the processing costs generated by releasing σ since the value of information is very low. Finally, when the asset's volatility is very high, both the seller and the regulator find it optimal to disclose new information. The seller has no reason not to allow the speculators to participate to the market and the regulator finds it optimal to pay the processing costs because the information is very valuable.

6.2 Licensing Access

In the previous section we have restricted the policy instrument space to mandating disclosure. However, in reality the policy maker has other instruments he can employ to regulate financial markets in order to maximize the expected gains from trade.

Stephen Cecchetti, head of the Basel-based body's monetary and economic department, for example, has suggested a solution to bring the vast OTC derivatives markets under closer supervision and to ensure they are traded and processed more transparently to safeguard the wider financial system: "The solution is some form of product registration that would constrain the use of instruments according to their degree of safety." He said that the "safest" securities would be available to everyone, much like non-prescription medicines. Next would be financial instruments available only to those with a licence, like prescription drugs. Finally would come securities available "only in limited amounts to qualified professionals and institutions, like drugs in experimental trials". Securities "at the lowest level of safety" would be deemed illegal.[18]

Since the speculators if endowed with the signal σ perfectly forecast the asset's value and they do not incur in any processing costs, it might be optimal for the regulator to limit market participation to the speculators, inducing in this way the seller to disclose his

[18] Financial Times, June 16 2010 available at http://cachef.ft.com/cms/s/0/a55d979e-797b-11df-b063-00144feabdc0.html#axzz1JDvAWQa2.

information. We analyze the conditions under which this constitutes a socially efficient policy to implement

$$\frac{v_g - \omega_s}{2} > \mu \left[\frac{(v_g - \omega_h)}{2} - \frac{1 - a_h^*}{4} (\omega_s - v_b) - \frac{\theta a_h^{*2}}{4} \right] + (1 - \mu) \frac{v_g - \omega_s}{2}. \qquad (7)$$

We can characterize the planner's decision in the following proposition:

Proposition 7 *The seller never finds it optimal to preclude hedgers from participating in the market. However, licensing access to speculators is welfare-improving as θ increases and ω_s decreases.*

This proposition first shows that in these markets the seller's incentives are never aligned with the regulator's, in fact, he never finds optimal to license access only to speculator. This means that selling complex assets as derivatives and MBS to low-risk profile investors is in the seller's interest. This means that the market will not self-regulate in this respect and that the regulator's intervention is needed. Proposition 6 identifies the main trade-off the regulator is facing. Intuitively, θ increases the planner's incentive to license the access to the market exclusively to speculators, because in this way he can save the processing costs the hedgers would pay. That is, when information is difficult to digest, the planner prefers leaving the seller with the "smart money" to making the assets available to all comers. We can imagine this is indeed the case for more complex assets such as asset-backed securities and credit-default swaps that had a leading role in the recent financial crisis.

However, licensing access to financial markets is not always optimal. In particular, when the asset becomes less attractive for the speculators, that is, when ω_s increases the policy maker has lower incentive to restrict market participation. This is because the realized gains from trade are potentially lower. This captures what should be optimal in markets where the information are relatively easy to process and the assets sold do not attract speculators' attention such as the market for treasuries.

7 Conclusion

We proposed a model of financial disclosure where some investors ("hedgers") are bad at information processing, while other ("speculators") trade purely to exploit their superior information processing ability. We make two main contributions. First, we show that enhancing information disclosure might not benefit the unsophisticated investors as claimed by policy makers, but can exacerbate the informational advantage of the most sophisticated agents. Key in our model is the fact that releasing information about the asset's value induces an externality: since speculators are known to understand its pricing implications, hedgers will imitate their decision to abstain from trading, depressing the asset's price compared to its no-disclosure level. We further investigate this result by analyzing how the equilibrium is affected by the opacity of the market, by allowing only a fraction of hedgers to observe the order flow. This has two effects. On the one hand, in a more opaque market, hedgers cannot rely on information extracted by the speculators' trading strategy and this reduces the pricing externality and favors the seller. On the other hand, this creates asymmetric information between seller and buyers, which might even lead to market freeze.

