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COSTLY INFORMATION PROCESSING**

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ABSTRACT

Financial Disclosure and Market Transparency with Costly Information Processing*

We study a model where some investors (“hedgers”) are bad at information processing, while others (“speculators”) have superior information-processing ability and trade purely to exploit it. The disclosure of financial information induces a trade externality: if speculators refrain from trading, hedgers do the same, depressing the asset price. Market transparency reinforces this mechanism, by making speculators’ trades more visible to hedgers. As a consequence, asset sellers will oppose both the disclosure of fundamentals and trading transparency. This is socially inefficient if a large fraction of market participants are speculators and hedgers have low processing costs. But in these circumstances, forbidding hedgers’ access to the market may dominate mandatory disclosure.

JEL Classification: D83, D84, G18, G38, K22 and M48

Keywords: financial disclosure, information processing, liquidity, market transparency and rational inattention

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1 Introduction

Can the disclosure of financial information and the transparency of security markets be detrimental to issuers? One's immediate answer would clearly be in the negative; financial disclosure should reduce adverse selection between asset issuers and investors. The same should apply to security market transparency: the more that is known about trades and quotes, the easier it is to detect the presence and gauge the strategies of informed traders, again reducing adverse selection. So both forms of transparency should raise issue prices and thus benefit issuers. This is the rationale for much financial regulation, such as the Dodd–Frank Act, whose purpose is in fact to augment issuers' disclosure and improve transparency in off-exchange markets.

In this paper we show that this conclusion is not necessarily true if (i) it is costly to process financial information and (ii) not everyone is equally good at it. Under these assumptions, disclosing financial information may not be beneficial, because giving traders more information increases their information processing costs and thus accentuates the informational asymmetry between more sophisticated and less sophisticated investors, thus exacerbating adverse selection.

Specifically, we set out a simple search model with sequential trading. Upon receiving new fundamental information, investors must decide what weight to assign to it in judging its price implications, balancing the benefit to trading decisions against the cost of paying more attention. We show that when investors differ in processing ability, disclosure generates adverse selection: investors with limited processing ability will worry that if the asset has not already been bought by others, it could be because more sophisticated investors, who are better at understanding the price implications of new information, concluded that the asset is not worth buying. This depresses the price that unsophisticated investors are willing to pay; in turn the sophisticated investors, anticipating that the seller will have a hard time finding buyers among the unsophisticated, will offer a price below the no-disclosure level.

Hence, sellers may have good reason to reject disclosure, but they must weigh this concern against an opposite one: divulging information also helps investors avoid costly trading mistakes, and in this respect it stimulates their demand for the asset. Hence, 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 so triggers the pricing externality just described, to the detriment of issuers; on the other hand, it encourages demand from hedgers, because it protects them from massive errors in trading.

The decision discussed so far concerns the disclosure of information on cash flows via the release of accounting data, listing prospectuses, credit ratings, and so on. But in choosing the degree of disclosure, the issuer must also consider the transparency of the security market,

i.e. how much investors know about the trades of others. Market transparency amplifies the pricing externality triggered by financial disclosure, because it increases unsophisticated investors' awareness of the trading behavior of the sophisticated, and in this way fosters closer imitation of the latter by the former. In equilibrium, this increases the price concession that sophisticated investors require, and asset sellers will accordingly resist trading transparency. Hence, the interaction between financial disclosure and market transparency makes the two substitutes from the asset sellers' standpoint: they will be more willing to disclose information on cash flow if they can expect the trading process to be more opaque. The interaction between the two forms of transparency may even affect unsophisticated investors' willingness to trade: if market transparency increases beyond some critical point, financial disclosure might induce them to leave the market altogether, as they worry that the assets still available may have already been discarded 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: financial disclosure affects security prices, but the transparency of the trading process determines how and when the disclosed information is incorporated in market prices. We show that each of these two forms of transparency amplifies the other's impact on the security price. Interestingly, the recent financial crisis has brought both notions of transparency under the spotlight. The opacity of the structure and payoffs of structured debt securities – a form of low cash-flow transparency – is blamed 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 (mortgage-backed securities, collateralized debt obligations, credit default swaps, etc.) traded in opaque over-the-counter (OTC) markets – an instance of low trading transparency.

Our model shows that the choice of transparency pits issuers against both sophisticated and unsophisticated investors, unlike most market microstructure models where it typically redistributes wealth from uninformed to informed investors. In our model, less financial disclosure prevents sophisticated investors from exploiting their processing ability and induces more trading mistakes by the unsophisticated, both because they have less fundamental information and because they cannot observe previous trades in order to update their beliefs about the asset's value.

Besides providing new insights about the political economy of regulation, the model helps to address several pressing policy issues: if a regulator wants to maximize social welfare, how much information should be required when processing it is costly? When are the seller's incentives to disclose information aligned with the regulator's objective and when instead should regulation compel disclosure? How does mandatory disclosure compare with a policy that prohibits

unsophisticated investors from buying complex securities?

First, we show that in general there can be either over- or under-provision of information, depending on processing costs and the seller’s bargaining power. Surprisingly, there is a region in which the seller has a greater incentive than the regulator for disclosure. This occurs when enough unsophisticated investors are in the market and the expected value of the asset is low: sellers will spontaneously release more information when their assets are not much sought-after. This is also more likely when the seller appropriates a large part of the expected trading gains.

When instead there are many sophisticated investors, issuers fear their superior processing ability and therefore inefficiently prefer not to disclose. Hence, regulatory intervention for disclosure is required. This is likely to occur in markets for complex securities, such as asset-backed securities, where sophistication is required to understand the asset’s structure and risk implications, so that sophisticated investors are attracted. 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 are unsophisticated, 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 bear. Thus, when information is difficult to digest, as in the case of complex securities, the planner should allow placement only with the “smart money”, not to all comers.

These insights build on the idea that not all the information disclosed to investors is easily and uniformly digested – a distinction that appears to be increasingly central to regulators’ concerns. For instance, in the U.S. there is controversy about the effects of Regulation Fair Disclosure promulgated in 2000, which prohibits firms from disclosing information selectively to analysts and shareholders: 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”.¹ Similar concerns lie behind the current proposals to end quarterly reporting obligations for listed companies in the revision of the EU Transparency Directive: in John Kay’s words, “the time has come to admit that there is such a thing as too much transparency. The imposition of quarterly reporting of listed European companies five years ago has done little but confuse and distract management and investors” ([Kay \(2012\)](#)). In the same spirit, U.S. regulation is now seeking to mitigate the demanding disclosure requirements of the Sarbanes-Oxley Act: the 2012 Jumpstart Our Business Startups (JOBS) Act reduces the

¹[Bushee et al. \(2004\)](#) find that firms that 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 greater need to communicate complex information (proxied by intangible assets).

accounting and security market transparency requirements for new public companies, lifting the threshold for SEC registration from 500 to 2,000 shareholders and allowing smaller companies to use internet portals to obtain “crowd funding” with minimal reporting obligations.

The rest of the paper is organized as follows. Section 2 places it in the context of the literature. Section 3 presents the model. Section 4 derives the equilibrium under the assumption of complete transparency of the security market. Section 5 relaxes this assumption and explores the interaction between financial disclosure and market transparency. Section 6 investigates the role of regulation, and Section 7 concludes.

2 Related literature

This paper is part of a growing literature on costly information processing, initiated by Sims (2003) and Sims (2006), which argues that agents are unable to process all the information available, and accordingly underreact to news. Subsequent work by Peng and Xiong (2006), Van Nieuwerburgh and Veldkamp (2009), Van Nieuwerburgh and Veldkamp (2010) and Woodford (2005) brought out the implications of information constraints for portfolio choice problems and monetary policy.² While in these papers limited cognition stems from information capacity constraints, in our setting it arises from the cost of increasing the precision of information.

The idea that information processing is costly squares with a large body of empirical evidence, as witnessed by surveys of studies in psychology (Pashler and Johnston (1998) and Yantis (1998)), in experimental research on financial information processing (Libby et al. (2002) and Maines (1995)), and in asset pricing (Daniel et al. (2002)).³ In particular, there is 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 skills drawn from the Survey of Health, Ageing and Retirement in Europe (SHARE), and find that the propensity to invest in stocks is positively associated with cognitive skills and is driven by information constraints, not preferences or psychological traits.⁴ Moreover, investors appear to respond quickly to the more salient data, at the expense of other price-relevant information (see for instance Huberman and Regev (2001), Barber and Odean (2008), and DellaVigna and

²See also Hirshleifer and Teoh (2003) who analyze firms’ choice between alternative methods for presenting information and the effects on market prices, when investors have limited attention.

³See 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.

⁴The accounting literature too sees 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 the disclosure and the recognition of information, and observe that the latter has a stronger empirical impact, presumably reflecting better understanding of the information.

Pollet (2009)). Investors' limited attention can result in slow adjustment of asset prices to new information, and thus in return predictability: the delay in price response is particularly long for conglomerates, which are harder to value than standalone firms and whose returns can accordingly be predicted by those of the latter (Cohen and Lou (2011)).