Second, we can analyze the effects of the government intervention proposed in the aftermath of the 2007 financial crisis. We show that forbidding hedgers' access to the market may be optimal whenever their processing costs are high, whereas mandatory disclosure is required when speculators are a large fraction of market participants, because the seller withhold information for fear to unleash their superior processing ability.

Several extensions would be worth exploring. We mention two of them. First, it would be interesting to investigate these same issues in a dynamic game, to study the impact of endogenous information flows on price dynamics and trading volume. Second, it would be interesting to allow the seller to influence the quality of the assets on sale, to capture for example the issuer effort in selecting the pool of assets underlying a CDO. We leave the analysis of these extensions to future research.

8 Appendix

TO BE COMPLETED

Proof of Proposition 1 and 2

We prove the two propositions together for ease of exposition. We first solve for the bargaining stage with taking as given the seller's outside options. Then, we compute these outside options in order to obtain the prices paid in equilibrium. Suppose the seller has an outside option of $\bar{\omega}_i$ and the investor of type i has an outside option of ω_i, and the expected value is $\mathbb{E}(v|\Omega) = \hat{v}$ where Ω is the investor's information set. Then the Nash bargaining problem is

$$\max_{p_i} \beta_i \log(p_i - \bar{\omega}_i) + (1 - \beta_i) \log(\hat{v} - p_i - \omega_i)$$

Solving for p_i, we get

$$p_i = \beta_i (\hat{v} - \omega_i - \bar{\omega}_i) + \bar{\omega}_i$$

Therefore, the price paid to the seller includes the seller's outside option and a fraction β_i of the total surplus. The investor gets a profit of

$$\begin{aligned} u_i = \hat{v} - p_i - \omega_i &= (\hat{v} - \omega_i - \bar{\omega}_i)(1 - \beta_i) \\ &= \mathbb{E}[(v - \omega_i - \bar{\omega}_i)(1 - \beta_i)|\Omega] \end{aligned}$$

First Match

Next, we solve for the choice of attention for the two types of investors in the seller's first match in a subgame equilibrium after $d = 1$, assuming that in all future matches, a speculator always chooses $a = 1$, while a hedger always chooses $a = 0$. Let us denote this assumption (*). We will show later that, for any possible choices of attention in the first match derived using (*), the choice of attention in the first match and (*) constitutes a subgame equilibrium. Essentially, we are proving that for any set of parameters, there exist a subgame equilibrium after $d = 1$ such that (*) is true.

If a speculator has a positive belief about v_g, i.e. $\phi_s(v_g) = \Pr(v_g|\sigma_g) > 0$, his dominant strategy is to choose $a = 1$ and trade if and only if he observes σ_g, because this ensures that the two parties together obtain the maximum social surplus and the seller has zero outside option. When the speculator receives the signal σ_g, the price is

$$p_s = \beta_s (v_g - \omega_s).$$

To solve for a_h in the first match, we need to find $\bar{\omega}_h$ using (*). Suppose the seller was matched with a hedger who chooses a_h in the first match and they bargain after the hedger receives the signal σ_g. The seller's and hedger's common belief is

$$\phi(v_g|\sigma_g) = \frac{\frac{1+a_h}{2}\frac{1}{2}}{\frac{1}{2}} = \frac{1+a_h}{2}.$$

According to (*), if the negotiation fails and no trade happens, the seller would continue searching and end searching when he meets a speculator. This speculator will choose $a_s^* = 1$ and trade if and only if he observes σ_g. If this speculator receives the signal σ_b, the seller can never sell the asset. Hence, if trade happens, the price would be p_s, and the seller's expected revenue, which forms the seller's outside option in the first and second match with a hedger, is

$$\bar{\omega}_h = \phi(v_g|\sigma_b)\, p_s = \frac{1+a_h}{2}\beta_s(v_g - \omega_s).$$

Now in the first match, suppose the hedger only trades after observing σ_g. If his attention level is a_h and the reading of the signal is σ_g, the hedger's expected payoff given σ_g is

$$\begin{aligned} u_h|\sigma_g &= (1-\beta_h)(\hat{v} - \omega_h - \bar{\omega}_h) \\ &= (1-\beta_h)\left(\frac{1+a_h}{2}v_g + \frac{1-a_h}{2}v_b - \omega_h - \bar{\omega}_h\right) \\ &= (1-\beta_h)\left[\left(v^e - \omega_h - \frac{1+a_h}{2}(v_g-\omega_s)\beta_s\right) + \frac{a_h}{2}(v_g - v_b)\right]. \end{aligned}$$

The hedger maximizes the expected payoff:

$$\max_{a\in[0,1]} \frac{1}{2}u_h|\sigma_g - \frac{1}{2}\theta a^2.$$

The unconstrained solution is

$$a_h^* = \frac{[(v_g - v_b) - \beta_s(v_g-\omega_s)](1-\beta_h)}{4\theta} = \frac{B(1-\beta_h)}{4\theta}$$

where for simplicity, we have denoted $A = v^e - \omega_h - \frac{1}{2}\beta_s(v_g - \omega_s)$ and $B = v_g - v_b - \beta_s(v_g - \omega_s)$.

Clearly $a_h^* > 0$. The conditions for a_h^* to be the hedger's strategy are

$$a_h^* \leq 1$$

and the hedger gets a higher expected profit than deviating to $a_h^* = 0$, i.e.

$$\frac{1}{2}u_h|\sigma_g - \frac{1}{2}\theta a_h^{*2} \geq \max\left\{0, \left(v^e - \omega_h - \frac{1}{2}(v_g - \omega_s)\beta_s\right)(1-\beta_h)\right\}$$
$$\iff \quad \frac{B^2(1-\beta_h)}{16\theta} > |A|$$

which is the parameter restriction imposed in the text. This proves Proposition 2.

Second Match

Now as the second step, we investigate the strategies of a hedger in the second match after the first match resulted in no trade. Note that future investors cannot distinguish between the two possible reasons of no trade in previous matches: a negative signal σ_b or a breakdown of negotiations. However, they will believe that no trade is invariably due to a negative signal σ_b.If the seller was matched with a speculator or a hedger that chooses $a = 1$ in the first match, the second investor (and any investors in future matches) would not trade, because in equilibrium the first investor would not trade if and only if he knows v_b for sure. In order to show that assumption (*) holds, it is left to be determined what a hedger would do in the second match if the first investor was also a hedger that chose $a = a_h^* < 1$.

Now we show that the condition for $a_h^* < 1$ to be the hedger's strategy implies that a hedger would choose $a = 0$ and refuse to trade if the first investor was also a hedger that chose $a = a_h^* < 1$. In equilibrium, the second match happens if and only if the first hedger receives the signal σ_b; hence, the second hedger's and seller's common prior about v_g at the beginning of the second match is

$$\phi(v_g|\sigma_b) = \frac{1-a_h^*}{2}.$$

If the second hedger allocates no attention, he should make the same no-trade decision as the previous hedger in equilibrium. We show this by contradiction: suppose that the second hedger were to deviate by choosing $a > 0$, and trade only after σ_b. Then, his expected payoff would be

$$u_h = (1-\beta_h)\left(\frac{1+a_h^*}{2}\frac{1-a}{2}\left(v_b - \omega_h - \boldsymbol{\omega}_h^2\right) + \frac{1-a_h^*}{2}\frac{1+a}{2}\left(v_g - \omega_h - \bar{\omega}_h\right)\right) - \frac{1}{2}\theta a^2.$$

Note that if the negotiation fails, the seller can always wait until he meets a speculator, and her outside option would again be her belief about v_g times p_s:

$$\bar{\omega}_h = \frac{\frac{1-a_h^*}{2}\frac{1+a}{2}}{\frac{1+a_h^*}{2}\frac{1-a}{2}+\frac{1-a_h^*}{2}\frac{1+a}{2}}\left(v_g-\omega_s\right)\beta_s.$$