Several recent papers show that investors may overinvest in information acquisition. For instance, in Glode et al. (2011) traders inefficiently acquire information as more expertise improves their bargaining positions. In Bolton et al. (2011), too many workers choose to become financiers compared to the social optimum, due the rents that informed financiers can extract from entrepreneurs by cream-skimming the best deals. In these papers, the focus is on the acquisition of information. Our focus is instead on information processing, and its effects on the issuers' incentive for disclosure information in the first place.

Several authors have suggested possible reasons why limiting disclosure may be efficient, starting with the well-known argument by Hirshleifer (1971) that revealing information may destroy insurance opportunities. The detrimental effect of disclosure has been shown in settings where it can exacerbate externalities among market participants, as in our setting: Morris and Shin (2011) analyze a coordination game among differentially informed traders with approximate common knowledge; Vives (2011) proposes a model of crises with strategic complementarity between investors and shows that issuing a public signal about weak fundamentals may backfire, aggravating the fragility of financial intermediaries. In our model too, disclosure creates trading externalities and strategic behavior, which are exacerbated by transparency about the trading process; but as disclosure is decided by issuers, this may produce an inefficiently low level of transparency.

Our result that issuers may be damaged by financial disclosure parallels Pagano and Volpin (2010), who show that when investors have different information processing costs, transparency exposes the unsophisticated to a winners' curse at the issue stage: to avoid the implied underpricing, issuers prefer opacity. But opting for an opaque primary market may generate an illiquid secondary market, if the information not divulged is later discovered by secondary market traders; if this illiquidity generates negative externalities, it may be socially efficient to require disclosure. Our present setting shares with Pagano and Volpin (2010) the idea that disclosure may aggravate adverse selection if investors have different information processing ability, but we differ in other important respects. First, here we show that issuers do not always opt for opacity, since they will trade off the costs of disclosure (investors' information processing costs and the strategic interaction among them) against its benefits (contribution to avoiding mistaken portfolio choices). Moreover, unlike Pagano and Volpin (2010), this paper shows that the level of disclosure chosen by issuers may either exceed or fall short of the socially

efficient level, and is also affected by the degree of trading transparency.⁵

Another model in which issuers may choose an inefficiently low level of disclosure is [Fishman and Hagerty \(2003\)](#). In their setting, some customers fail to grasp the meaning of the information disclosed by the seller, seeing only whether or not the seller discloses a signal or not. They show that if the fraction of sophisticated customers is too small, voluntary disclosure will not occur, and mandatory disclosure benefits informed customers and harms the seller. They conclude that in markets where information is difficult to understand disclosure should be mandatory. We find opposite results: a small fraction of sophisticated customers encourages the seller to disclose information, since it is associated with less adverse selection. Moreover, regulators are less likely to require disclosure in markets where information is hard to understand, since they realize that unsophisticated investors must spend resources to understand it: hence, if their information-processing costs are large, the regulator may prefer to save these costs by not requiring disclosure or, better, by restricting investment in complex assets to sophisticated investors.

In practice, issuers may want to refrain from disclosing information for other reasons as well. First, disclosure may be deterred by the costs of credibly transmitting information to investors (listing fees, auditing fees, regulation compliance costs, etc.). A second, less obvious cost arises from the non-exclusive nature of disclosure: information to investors is disclosed simultaneously to competitors, who may then exploit it to appropriate the firm's profit opportunities, as noted by [Campbell \(1979\)](#) and [Yosha \(1995\)](#). A third cost arises from the company's lesser ability to evade or elude taxes: the more detailed accounting information for investors naturally goes also to the tax authorities, and the implied additional tax burden may induce them limit disclosure (see [Ellul et al. \(2012\)](#)).

3 The model

The seller has an indivisible asset that he wants to sell to investors: he might be an entrepreneur undertaking an IPO, an investment banker placing a security with investors, or a real estate agent seeking a buyer for a house. The sale comes through a search market that randomly matches the seller with buyers. Before the trade, the seller can disclose a noisy signal about the value of the asset. To understand the pricing implications, potential buyers must devote some attention to analyzing the signal. But investors face different costs: understanding financial news is more costly for unsophisticated investors than for professionals with expertise, better equipment and more time. Unsophisticated investors may still want

⁵Recently, [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.

to buy for non-informational reasons, such as to hedge some risk (these we accordingly call “hedgers”). By contrast, sophisticated investors are assumed to trade purely to exploit their superior information-processing ability, and are accordingly labeled “speculators”.

We posit two equally likely states of the world: in the good state, the asset’s value v equals v_g , in the bad, v_b , where $v_b < 0 < v_g$. The unconditional mean of the value is $v^e \equiv (v_g + v_b)/2$.⁶ The seller can disclose a signal $\sigma \in \{\sigma_b, \sigma_g\}$ correlated with the value of the security. If he does, before trading investor i must decide the level of attention $a \in (0, 1)$ devoted to this signal, which increases the probability of correctly estimating the probability distribution of the value: $\Pr(\sigma_i = v_i | v_i) = \frac{1+a}{2}$. So by paying more attention, investors read the signal more accurately. The choice of a captures the investors’ effort to understand the information in an IPO prospectus, say, or a company’s earnings announcement or the data on CDO’s asset pool.

However, greater precision comes at an increasing cost: the cost of information processing is $C_i(a, \theta)$, with $\partial C_i / \partial a > 0$ and $\partial^2 C_i / \partial a^2 > 0$, where the shift parameter θ_i measures inefficiency in processing, i.e. the investor’s “financial illiteracy”.⁷ To simplify the analysis, we posit a quadratic cost function: $C_i(a, \theta) = \theta_i a^2 / 2$. The greater θ_i , the harder for investor i to measure the asset’s price sensitivity to factors like interest rates, commodity and housing price changes, possibly because of its complexity: as the recent financial crisis has made apparent, understanding the price implications of a CDO’s structure requires considerable skills and substantial resources. Information processing costs differ across investors: some are unsophisticated “hedgers” ($i = h$), whose cost is $\theta_h = \theta$; others are sophisticated “speculators” ($i = s$) who face no such costs: $\theta_s = 0$.⁸

Trading is via a matching and bargaining protocol: with probability μ , the seller is initially matched with a hedger; with probability $1 - \mu$, with a speculator. If the initial match produces no trade, the seller is contacted by the other type of investor.⁹ The parameter $1 - \mu$ has two possible interpretations. First, it can capture how fast speculators enter their orders, hence their chance of being the first contact the seller. The relative speed of investors’ market access has come under the spotlight recently, due to the increasing prominence of high-frequency trading (which now accounts for 73% of U.S. equity trading volume) and its role in the May 2010 “flash crash”. And second, if investors’ ability or speed in placing orders is drawn from a

⁶This binary distribution is assumed just to simplify the exposition, but the results are qualitatively the same with a continuum of possible asset’s values.

⁷Like [Tirole \(2009\)](#), we do not assume bounded rationality: in Tirole’s framework information-processing costs rationally lead to incomplete contracts, which impose costs on the parties. Similarly, in our setting unsophisticated investors decide how much information they wish to process rationally, in the awareness that a low level of attention may lead to mistakes in trading.

⁸The model easily generalizes to the case where speculators too have positive information-processing costs or where there are more than two types of investors.

⁹This assumption is with no loss of generality: if the seller were contacted again by an investor of the same type, the new match naturally again produces no trade: since investors of the same type are identical. Only a new match with an investor of the other type could produce a trade.

common distribution, the parameter $1 - \mu$ captures the fraction of speculators in the population of investors: in a securities market that attracts more speculators, one of them is more likely to be the first to deal with the issuer. In what follows, we rely more on the second interpretation, but the first one is in no way excluded.

Each investor i has a reservation value $\omega_i > 0$, independent of v and the net value from purchasing the asset for investor i is $v - \omega_i$. But the seller places no value on the asset. Once the seller is matched with a buyer, they negotiate a price and the trade occurs whenever the buyer expects to gain a surplus: $\mathbb{E}(v - \omega_i | \Omega_i) > 0$, where Ω_i is buyer i 's information set. The seller makes a take-it-or-leave-it offer with probability β_i .

The outcome of bargaining is given by the generalized Nash solution under symmetric information: the 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.¹⁰ As in the search-cum-bargaining model of [Duffie et al. \(2005\)](#), the seller can observe the investor's type. Real-world examples of such a setting are OTC and housing markets, where matching via search gives rise to a bilateral monopoly at the time of a transaction.

We impose the following restrictions on the parameters:

Assumption 1 $\omega_s = v^e > \omega_h > 0$.

Hence, the two types of investors differ in their outside options. Hedgers have a comparatively low outside option, and therefore view the asset as a good investment on average ($v^e > \omega_h > 0$). Say, they are farmers who see the asset as a hedge against crop's price risk. In contrast, speculators are in the market only to exploit their information processing ability, because they have no intrinsic need to invest in the asset: $\omega_s = v^e$. For example, they may be hedge funds or investment banks with strong quant teams.

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

This assumption on θ implies that the hedgers' information processing cost is high enough to deter them from achieving perfectly precise information; that is, they will choose an optimal attention level $a_h^* < 1$. Otherwise, in equilibrium hedgers would have the same information as speculators ($\Omega_h = \Omega_s$).

The two types of investor may also differ in bargaining power: the seller captures a fraction β_h of the expected gains from trade when dealing with hedgers, but a smaller fraction $\beta_s \leq \beta_h$ when dealing with speculators, who are better at shopping around for the best deals and obtaining price concessions as part of a stable trading relationship.

In the baseline version analyzed in the next section, the timeline of the game is as follows:

¹⁰The assumption that bargaining occurs under symmetric information is discussed in detail at the end of this section.

1. The seller decides whether or not to disclose the signal, i.e. $d \in \{0, 1\}$.
2. Investor i is randomly matched with the seller: with probability μ , he is type h and with probability $1 - \mu$, type s .
3. Investor i chooses his attention level a_i and forms his expectation of the asset value $\hat{v}_i(a_i, \sigma)$.
4. If he decides to buy, buyer and seller bargain over the expected surplus.
5. If he does not buy, the other investor, upon observing the outcome of stage 4, is randomly matched to the seller and bargains with him over the expected surplus.

This means that in this baseline version, the final stage of the game posits complete market transparency, previous trades being observable to all market participants. In Section 5 we relax this assumption, and allow investors to fail to observe previous trades: this enables us to explore how less trading transparency affects the equilibrium outcome.

3.1 Discussion

We now discuss the main assumptions of the model.

First, we posit that investors choose their level of attention after matching with the seller: they do not analyze a security's prospectus, say, until they have found a security available for purchase. The alternative is to assume that buyers make their information inquiries in advance, before matching. But this entails greater costs for investors, who would sustain information-processing costs even for securities that they do not buy: so if given the choice they would opt for the sequence we assume.

Second, there is the possibility that the seller might commit to trade only with hedgers. This would allow him to disclose information without attracting the speculators. However, the externality posited arises from simply receiving an offer from a speculator, not trading with him: even if the seller excluded trading with speculators, he could not avoid receiving offers from them. This is sufficient to induce learning by hedgers and hence generate the externality present in the model.

Third, the seller is assumed not to condition his disclosure policy upon the signal of the asset's cash flow. This assumption is not essential, however: for instance, if the seller were to release the signal only if good ($\sigma = \sigma_g$), investors would infer that the signal is bad when not released. A similar unraveling argument shows that any other disclosure policy conditional on the signal is equivalent to our assumed policy ($d = 1$), as in [Grossman \(1981\)](#) and [Milgrom \(1981\)](#). Moreover, this policy captures situations in which the seller does not know which signal

value will increase the investors' valuation of the asset, perhaps because investors' trading motives or risk exposures are not known.

Fourth, since we model bargaining under symmetric information, we assume that in the bargaining stage the seller does not exploit his private information about the asset's value. In our context, the seller could exploit any such information only vis-à-vis hedgers (since in equilibrium speculators, if they trade, are perfectly informed): however, such behavior by the seller would be anticipated by hedgers and lead to no trade. Hence, if the seller is interested in actually selling the asset, in a repeated setting he will want to precommit not to engage in such opportunistic behavior.¹¹

4 Equilibrium

We solve the game backwards to identify the subgame perfect equilibrium, 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 typical buyer i 's expected gains from trade; (iii) the prices p_s bid by speculators and p_h bid by hedgers solve the bargaining problem specified above. Specifically, each type of investor pays a different price depending on the disclosure regime, and possibly on whether he is matched with the seller at stage 4 (when he is the first bidder) or 5 (when he bids after another investor elected not to buy). Each of the following sections addresses one of these decision problems.

4.1 The bargaining stage

When the seller bargains with an investor i , his outside option $\bar{\omega}_i$ is endogenously determined by the other investors' equilibrium behavior. The price p_h agreed by hedgers solves the following program:

$$p_h \in \arg \max (p_h - \bar{\omega}_h)^{\beta_h} (\hat{v}(a, \sigma) - p_h - \omega_h)^{1-\beta_h}. \quad (1)$$

The first term in this expression is the seller's surplus: the difference between the price that he obtains from the sale and his outside option $\bar{\omega}_h$, which is the price the hedger expects a

¹¹Alternatively, we may assume the seller to be uninformed about the value of the asset. In this case, the assumption that bargaining occurs under symmetric information is without loss of generality. If the seller is matched with a speculator, who in equilibrium perfectly infers the asset value from the signal and gains from trade only if $v = v_g$, the seller can infer this information from the speculator's willingness to buy. Similarly, if the seller is matched with a hedger who is willing to buy the asset, he can infer the hedger's posterior belief about the asset's value (since he knows the parameters of the hedger's attention allocation problem, and therefore can infer the attention chosen by the hedger). Hence, the gains from trade between seller and hedger are common knowledge, so that in this case too bargaining occurs under symmetric information. This is the same reasoning offered by [Duffie et al. \(2005\)](#) to justify the adoption of the Nash bargaining solution in their matching model.

speculator to offer if the trade does not go through. The second term is the buyer's surplus: the difference between the hedger's expected value of asset \hat{v} over and above the price paid to the seller, and his outside option ω_h .

The expected value from the hedger's standpoint, as a function of his choice of attention a and of the signal σ , is

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

where $\frac{1+a}{2}$ is the probability that the signal is correct (and $\frac{1-a}{2}$ the complementary probability that it is not). This probability is an increasing function of the attention a that hedgers pay to the signal: in the limiting case $a = 0$, their estimate would be the unconditional average v^e , whereas in the polar opposite case $a = 1$, their estimate would be perfectly precise. In what follows, we conjecture that speculators, who have no information processing costs, will choose $a_s^* = 1$, while hedgers choose a lower attention level $a_h^* \in [0, 1)$.¹² Thus, in equilibrium speculators know the value of the asset and hedgers hold a belief $\hat{v}(a, \sigma)$ whose precision depends on the attention level they choose.

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

$$p_s \in \arg \max (p_s - \bar{\omega}_s)^{\beta_s} (v - \omega_s - p_s)^{1-\beta_s}, \quad (2)$$

where $\bar{\omega}_s$ is the price that will be offered by hedgers if speculators do not buy.

By solving problems (1) and (2), we can characterize the solution to the bargaining problem:

Proposition 1 (Bargaining outcome) *Suppose that the signal is disclosed at stage 1. Then if at stage 2 the seller is initially matched with the speculator and the trade fails to occur, the hedger will subsequently refuse to buy. If instead the seller is initially matched with the hedger and the trade fails to occur, the seller will subsequently trade with the speculator. The prices at which trade occurs with the two types of investor are*

$$p_h^d = \beta_h (\hat{v}(a_h, \sigma_g) - \omega_h) + (1 - \beta_h) p_s \frac{1 + a_h}{2} \quad \text{and} \quad p_s^d = \beta_s (v_g - \omega_s). \quad (3)$$

If instead the signal is not disclosed at stage 1, the trade occurs only with the hedger at the price

$$p_h^{nd} = \beta_h (v^e - \omega_h). \quad (4)$$

When the signal is disclosed ($d = 1$), an initial match with the speculator leads to trade only if the asset value is high, because the speculator's reservation value ω_s exceeds the low

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

realization v_b . Therefore, upon observing that the speculator did not buy the hedger will revise his value estimate down to v_b . Since this value falls short of his own reservation value (as $v_b < 0 < \omega_h$), he too will be unwilling to buy, so the seller's outside option is zero: $\bar{\omega}_s = 0$. This information externality weakens the seller's initial bargaining position vis-à-vis the speculator, by producing a lower outside option than when the hedger comes first (and so is more optimistic about the asset value, his estimate being $\hat{v}(a_h, \sigma_g) > v_b$).

What hedgers infer from speculators' decisions in our model is reminiscent of the results in the literature on herding (Scharfstein and Stein (1990) and Banerjee (1992)). In our case, however, the hedger always benefits from observing speculators' decisions, because his "herding" involves no loss of valuable private information. By contrast, the speculator does not learn from the hedger's behavior: since in equilibrium he has better information, he draws no value inference upon seeing that the hedger does not buy.

In equilibrium, the hedger buys only when he is the first to be matched, and only upon receiving good news. Hence, the price p_h at which he trades according to expression (3) is his expected surplus conditional on good news: the first term is the fraction of the hedger's surplus captured by the seller when he makes the take-it-or-leave-it offer; the second term is the fraction of the seller's outside option p_s that the hedger must pay when he makes the take-it-or-leave-it offer. This outside option is weighted by the probability $\frac{1+a_h}{2}$ that the hedger attaches to the asset value being high, and therefore is increasing in the hedger's level of attention a_h .

By contrast, the price offered by the speculator is affected only by his own bargaining power: he captures a share $1 - \beta_s$ of the surplus conditional on good news. This is because when he bargains with the speculator, the seller's outside option is zero: if he does not sell to him, the asset goes unsold, as the hedger too will refuse to buy.

It is important to see that the price concession that speculators obtain as a result of hedgers' emulation depends on the hedgers' awareness of the speculators' superior information-processing ability, which exposes hedgers to a "winner's curse". But this adverse selection effect itself depends on the seller's initial public information release, since without it speculators would lack the very opportunity to exploit their information-processing advantage.