Therefore, the hedger's expected payoff would be

$$u_h = (1-\beta_h)\left(\frac{1+a_h^*}{2}\frac{1-a}{2}\left(v_b-\omega_h\right)+\frac{1-a_h^*}{2}\frac{1+a}{2}\left(v_g-\omega_h-\left(v_g-\omega_s\right)\beta_s\right)\right)-\frac{1}{2}\theta a^2,$$

so that his optimal attention would be

$$\begin{aligned} a^{**} &= \arg\max u_h \\ &= \frac{(1-\beta_h)}{\theta}\left(\frac{1-a_h^*}{4}\left(v_g-\omega_h-\left(v_g-\omega_s\right)\beta_s\right)-\frac{1+a_h^*}{4}\left(v_b-\omega_h\right)\right) \\ &= \frac{(1-\beta_h)}{\theta}B\left(\frac{1}{4}-\frac{(1-\beta_h)}{8\theta}A\right) \end{aligned}$$

Now we can compute his expected profits evaluated at the optimal a^{**}:

$$\begin{aligned} u_h\left(a^{**}\right) &= (1-\beta_h)\left(\frac{1+a_h^*}{2}\frac{1}{2}\left(v_b-\omega_h\right)+\frac{1-a_h^*}{2}\frac{1}{2}\left(v_g-\omega_h-\left(v_g-\omega_s\right)\beta_s\right)\right)+\frac{1}{2}\theta a^{**2} \\ &= (1-\beta_h)\left(\frac{1}{2}A-\frac{(1-\beta_h)}{16\theta}B^2\right)+\frac{1}{2}\frac{(1-\beta_h)^2}{\theta}B^2\left(\frac{1}{4}-\frac{(1-\beta_h)}{8\theta}A\right)^2 \\ &= \frac{1}{128\theta}(1-\beta_h)\left(A^2B^2(1-\beta_h)^3-4AB^2\theta(1-\beta_h)^2+64A\theta^3-4B^2\theta^2(1-\beta_h)\right). \end{aligned}$$

The conditions for $0 < a_h^* < 1$ are

$$\frac{B^2(1-\beta_i)}{16\theta} > |A| \Longleftrightarrow 16|A|\theta < B^2(1-\beta_i) \quad (8)$$

$$\frac{B(1-\beta_h)}{4\theta} < 1 \Longleftrightarrow B(1-\beta_h) < 4\theta \Longrightarrow B^2(1-\beta_h)^2 < 16\theta^2 \quad (9)$$

Also,

$$B(1-\beta_h) < 4\theta \text{ and } A < B \Longrightarrow A(1-\beta_h) < 4\theta.$$

Hence, if $A > 0$, we can write $u_h(a^{**})$ as

$$u_h\left(a^{**}\right) = \frac{1}{128\theta}(1-\beta_h)\left(A(1-\beta_h)^2B^2\left(A(1-\beta_h)-4\theta\right)+4\theta^2\left(16A\theta-B^2(1-\beta_h)\right)\right) < 0.$$

Also, because if $A < 0$,

$$\begin{aligned} B &= (v_g - v_b) > 2(v_g - \omega_s) > 2|A| = -2\left(v_g - \omega_h - \frac{1-a_h^*}{2}(v_g - \omega_s)\right) \\ \text{and} \quad & B(1-\beta_h) < 4\theta \\ \Longrightarrow \quad & A^2 (1-\beta_h)^2 < 4\theta^2, \end{aligned}$$

we can rewrite $u_h(a^{**})$ as

$$\begin{aligned} \pi_h(a^{**}) &= \frac{1}{128\theta}(1-\beta_h)\left(B^2(1-\beta_h)\left(A^2(1-\beta_h)^2 - 4\theta^2\right) - 4A\theta\left(B^2(1-\beta_h)^2 - 16\theta^2\right)\right) \\ &< 0. \end{aligned}$$

Therefore, as long as (8) and (9) are satisfied,

$$u_h(a^{**}) < 0,$$

so the second hedger would not want to deviate.