Indeed, if there is no signal disclosure ($d = 0$), the speculator will be willing to buy the asset only at a zero price, because when matched with the seller his expected gain from trade would be nil: $v^e - \omega_s = 0$. This is because in this case he cannot engage in information processing, which is his only rationale for trading. By the same token, absent both the signal and the implicit winner's curse, the hedger will value the asset at its unconditional expected value v^e , and will always be willing to buy it at a price that leaves the seller with a fraction β_h of his surplus $v^e - \omega_h$.

4.2 Attention allocation

So far we have taken investors' choice of attention as given. Now we characterize it 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 fail to buy the asset when it is worth buying, i.e. when its value exceeds their outside option ω_i : in this case, not buying means forgoing the trading surplus $v_g - \omega_i$.

In principle there are four different outcomes: the hedger may (i) never buy, (ii) always buy, irrespective of the signal realization; (iii) buy only when the signal is σ_g or (iv) buy only when the signal is σ_b . Proposition 2 characterizes the optimal choice of attention allocation 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".

Investors choose their attention level a_i to maximize expected utility:

$$\max_{a_i \in [0,1]} (1 - \beta_i) \left(\frac{1 + a_i}{2} v_g + \frac{1 - a_i}{2} v_b - \omega_i - \bar{\omega}_i(a_i) \right) - \theta_i \frac{a_i^2}{2}, \text{ for } i \in \{h, s\}, \quad (5)$$

which shows that the seller's outside option is a function of the attention choice. The solution to problem (5) is characterized as follows:

Proposition 2 (Choice of attention) *The speculator's optimal attention is the maximal level $a_s^* = 1$. The hedger's optimal attention is*

$$a_h^* = \frac{1 - \beta_h}{4\theta} \left(1 - \frac{\beta_s}{2} \right) (v_g - v_b),$$

which is decreasing in financial illiteracy θ and in the seller's bargaining power β_h and β_s , and increasing in the asset's volatility $v_g - v_b$. The hedger buys the asset if and only if the realized signal is σ_g when the asset's volatility is sufficiently high.

The first part of the proposition captures the speculator's optimal choice of attention, which confirms the conjecture made in deriving the bargaining solution: as he has no processing costs, the speculator chooses the highest level of attention, and therefore extracts the true value of the asset.

The second part characterizes the choice of attention by hedgers, for whom processing the signal is costly. First, their optimal choice is an interior solution, due to Assumption 2. And, when the seller extracts a larger fraction of the gains from the trade (i.e. β_h is large), the hedger spends less on analyzing the information, because he expects to capture a smaller fraction of the gains from trade. Moreover, the optimal choice a_h^* is increasing in the range of values that

the asset can take, because a larger range $v_g - v_b$ increases the magnitude of the two types of errors that the hedger must guard against.

As one would expect, the hedger's optimal attention a_h^* is decreasing in his financial illiteracy θ , because the greater the cost of analyzing the signal σ , the less worthwhile it is to do so. Alternatively, one can interpret θ as a measure of the informational complexity of the asset (the pricing implications of information being harder to grasp for asset-backed securities than for plain-vanilla bonds).

The comparative-statics result on β_s is less immediate, and follows from the sequential bargaining structure of our model. When the seller has high bargaining power β_s vis-à-vis the speculator, the hedger chooses a lower attention level: the informational rent the seller must pay to the speculator is lower, so he is less eager to sell to the hedger; this reduces the hedger's trading surplus, hence his incentive to exert attention.

Finally, the hedger allocates positive attention a_h^* to process the signal only if it is positive and the asset's volatility $v_g - v_b$ is sufficiently great. Intuitively, if $v_g - v_b$ is low, it is optimal to save the processing costs and buy regardless of the information disclosed. In what follows we focus on the more interesting case in which it is optimal for the hedger to buy the asset only when he gets a positive signal about the asset value.

4.3 Disclosure policy

To determine what incentive the seller has to disclose the signal σ , we must compare his expected profits in the two different disclosure regimes, building on the foregoing analysis. In the no-disclosure regime, the seller's expected profit is simply

$$\mathbb{E}[\pi^{nd}] = p_h^{nd} = \beta_h(v^e - \omega_h), \quad (6)$$

because, as we have shown, the speculator does not buy when $d = 0$.

Under disclosure, however, the seller is matched with the hedger with probability μ , so that his expected profit is $\mathbb{E}[\pi_h^d]$, whereas with probability $1 - \mu$ he is matched with the speculator and has expected profit of $\mathbb{E}[\pi_s^d]$. Hence on average the seller's profit is

$$\mathbb{E}[\pi^d] = \mu\mathbb{E}[\pi_h^d] + (1 - \mu)\mathbb{E}[\pi_s^d]. \quad (7)$$

Let us consider the two terms in this expression. The first refers to the case in which the seller first meets the hedger, and is equal to

$$\mathbb{E}[\pi_h^d] = \frac{1 + a_h^*}{4}p_h^d + \frac{1 - a_h^*}{4}p_s^d, \quad (8)$$

where p_h^d and p_s^d are the equilibrium prices defined by Proposition 1. With probability $(1 + a_h^*)/4$ 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 buy the asset at the price p_h^d . With probability $(1 - a_h^*)/4$, instead, the asset's value is v_g but the signal received by the hedger is σ_b , in which case he does not trade, so the asset ends up being bought by the speculator at price p_s^d .

If the seller is matched with the speculator, his expected profit is

$$\mathbb{E}[\pi_s^d] = \frac{1}{2}p_s^d. \quad (9)$$

In this case, with probability 1/2 the signal tells the speculator that the asset's value is higher than his outside option, so that he is willing to trade at the price p_s . With complementary probability 1/2 the value turns out to be v_b , which induces both the speculator and the hedger to refrain from trading (for the hedger this reflects a negative inference from seeing that speculator does not buy).

Using expressions (8) and (9), the expression (7) for the seller's expected profits under disclosure becomes:

$$\mathbb{E}[\pi^d] = \mu \frac{1 + a_h^*}{4} (p_h^d - p_s^d) + \frac{1}{2}p_s^d. \quad (10)$$

To choose between disclosure ($d = 1$) and no disclosure ($d = 0$), the seller compares the expected profits (10) and (6) in the two regimes, evaluated at the equilibrium prices defined by Proposition 1. Using this comparison we can characterize the seller's incentive to disclose information:

Proposition 3 (Choice of financial disclosure) *The seller's net benefit from disclosing the signal σ is increasing in the fraction μ of hedgers and in the asset's volatility $v_g - v_b$ and decreasing in the hedgers' financial illiteracy θ .*

To intuit the reason for these results, consider that in this model financial disclosure has both costs and benefits for the seller. The cost consists in the fact that disclosure enables speculators to deploy their information-processing skills, triggering an information externality that depresses the price. The benefits are twofold: first, disclosure induces hedgers to invest attention in the valuation of the asset and thereby enhances their willingness to pay for it (as can be seen by comparing p_h^d in (3) to p_h^{nd} in (4)); second, it increases the speculator's willingness to pay in good states of the world.

The cost arises with probability $1 - \mu$, which is the likelihood of the seller being matched initially with the speculator.¹³ Conversely, the higher the chance μ of trading immediately with

¹³Since high-frequency trading, in which computers initiate orders based on information received electroni-

the hedger, the less the seller worries that disclosure may trigger the informational externality: this explains why the seller's willingness to disclose is increasing in μ .

The benefits of disclosure for the seller are increasing in the asset's volatility: first, a more volatile asset induces the hedger to pay more attention to its valuation (Proposition 2), which increases the price p_h^d he is willing to pay (from expression (3)); second, volatility increases the surplus that the seller can extract, under disclosure, from trading with the speculator, because it increases the latter's willingness to pay in the good state.

The comparative statics are summarized in Figure 1: the seller opts for disclosure in the region where the fraction μ of hedgers is high and/or volatility $v_g - v_b$ is high.

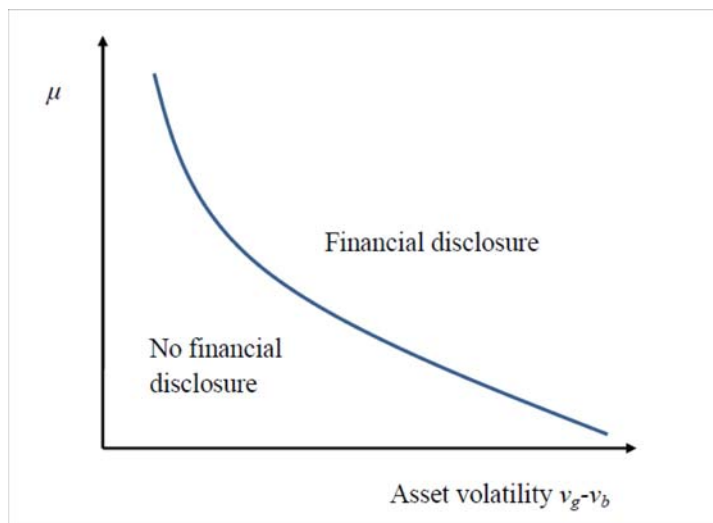


Figure 1: Seller's disclosure policy

Proposition 3 also highlights that the seller is less inclined to disclosure when the parameter θ is high, i.e. when the financial literacy of investors is low and/or the asset is complex, as in these circumstances the seller anticipates that disclosure will fail to elicit a high level of attention by investors and accordingly not raise their valuation of the asset significantly.