Given this subgame equilibrium, we go back to the first match. Here, the price for a hedger would then be

$$\begin{aligned} p_h &= \left(A + \frac{a_h^*}{2}B\right)\beta_h + \bar{\omega}_h \\ &= \left(A + \frac{a_h^*}{2}B\right)\beta_h + \frac{1+a_h^*}{2}\beta_s(v_g - \omega_s). \end{aligned}$$

When the hedger receives the signal σ_b, trade cannot happen, and the seller will continue searching until she meets a speculator. Her belief about v_g is $(1-a_h^*)/2$. This proves Proposition 2.

Information disclosure

Proof of Proposition 3 and 4:

We can compute the seller's total expected revenue after $d = 1$ as

$$\begin{aligned} \mathbb{E}\left[\pi^D\right] &= \mu\left(\frac{1}{2}p_h + \frac{1}{2}\frac{1-a_h^*}{2}(v_g - \omega_s)\beta_s\right) + (1-\mu)\frac{1}{2}p_s \\ &= \frac{\mu}{2}\left(A + \frac{a_h^*}{2}B\right)\beta_h + \frac{1}{2}(v_g - \omega_s)\beta_s \end{aligned}$$

Therefore, the profits consist of two parts: the first part captures the seller's benefit from the additional value of the hedgers, and the second part captures the seller's benefit from the speculator's information analysis ability.

If the seller releases no signal, he will sell the asset to the first hedger she meets, and in the bargaining stage, because the seller can always sell the asset at the same price to the next hedger, her outside option equals the price. Therefore, in equilibrium,

$$p_0 = (v^e - \omega_h)\,\beta_h + p_0\,(1 - \beta_h)$$

Therefore

$$p_0 = v^e - \omega_h.$$

So, although the seller makes the offer with probability β_h, in long run he can always wait for her chance as she gets matched to new hedgers: hence the seller takes all the surplus. So if the seller chooses $d = 0$, his profits are

$$\pi^{ND} = p_0 = v^e - \omega_h.$$

In order to find the seller's disclosure policy, we compare the expected profits earned upon different choices of d:

$$\begin{aligned}
& \mathbb{E}\left[\pi^{ND}\right] - \mathbb{E}\left[\pi^{D}\right] \\
= \ & v^e - \omega_h - \mu\left(\frac{1}{2}\left(A + \frac{a_h^*}{2}B\right)\beta_h + \frac{1}{2}\left(v_g - \omega_s\right)\beta_s\right) - (1-\mu)\,\frac{1}{2}\left(v_g - \omega_s\right)\beta_s \\
= \ & A - \frac{\mu}{2}\left(A + \frac{a_h^*}{2}B\right)\beta_h \\
= \ & A\left(1 - \frac{\mu\beta_h}{2}\right) - B^2\,\frac{\mu\beta_h\,(1-\beta_h)}{16\theta}
\end{aligned}$$

This difference can be either positive or negative, depending on the parameters. For example, when A is much smaller than B, the seller would choose to disclose the signal, when μ is small, the seller would like to conceal the signal.

However, we can compute the derivative of $R_0 - R$ with respect to μ which is

$$\frac{d\left(\mathbb{E}\left[\pi^{ND}\right] - \mathbb{E}\left[\pi^{D}\right]\right)}{d\mu} = -\frac{1}{2}\left(A + \frac{a_h^*}{2}B\right)\beta_h < 0.$$

Therefore, information disclosure increases with μ. This shows that there exists a threshold μ^* such that it is optimal for the seller to disclose if and only if $\mu > \mu^*$.

Furthermore, the difference decreases in B. Notice that

$$A = \frac{\left[v_g - (v_g - \omega_s)\,\beta_s\right] + v_b}{2} - \omega_h \text{ and } B = \left[v_g - (v_g - \omega_s)\,\beta_s\right] - v_b$$

We can interpret $\left[v_g - (v_g - \omega_s)\,\beta_s\right]$ as maximum available value (because the seller can get $(v_g - \omega_s)\,\beta_s$ for sure) to hedger, then B is a measure of volatility. Therefore, information disclosure increases with volatility. Moreover, it follows that information disclosure increases in ω_h while decreases in the financial illiteracy θ.