5 The effect of market transparency

In analyzing sellers' choice of disclosure, so far we have assumed that the market is fully transparent; that is, that subsequent buyers perfectly observe whether a previous trade has occurred or failed. This need not always be the case however: securities markets differ in their

cally, before human traders could ever process it, 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.

post-trade transparency, the extent to which information on previous trades is disseminated to actual and potential participants.¹⁴ Accordingly, we now generalize to examine how the results are affected by less than perfect market transparency. We now assume that at stage 5 players observe the outcome of the match that occurred at stage 4 only with probability γ . Hence the parameter γ can be taken as a measure of transparency, and conversely $1 - \gamma$ as a measure of opacity.

In this model, market opacity attenuates the information externality between speculators and hedgers: the less likely hedgers are to know whether a previous match between seller and speculator failed, the less frequently they themselves will refrain from buying, thus depressing the price. In turn, since speculators' failure to buy may go unobserved by hedgers, they will be able to obtain less of a price concession. Hence, greater market opacity (lower γ) enables the seller to get a higher price.

However, opacity also has a more subtle – and potentially countervailing – effect: even if the hedger does not observe that a previous match has failed to result in a trade, he might still suspect that such a match did occur, and that he should accordingly refrain from buying. If the market is very opaque (γ very low), this suspicion may lead the hedger to withdraw from the market entirely: in other words, market opacity may generate a “lemons problem”. Hence, we shall see that, although opacity attenuates information externalities between traders, if it becomes too extreme it may lead to a market freeze. The latter result is closer than the former to typical market microstructure models.

Let us analyze the first effect in isolation, taking the hedger's participation and pricing decision as given. Suppose the seller discloses the signal σ at stage 1 and is matched with a speculator at stage 4. If the market is opaque, the seller might be able to place the asset even if bargaining with the speculator broke down, since the hedger might still be willing to buy. Hence, the speculator must offer a price that compensates the seller for this outside option, which did not exist under full transparency ($\gamma = 1$). Specifically, if $\gamma < 1$, the opaque-market price $p_s^o(\gamma)$ at which the speculator will buy is a weighted average of his surplus $v_g - \omega_s$ and the seller's outside option, i.e. the price p_h^o the hedger is willing to pay in the opaque market when he fails to see the previous match (which occurs with probability $1 - \gamma$) and believes that the asset has high value (which occurs with probability $\frac{1+a_h}{2}$):

$$p_s^o(\gamma) = \beta_s (v_g - \omega_s) + (1 - \beta_s) (1 - \gamma) \frac{1 + a_h}{2} p_h^o. \quad (11)$$

¹⁴For empirical studies on the effect of post-trade transparency on market quality see [Naik et al. \(1994\)](#), [Gemmell \(1996\)](#), [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.

This expression shows that speculators' offer is decreasing in market transparency γ , and is lowest when the market is fully transparent: $p_s^o(1) = \beta_s(v_g - \omega_s)$, which is expression p_s^d in (3). Hence, market opacity increases the expected gain for the seller for any given price p_h^o offered by the hedger.

However, since in our model hedgers are unsophisticated but not naïve, we must consider that the offer price p_h^o is itself affected by the degree of market transparency. 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, that is, opacity creates asymmetric information between seller and investors. The seller who has been previously matched with a speculator knows that the match failed, but the hedger does not. Hence, there may be “informed” sellers, who went through a failed negotiation, or “uninformed” ones, who did not.

Following the literature on bargaining under asymmetric information (Ausubel et al. (2002), and the references therein), we assume that the hedger makes a take-it-or-leave-it bid to the seller. As shown by Samuelson (1984), for the trade to take place, a necessary and sufficient condition is that the buyer can make a profitable first-and-final offer. Then, altering the baseline case set out in the previous section, where opacity generates information asymmetry between the seller and the hedger, we modify the bargaining protocol: we seek the price p_h^o that the hedger is willing to offer as a function of his beliefs about the asset's value, assuming he will not be able to infer it perfectly from the speculator's trading. As a result of the seller's informational advantage in the trading process, he extracts a rent from the hedger. When the hedger's likelihood μ of being the first to contact the seller is sufficiently low, this rent becomes so great that the hedger simply refrains from trading. This implies the following proposition:

Proposition 4 *When the market is opaque, i.e. $\gamma < 1$, if the fraction of hedgers is high enough ($\mu \geq \underline{\mu}$), the price offered by the hedger is $p_h^o = \beta_s(v_g - \omega_s)/2$ and the seller accepts it. Otherwise ($\mu < \underline{\mu}$), the hedger does not trade.*

Intuitively, the fewer hedgers there are, the more leery they are of meeting the seller after a failed match and buying a low-value asset at a high price. At the limit, when the fraction of hedgers among all buyers μ drops below the threshold $\underline{\mu}$, this concern leads them to leave the market.

Having characterized the hedger's trading strategy, we can calculate the seller's expected profit under disclosure ($d = 1$) when the market is less than fully transparent ($\gamma < 1$). Since the seller places no value on the asset, his profit coincides with the selling price. If $\mu \geq \underline{\mu}$, so that the hedger is present in the market, he sells to the speculator at the price $p_s^o(\gamma)$ in (11) with probability $\frac{1-\mu}{2}$ (since the speculator buys only if the asset value is high) and to the hedger at the price $p_h^o = \beta_s(v_g - \omega_s)/2$; if instead $\mu < \underline{\mu}$, he can only sell to the speculator

in the good state at price $\beta_s (v_g - \omega_s)$. Therefore the seller's profit under disclosure, when the market is not fully transparent, is:

$$\mathbb{E}(\pi^{o,d}) = \begin{cases} \frac{1-\mu}{2} p_s^o(\gamma) + \frac{\mu}{2} \beta_s (v_g - \omega_s) & \text{if } \mu \geq \underline{\mu}, \\ \frac{1}{2} \beta_s (v_g - \omega_s) & \text{if } \mu < \underline{\mu}. \end{cases}$$

Recalling that by expression (11) the speculator's bid price $p_s^o(\gamma)$ is linearly decreasing in the degree of market transparency, when the hedger trades ($\mu \geq \underline{\mu}$) the seller's profit is also decreasing in γ . When the hedger does not trade ($\mu < \underline{\mu}$), the seller's profit does not depend on market transparency, but coincides with his lowest profit when the hedger is active.

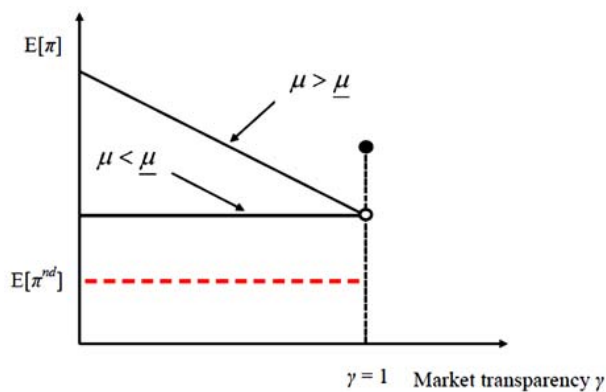


Figure 2: Financial disclosure and market transparency: case (a)

The expected profits under disclosure for these two cases are plotted as a function of market transparency γ by the two solid lines in Figures 2 and 3. Notice that in both cases the profit function has a discontinuity at $\gamma = 1$: when the market achieves full transparency, the seller's expected profit jumps up to the level given by expression (10). This is because complete transparency eliminates adverse selection between hedger and seller. This non-monotonicity in the relationship between average asset price and transparency highlights that in our setting market transparency has two opposite effects: it exacerbates the externality between hedger and speculator, which damages the seller; but it eliminates the adverse selection between seller and hedger, which benefits the seller.

We are now in a position to investigate whether the seller opts for disclosure, and how this decision is affected by market transparency. First, notice that the seller's expected profit with no disclosure $\mathbb{E}(\pi^{nd})$ is not affected by market transparency, since the speculator refrains from trading and the seller's expected profit is accordingly given by expression (6). This level

of expected profit is shown as the dashed line in Figures 2 and 3. The figures illustrate two different cases. Figure 2 shows the case in which the seller's expected profit under disclosure $\mathbb{E}(\pi^{o,d})$ exceeds that under no disclosure $\mathbb{E}(\pi^{nd})$ for *any* degree of market transparency: in this case, the seller will always opt for disclosure ($d = 0$). Figure 3 shows the case in which if transparency γ is low and $\mu \geq \underline{\mu}$, the seller prefers to disclose, but if transparency is high the seller prefers not to disclose. Only when the market becomes fully transparent ($\gamma = 1$), does the seller again prefer to disclose, and this reversal occurs irrespective of the value of μ . Hence, over a certain range of parameters the seller will want to protect himself from the loss due to transparency by opting against disclosure, and only when transparency is complete will he again see a net benefit in disclosure.