Proof of Proposition 5:

When a seller is matched with a speculator and the speculator reads σ_g, the seller's outside option is no longer zero, because there is a chance that the hedger does not observe the outcome of the current match, and still wish to pay positive price when he sees a positive signal. Then, the price paid by the speculators is now:

$$\begin{aligned} p_s(\gamma) &= (v_g - \omega_s)\,\beta_s + (1-\beta_s)(1-\gamma)\frac{1+a_h}{2}p_h \\ &> (v_g - \omega_s)\,\beta_s \end{aligned}$$

The new expected profits of the seller are

$$\begin{aligned} \mathbb{E}\left[\pi^D(\gamma)\right] &= \mu\left(\frac{1}{2}p_h + \frac{1}{2}\frac{1-a_h^*}{2}p_s(\gamma)\right) + (1-\mu)\frac{1}{2}p_s(\gamma) \\ &= \frac{\mu}{2}\left(A + \frac{a_h^*}{2}B\right)\beta_h + \frac{1}{2}p_s(\gamma) \\ &> \mathbb{E}\left[\pi^D\right] \end{aligned}$$

So the seller has greater incentive to disclose information, because the expected revenue after $d = 0$ does not change.

Proof of Proposition 6:

The total social surplus of the game after $d = 1$ is

$$\begin{aligned} S^D &= \frac{\mu}{2}\frac{1-a_h^*}{2}v_b + \frac{\mu}{2}\frac{1+a_h^*}{2}v_g - \frac{\mu}{2}\omega_h \\ &\quad + \left(\frac{\mu}{2}\frac{1-a_h^*}{2} + \frac{1-\mu}{2}\right)(v_g - \omega_s) - \frac{1}{2}\theta a_h^{*2} \end{aligned}$$

The total social surplus of the game after $d = 0$ is

$$S^{ND} = v^e - \omega_h$$

Therefore, the social surplus gain from information disclosure is

$$\begin{aligned} S^D - S^{ND} &= \frac{\mu}{2}\frac{1-a_h^*}{2}v_b + \frac{\mu}{2}\frac{1+a_h^*}{2}v_g - \frac{\mu}{2}\omega_h \\ &\quad + \left(\frac{\mu}{2}\frac{1-a_h^*}{2} + \frac{1-\mu}{2}\right)(v_g - \omega_s) - \frac{1}{2}\theta a_h^{*2} - (v^e - \omega_h) \\ &= \left(\frac{\mu}{2}\frac{1+a_h^*}{2} + \frac{1-\mu}{2}\right)(\omega_h - v_b) - \left(\frac{\mu}{2}\frac{1-a_h^*}{2} + \frac{1-\mu}{2}\right)(\omega_s - \omega_h) \\ &\quad - \frac{1}{2}\theta a_h^{*2} \end{aligned}$$

So the planner's incentives from disclosing increase with $(\omega_h - v_b)$, because inefficient trade, which destroy $(\omega_h - v_b)$ of social surplus, is prevented with probability $\left(\frac{\mu}{2}\frac{1+a_h^*}{2} + \frac{1-\mu}{2}\right)$. However, the incentives to disclose decreases with $(\omega_s - \omega_h)$, because with probability of $\left(\frac{\mu}{2}\frac{1-a_h^*}{2} + \frac{1-\mu}{2}\right)$, the trading opponent switches from hedger to speculator, which is inefficient.

In order to see the inconsistency between the social planner and the seller's choice, recall the seller's decision problem

$$\mathbb{E}\left[\pi^{ND}\right] - \mathbb{E}\left[\pi^{D}\right] = \left(1 - \frac{\mu\beta_h}{2}\right)A - \frac{\mu a_h^*}{4}\beta_h B$$

While we can rewrite $S^{ND} - S^D$ as

$$\begin{aligned} S^{ND} - S^D &= -\left(\frac{\mu}{2}\frac{1+a_h^*}{2} + \frac{1-\mu}{2}\right)(\omega_h - v_b) \\ &\quad + \left(\frac{\mu}{2}\frac{1-a_h^*}{2} + \frac{1-\mu}{2}\right)(\omega_s - \omega_h) + \frac{1}{2}\theta a_h^{*2} \\ &= \left(1 - \frac{\mu}{2}\right)\left(v^e - \omega_h - \frac{(v_g - \omega_s)}{2}\right) - \frac{\mu a_h^*}{4}\left(v_g - v_b - (v_g - \omega_s)\right) + \frac{1}{2}\theta a_h^{*2} \end{aligned}$$