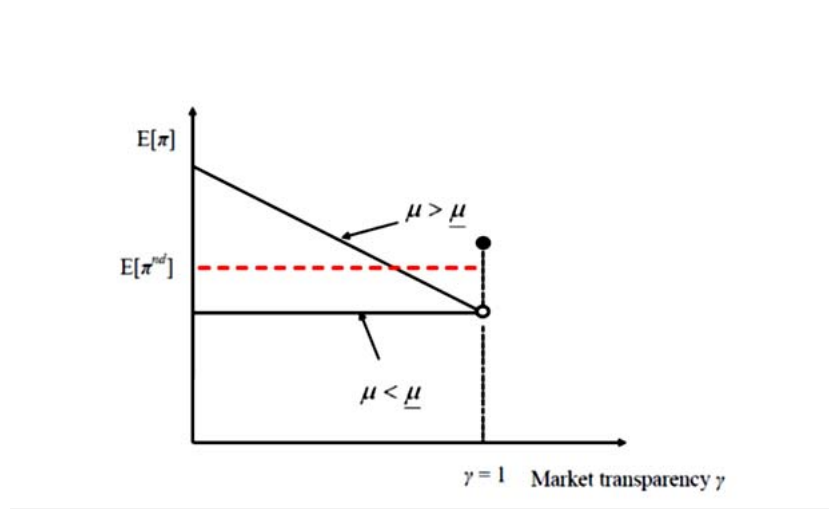


Figure 3: Financial disclosure and market transparency: case (b)

The following proposition summarizes the effects of market transparency on the seller's incentive to disclose information:

Proposition 5 (Financial disclosure and market transparency) (i) *When the fraction of hedgers is sufficiently high ($\mu > \underline{\mu}$), the seller's net benefit from disclosure is decreasing in the degree of market transparency γ .* (ii) *Otherwise ($\mu < \underline{\mu}$), the seller has a greater benefit from disclosure when the market is fully transparent ($\gamma = 1$) than when it is not ($\gamma < 1$).*

Proposition 5 shows that the seller considers financial disclosure and market transparency as substitutes: he will always disclose more information in more opaque than in a more transparent market.

Our results differ considerably from the mainstream literature on market transparency (Glosten and Milgrom (1985), Kyle (1985), Pagano and Roell (1996), Chowdhry and Nanda

(1991), [Madhavan \(1995\)](#) and [Madhavan \(1996\)](#) among others), which finds that opacity redistributes wealth from uninformed to informed investors. In our setting, instead, opacity damages both sophisticated and unsophisticated buyers to the benefit of seller.¹⁵ Sophisticated investors cannot fully exploit their superior processing ability, while the unsophisticated lose the chance to observe past order flow to update their beliefs about the asset's value.

Another difference from the prevalent literature is that our sophisticated investors would like to give their trading strategy maximum visibility, as by placing orders in non-anonymous fashion. This implication runs contrary to the traditional market microstructure view, that informed investors should prefer anonymity to avoid dissipating their informational advantage. Our result is consistent with the evidence in [Reiss and Werner \(2005\)](#), who examine how trader anonymity affects London dealers' decisions about where to place interdealer trades: surprisingly, informed interdealer trades tend to migrate to the direct and non-anonymous public market. Moreover, the experimental evidence in [Bloomfield and O'Hara \(1999\)](#) that trade transparency raises the informational efficiency of prices accords with our model's prediction that a more transparent market (higher γ) increases hedgers' ability to infer the asset value. Finally, [Foucault et al. \(2007\)](#) find that in the Euronext market uninformed traders are more aggressive when using anonymous trading systems, which parallels our result that hedgers are willing to offer a higher price when $\gamma = 0$.

6 Regulation

So far we have analyzed the seller's incentives to disclose information, but not whether it is in line with social welfare. The recent financial crisis has highlighted the drawbacks of opacity, in both of our acceptations. For instance, the mispricing of asset-backed securities and the eventual freezing of that market were due chiefly to insufficient disclosure of risk characteristics as well as to the opacity of the markets in which they were traded. This has led some observers to advocate stricter disclosure requirements for issuers and greater transparency of markets; alternatively, others have proposed limiting access to these complex securities to the most sophisticated investors.

Our model can be used to analyze these policy options: the policy maker could (i) choose the degree of market transparency (set γ), (ii) make disclosure compulsory (set $d = 1$) and (iii) restrict market participation (for instance, ban hedgers from trading, setting $\mu = 0$).

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

6.1 Market transparency

There are several reasons why regulators might want to increase market transparency – to monitor the risk exposure of financial institutions, say, or to enable investors to gauge counterparty risk. Nevertheless, our analysis points to a surprising effect of greater transparency: it might reduce the issuer’s incentive to divulge information. This effect stems from the endogeneity of the decision and the way in which it depends on market transparency γ .

As Figure 3 shows, the seller’s incentive to disclose the signal σ is decreasing in transparency γ . Hence, if the regulator increases γ beyond the intersection of the dashed line with the decreasing solid line, the seller will decide to conceal the signal σ , making the policy ineffective. In this case, in fact, speculators will abstain from trading, and the heightened transparency will actually reduce the information contained in the price. This will affect the hedgers’ trading decision adversely, as they will have no information on which to base their decisions.

This result, which follows from Proposition 5, is summarized in the following corollary:

Corollary 1 *Increasing the degree of market transparency γ may ultimately reduce the information available to investors.*

This implication constitutes a warning to regulators that imposing transparency may backfire, as a consequence of the potential response of market participants. Specifically, issuers’ reaction might not only attenuate the effect of the policy, but actually result in a counterproductive diminution in the total amount of information available to investors, by reducing disclosure. This suggests that making the disclosure compulsory may be a better policy than regulating the degree of market transparency. The next section investigates when mandatory disclosure is socially efficient.

6.2 Mandating disclosure

In this section we analyze the conditions under which the regulator should make disclosure compulsory. We assume the regulator wishes to maximize the sum of market participants’ surplus from trading, defined as the difference between the final value of the asset and the reservation value placed on it by the relevant buyer.

We compute the expected gains from trade when information is disclosed and when it is not. The expected social surplus when no information is disclosed is simply

$$\mathbb{E} [S^{nd}] = v^e - \omega_h,$$

while under disclosure it is

$$\mathbb{E} [S^d] = \mu \mathbb{E} [S_h^d] + (1 - \mu) \mathbb{E} [S_s^d], \quad (12)$$

that is, the expected value generated by a transaction with each type of investor.

The expected gain from a trade between the seller and a hedger is

$$\mathbb{E} [S_h^d] = \left[\frac{1 + a_h^*}{4} (v_g - \omega_h) + \frac{1 - a_h^*}{4} (v_b - \omega_h) + \frac{1 - a_h^*}{4} (v_g - \omega_s) \right] - \frac{\theta a_h^{*2}}{2}. \quad (13)$$

The first term is the surplus if the asset value is v_g and the realized signal is σ_g , which occurs with probability $\frac{1+a}{4}$: the hedger buys the asset and the realized surplus is positive. The second term refers to the case in which the value is v_b but the hedger is willing to buy because the realized signal is σ_g , which occurs with probability $\frac{1-a}{4}$: in this case the realized surplus is negative. The third term captures the case in which the hedger refrains from buying the asset even though it was worth doing so, so that the asset is bought by the speculator. Finally, the last term is the information-processing cost borne by the hedger.

The expected gain from trade between the seller and a speculator instead is

$$\mathbb{E} [S_s^d] = \frac{v_g - \omega_s}{2}, \quad (14)$$

because the speculator only buys when the asset has high value, which occurs with probability $\frac{1}{2}$.

Recall that the main cost of disclosure for the seller is the fall in price due to the information externality among investors, so that he is more willing to disclose when the probability μ of being immediately matched with a hedger is high. For the regulator, instead, the main cost of disclosure consists in hedgers' information-processing costs, so the regulator is more willing to force disclosure when hedgers are less likely to buy, i.e. μ is lower. Hence:

Proposition 6 (Optimal disclosure policy) *Both under- and over-provision of information can occur in equilibrium. The regulator's net benefit from disclosure is decreasing in the hedgers' financial illiteracy θ , in the asset expected value v^e , and in the fraction μ of hedgers, and is increasing in the asset volatility $v_g - v_b$.*

The regulator's objective function differs from the seller's expected profits as computed earlier in three ways. First, the planner ignores the distributional issues driven by the bargaining protocol, so bargaining power does not affect the expected social gains. Second, the planner considers that disclosing information means the hedgers must investigate it, which is costly. Third, the regulator does not directly consider the externality generated by the speculators'

superior processing ability and its effect on the seller's profit. This affects the social surplus only when it would be efficient for the seller to trade with the hedger, because of the latter's lower reservation value ω_h , and instead the asset is sold to a speculator. These differences generate 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. First, the social planner considers the total gains from trade, not the fraction accruing to issuers: on this account, the regulators' interest in disclosure is greater than the seller's. At the same time, the seller does not directly internalize the cost of processing information, which is instead taken into account by the regulator. Interestingly, there is a region in which the seller has a *greater* incentive than the regulator for disclosure. This happens when enough hedgers participate in the market (high μ), where the seller will disclose the signal σ even if it would be socially efficient to withhold it. This is even more likely if a high level of financial literacy is required (high θ), so that disclosure would imply high information-processing costs for hedgers.

Conversely, in a market with a large share of speculators (low μ), the seller will fear their superior processing ability, and so will not disclose even when it would be socially efficient. This is likely in the markets for complex assets, such as asset-backed securities, where considerable sophistication is required to understand the structure of the asset and its pricing implications, so that speculators are more likely to participate. Hence, in such markets mandating information disclosure by sellers is warranted. This probably does not apply to markets for treasuries and simple corporate bonds, where the speculators' information-processing ability gives them a smaller advantage.

6.3 Licensing access

In practice, policy makers also have other instruments to regulate financial markets so as to maximize the expected gains from trade. Stephen Cecchetti, head of the BIS monetary and economic department, for example, has suggested that to safeguard investors "The solution is some form of product registration that would constrain the use of instruments according to their degree of safety." 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 illegal.¹⁶

Since speculators, when they get the signal σ , forecast the asset's value perfectly and incur

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

no processing costs, it might be optimal to limit market participation to them, thereby inducing the seller to disclose information. Limiting access to speculators only is a socially efficient policy when the expected surplus generated by trading with them (14) exceeds the expected gain (12) generated by the participation of all types of investors. The relevant condition is

$$\frac{v_g - \omega_s}{2} > \mu \left[\frac{1 + a_h^*}{4} v_g + \frac{1 - a_h^*}{4} v_b - \omega_h + \frac{1 - a_h^*}{4} (v_g - \omega_s) - \frac{\theta a_h^{*2}}{2} \right] + (1 - \mu) \frac{v_g - \omega_s}{2}, \quad (15)$$

which leads to the following proposition:

Proposition 7 (Ban hedgers from trading) *Making market access exclusive to speculators is welfare-improving when financial illiteracy θ is high and the expected value v^e of the asset is low. For the seller this policy is never optimal.*

In this case too, therefore, the seller’s and the regulator’s incentives are not aligned: in fact, sellers are always hurt by a policy that excludes hedgers, even when they deal with complex assets and unsophisticated investors. In contrast, Proposition 7 indicates that in these circumstances it may be socially efficient to limit access to speculators alone, because this saves unsophisticated investors from the high processing costs incurred when information is difficult to digest.

However, restricting access is not always optimal. In particular, it is inefficient when the expected asset value v^e is high: in this case the expected gains from trade are greater when all investors participate and it is less likely that hedgers will buy the asset when it is not worth it. Finally, volatility $v_g - v_b$ has ambiguous effects on the regulator’s incentive to exclude hedgers: on the one hand, it raises the costs associated with their buying a low-value asset, and hence the regulator’s interest in keeping them out of the market; on the other hand, it induces hedgers to step up their attention level, making the regulator more inclined to let them in.

7 Conclusion

We propose a model of financial disclosure in which some investors (whom we call “hedgers”) are bad at information processing, while others (“speculators”) trade purely to exploit their superior information processing ability. We make three main contributions.

First, we show that enhancing information disclosure may not benefit unsophisticated investors, but can actually augment the informational advantage of the more sophisticated. A key point is that disclosing information about fundamentals induces an externality: since speculators are known to understand the pricing implications, hedgers will imitate their decision to abstain from trading, driving the price of the asset below its no-disclosure level.

Second, we investigate how this result is affected by the opacity of the market, as measured by the probability of investors observing previous orders placed before theirs. This has two effects. On the one hand, in a more opaque market hedgers cannot count on information extracted from the speculators' trading strategy, which attenuates the pricing externality and favors the seller, so that opacity increases the seller's incentive for disclosure. On the other hand, opacity creates an information asymmetry between seller and hedgers, which in extreme cases might even lead the latter to leave the market entirely.

Third, in general the seller's incentives to disclose are not aligned with social welfare considerations, thus warranting regulatory intervention. For instance, disclosure must be made compulsory when speculators constitute a large fraction of market participants, a situation in which the seller would otherwise withhold information to prevent speculators from exploiting their superior processing ability. Similarly, excluding hedgers from the market may be optimal when their processing costs are high – a policy that always damages sellers.

Several extensions would be worth exploring. Let us mention two. First, casting these issues in an infinite-horizon game one could study the impact of endogenous information flows on price dynamics and trading volume. Second, one could allow the seller to influence the quality of the assets for sale, for example by calibrating his effort in choosing the asset pool underlying a CDO. We leave these extensions to future research.

8 Appendix

Proof of Proposition 1

We first solve the bargaining stage of the game taking the seller's outside options as given. Then we compute these outside options to get the equilibrium prices. Let us restate the Nash bargaining problem of the two investors:

$$\max_{p_i} \beta_i \log(p_i - \bar{\omega}_i) + (1 - \beta_i) \log(\hat{v} - p_i - \omega_i), \text{ for } i \in \{h, s\}.$$

Solving for p_i , we obtain

$$p_i = \beta_i (\hat{v} - \omega_i - \bar{\omega}_i) + \bar{\omega}_i, \tag{16}$$

where \hat{v} is the investor's estimate of the value of the asset and $\bar{\omega}_i$ is the seller's outside option after meeting investor i . Therefore the price to the seller includes his outside option and a fraction β_i of the total surplus. The investor's expected payoff is

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

Next, we investigate the possible strategies of the hedger in a second match following a first match between seller and speculator that results in no trade. We conjecture that in equilibrium $a_s^* = 1$ and $a_h^* < 1$. Since the outcome of the seller's negotiation with the speculator is observable, if the hedger sees that no trade occurred he infers that the asset is of low quality, so that the seller's outside option after being matched with the speculator is zero: $\bar{\omega}_s = 0$. Substituting this into expression (16) yields the price paid by the speculator:

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

Now suppose the seller is initially matched with a hedger who has observed a positive signal σ_g . The hedger's belief about the asset being of high value is

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

If the negotiation fails and no trade occurs, the seller keeps searching until he meets the speculator. If he trades with the speculator, he gets the price p_s , so that his outside option if

initially matched with the hedger is

$$\bar{\omega}_h = \begin{cases} \beta_s \frac{1+a_h}{2} (v_g - \omega_s) & \text{if } \sigma = \sigma_g, \\ \beta_s \frac{1-a_h}{2} (v_g - \omega_s) & \text{if } \sigma = \sigma_b. \end{cases} \quad (17)$$

Substituting (17) into expression (16) yields the equilibrium price paid by the hedger:

$$p_h^d = \beta_h (\hat{v} - \omega_h) + (1 - \beta_h) \beta_s \frac{1+a}{2} (v_g - \omega_s),$$

as stated in the proposition.

Proof of Proposition 2

Given the bargaining protocol, the hedger captures only a fraction $1 - \beta_h$ of the trading surplus, so his expected payoff is

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

where expression (17) is used in the last step.

Then, the optimal attention allocation solves the following maximization problem:

$$\max_{a_h \in [0,1]} \frac{1}{2} u(a_h) - \frac{1}{2} \theta a_h^2.$$

The solution is

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

where we have used the parameter restriction $\omega_s = v^e = (v_g + v_b) / 2$.

Clearly $a_h^* > 0$. The condition for a_h^* to be interior, $a_h^* \leq 1$, is given by

$$\theta > (v_g - v_b) (1 - \beta_s) (1 - \beta_h) / 4,$$

which is the parameter restriction in Assumption 2. The comparative statics results set out in the proposition clearly follow from this expression for a_h^* .

The expected payoff for the speculator is similar to that of the hedger:

$$\begin{aligned} u(a_s) &= (1 - \beta_s) (\hat{v}(a_s, \sigma_g) - \omega_s - \bar{\omega}_s) \\ &= (1 - \beta_h) \left(v^e - \omega_s + \frac{a_s}{2} (v_g - v_b) \right), \end{aligned}$$

where in the second step we have used $\bar{\omega}_s = 0$. Recall that the speculator incurs no information-processing cost; so he simply maximizes $\frac{1}{2}u(a_s)$, which is increasing in a_s . Hence his optimal attention is the corner solution $a_s^* = 1$.