So $S^{ND} - S^D$ equals $\mathbb{E}\left[\pi^{ND}\right] - \mathbb{E}\left[\pi^{D}\right]$ evaluated at $\beta_h = \beta_s = 1$ (but fix a_h^*) plus the information processing cost. This means that when θ and β_i are very low the planner would mandate disclosure, while when θ increases the planner might find it optimal to mandate opaqueness.

Proof of Proposition 7:

Suppose the seller license access only to speculators and thus disclose his information, then his expected profits are

$$\pi_L = \frac{1}{2}(v_g - \omega_s)\beta_s$$

Comparing it with π^D

$$\pi_L - \pi^D = -\frac{\mu}{2}\left(A + \frac{a_h^*}{2}B\right)\beta_h$$

Hence, it seems as long as $A + \frac{a_h^*}{2}B > 0$, the seller would never exclude hedgers. Also, $A + \frac{a_h^*}{2}B > 0$ is implied by the conditions for $a_h^* > 0$. This shows the first part of the proposition. The conditions according to which the planner finds it optimal to preclude hedgers access to the market are discussed in the text.

Proof of Proposition

We complete the argument in the main text by showing that there exists a cutoff $\bar{\mu}$ which determines the outcome of the bargaining between the hedger and the seller. Recall that the expected payoff is

$$\Gamma(\mu) = \widetilde{\mu}(p)\,\widehat{v} + (1 - \widetilde{\mu}(p))\,v_b - \omega_h - p_h^o$$

we then have $\Gamma(0) = v_b - \omega_h - p_h^o < 0$. Instead when $\mu = 1$ we have $\Gamma(1) = \widehat{v} - \omega_h - p_h^o$ which is positive as long as there exists gains from trade, i.e. whenever the hedger observes a good signal. Then, the strict monotonicity of $\Gamma(\mu)$ ensures that there exists a unique cutoff $\bar{\mu}$ such that trade occurs at a positive price whenever $\mu > \bar{\mu}$.

Proof of Proposition

We first show that when $\mu < \bar{\mu}$, that is, when high trading frictions coupled with market opacity make the buyer reluctant to buy the asset, the seller prefers a transparent market. To show this, we can simply compute the expected surplus when market is opaque $\gamma = 0$:

$$(1-\mu)\frac{\beta_s(v_g - \omega_s)}{2} < \mu\mathbb{E}[\pi_h] + (1-\mu)\frac{\beta_s(v_g - \omega_s)}{2}$$

where the right hand side is the expected profits in a transparent market.

We turn next to the case in which trading frictions do not preclude selling the asset to hedgers, i.e. $\mu < \bar{\mu}$. The seller prefers to operate in an opaque market if and only if the following condition holds:

$$
\begin{aligned}
\mu p_h^o + (1-\mu)\, p_s^o &= \mu p_h^o + (1-\mu)\left(\frac{\beta_s\,(v_g-\omega_s)}{2} + (1-\beta_s)\,\frac{1+a}{4} p_h^o\right) \\
&= \mu \frac{\beta_s\,(v_g-\omega_s)}{2} + (1-\mu)\left(\frac{\beta_s\,(v_g-\omega_s)}{2} + (1-\beta_s)\,\frac{1+a}{4} p_h^o\right) > \mu \mathbb{E}\,[\pi_h] + (1-\mu)\, p^T \\
&> \mu \mathbb{E}\,[\pi_h] + (1-\mu)\,\frac{\beta_s\,(v_g-\omega_s)}{2} \\
&= \mu\left(\frac{p_h^T}{2} + \frac{1-a}{4}\beta_s\,(v_g-\omega_s)\right) + (1-\mu)\,\frac{\beta_s\,(v_g-\omega_s)}{2}
\end{aligned}
$$

which can be simplified to the condition displayed in the proposition.

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