We can show that if asset volatility is sufficiently high it is optimal for the hedger to buy only after a positive signal σ_g is revealed. The hedger trades only when good news is released if the following condition holds:

$$\frac{1 - \beta_h}{2} \left[v^e - \omega_h - \frac{1 + a}{2} \frac{v_g - v_b}{2} \beta_s + \frac{a}{2} (v_g - v_b) \right] - \theta \frac{a^2}{2} > (1 - \beta_h) (v^e - \omega_h), \quad (18)$$

where the left-hand side is the expected payoff conditional on buying after good news and the right-hand side is the expected payoff of buying regardless of the type of news. In the latter case it is optimal for the hedger not to pay any attention, i.e. make any effort to understand the signal: $a_h^* = 0$. Condition (18) can be re-written as follows:

$$\frac{v_g - v_b}{v^e - \omega_h} \left[\frac{3}{4} a_h^* \left(1 - \frac{\beta_s}{2} \right) - \frac{\beta_s}{2} \right] > 1.$$

which shows that for sufficiently high values of asset volatility $v_g - v_b$, it becomes optimal for the hedger to buy only upon seeing a positive signal. Notice that when this condition holds, the hedger will want to buy the asset, since he expects a positive payoff $u(a_h^*)$, the left-hand expression in inequality (18) being positive (since $v^e - \omega_h > 0$).

Proof of Proposition 3

To prove this proposition, we compute the seller's total expected profit under disclosure ($d = 1$):

$$\begin{aligned} \mathbb{E} [\pi^d] &= \mu \frac{1 + a}{4} (p_h^d - p_s) + \frac{1}{2} p_s \\ &= \mu \frac{1 + a}{4} \left[\beta_h (\hat{v} - \omega_h) + (1 - \beta_h) \frac{1 + a}{2} p_s - p_s \right] + \frac{1}{2} p_s \\ &= \mu \frac{1 + a}{4} \left[\beta_h (v^e - \omega_h) + \beta_h \frac{v_g - v_b}{2} + (1 - \beta_h) \frac{1 + a}{2} p_s - p_s \right] + \frac{1}{2} p_s \\ &= \mu \frac{1 + a}{4} \left[\beta_h (v^e - \omega_h) + \left(\beta_h + (1 - \beta_h) \frac{1 + a}{2} \beta_s - \beta_s \right) \frac{v_g - v_b}{2} \right] + \frac{1}{2} p_s > 0, \end{aligned} \quad (19)$$

where in the first two steps we have substituted the expressions for the prices and imposed the

restriction $\omega_s = v^e$ on the speculator's outside option, and in the third we have used the fact that $p_s = \beta_s (v_g - v_b) / 2$. The final inequality follows from the assumption that $\beta_h \geq \beta_s$. The seller's choice on disclosure depends on his expected profit under disclosure (19) and under no disclosure (6). In this comparison, the only terms involving the parameters $\{\mu, v_g - v_b, \theta\}$ mentioned in Proposition 3 appear in expression (19). The seller's expected benefit from disclosure is clearly increasing in μ , because $p_h^d > p_s$, as shown. Volatility of value has two effects: first, a direct positive effect via prices, as shown by the terms inside the parenthesis in (19) (again recalling that $\beta_h \geq \beta_s$); and second, an indirect positive effect via the attention allocation a_h^* , recalling that $\frac{\partial a_h^*}{\partial (v_g - v_b)} > 0$ from Proposition 2. Finally, the financial illiteracy parameter θ affects the seller's expected profit only through its effect on the optimal choice of attention a_h^* : since $\frac{\partial a_h^*}{\partial \theta} < 0$ by Proposition 2, an increase in θ reduces the seller's benefit from disclosing.

Proof of Proposition 4

To solve for the hedger's equilibrium price, notice that a buyer must consider whether his bid is such that the seller will accept it or not. A seller who has not been previously matched with a speculator will require at least a price that compensates him for his outside option, which is to sell to a speculator: hence $p_h^o \geq \beta_s (v_g - \omega_s) / 2$, since the speculator would buy only if the value of the asset is high, which occurs with probability 1/2. Instead, a seller who knows that his previous match failed will accept any offer from the subsequent buyer. Hence, the hedger's belief about being the first to be matched with the seller is given by

$$\hat{\mu} = \begin{cases} \frac{\mu}{\mu + (1-\mu)/2} & \text{if } p_h^o \geq \beta_s (v_g - \omega_s) / 2, \\ 0 & \text{if } p_h^o < \beta_s (v_g - \omega_s) / 2, \end{cases} \quad (20)$$

where it is easy to see that the belief $\hat{\mu}$ is increasing in the hedger's probability μ of being the first to contact the seller, and therefore in the fraction of hedgers in the market.

Hence, the hedger faces a new adverse selection problem: if his bid price is below $\beta_s (v_g - \omega_s) / 2$, first-time sellers will reject the offer, while previously unsuccessful sellers will accept it, so he is certain to acquire a low-quality asset. However, a bid price above $\beta_s (v_g - \omega_s) / 2$ would be wasteful. Hence, the hedger will offer $p_h^o = \beta_s (v_g - \omega_s) / 2$. This price makes first-time sellers just break even, but leaves a rent to previously unsuccessful sellers, who get a positive price for a worthless asset.

The fact that the hedger pays an adverse-selection rent raises the issue of whether he will want to participate at all. Here, it is convenient to define the hedger's expected surplus from buying the asset:

$$\Gamma(\mu) \equiv \hat{\mu} \hat{v}(a_h, \sigma_g) + (1 - \hat{\mu}) v_b - \omega_h - p_h^o,$$

where the first term refers to the expected value when the hedger is the first to be matched with the seller, and the second to the value when he is the second. Since $\hat{v} > v_b$, the hedger's expected surplus Γ is increasing in his probability μ of being the first match. Thus his surplus is zero if μ is low enough to make the belief $\hat{\mu}$ sufficiently pessimistic: denoting by $\underline{\mu}$ the threshold such that $\Gamma(\underline{\mu}) = 0$, for any $\mu < \underline{\mu}$ the hedger will not want to participate in the market. Such a cutoff $\underline{\mu}$ exists and is unique because $\Gamma(0) = v_b - \omega_h - p_h^o < 0$, and when $\mu = 1$ the expected payoff for the hedger is $\Gamma(1) = \hat{v} - \omega_h - p_h^o$, which is positive as long as there are 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 $\underline{\mu}$, defined by $\Gamma(\underline{\mu}) = 0$, such that trade occurs at a positive price whenever $\mu > \underline{\mu}$. This concludes the proof.

Proof of Proposition 5

Point (i) of the Proposition follows from the fact that when $\mu > \underline{\mu}$ the expected profit for the seller is

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

where in the second step the hedger's equilibrium price p_h^o has been substituted in from Proposition 4. As is evident from this expression, the seller's expected profit under disclosure is decreasing in the degree of market transparency γ . Since under no disclosure this profit is not affected by γ , point (i) of the Proposition follows immediately.

We now demonstrate point (ii): when $\mu < \underline{\mu}$, i.e. when hedgers opt out of the market, the seller prefers to disclose if the market is fully transparent. To show this, simply compare the seller's expected profit under disclosure in a fully transparent market ($\gamma = 1$) and in an opaque market ($\gamma < 1$):

$$\begin{aligned} \mu \mathbb{E}[\pi_h^t] + (1 - \mu) \mathbb{E}[\pi_s^t] &= \mu \frac{1 + a}{4} (p_h^d - p_s) + \frac{1}{2} p_s \\ &> \frac{1}{2} p_s = \mathbb{E}[\pi_s^o], \end{aligned}$$

where the first line represents the expected payoff with disclosure the signal in a transparent market, with $p_h^d > p_s$ as shown in Proposition 3, and the second the expected profit with disclosure in an opaque market in which hedgers do not participate. This proves the second point of the proposition.

Proof of Proposition 6

We can show the comparative-statics results for the regulator's net benefit by computing the difference between the expected social surplus with and without disclosure. This difference is

$$\begin{aligned}
\Delta &\equiv \mathbb{E}[S^d] - \mathbb{E}[S^{nd}] = \mu \left[\frac{1+a}{4}(v_g - \omega_h) + \frac{1-a}{4}(v_b - \omega_h) + \frac{1-a}{4}(v_g - \omega_s) - \theta \frac{a^2}{2} \right] \\
&\quad + (1-\mu) \left(\frac{v_g - \omega_s}{2} \right) - v^e + \omega_h \\
&= \mu \left[\frac{v_g + v_b}{4} + a \frac{v_g - v_b}{4} - \omega_h + \frac{1-a}{4} \frac{(v_g - v_b)}{2} - \theta \frac{a^2}{2} \right] + (1-\mu) \left(\frac{v_g - \omega_s}{2} \right) - v^e + \omega_h \\
&= \mu \left[\frac{v_g - v_b}{8} + \frac{a}{8}(v_g - v_b) - \theta \frac{a^2}{2} \right] - v^e \left(1 - \frac{\mu}{2}\right) + (1-\mu)\omega_h + (1-\mu) \left(\frac{v_g - \omega_s}{2} \right).
\end{aligned}$$

It is easy to see that $\frac{\partial \Delta}{\partial \omega_h} > 0$ and $\frac{\partial \Delta}{\partial v^e} < 0$. Moreover, we can show that $\frac{\partial \Delta}{\partial \theta} < 0$:

$$\frac{\partial \Delta}{\partial \theta} = \frac{(v_g - v_b)}{8} \frac{da}{d\theta} - \frac{a^2}{2} - \theta a \frac{da}{d\theta},$$

where

$$\frac{da}{d\theta} = - \frac{(1 - \beta_h)(1 - \beta_s/2)(v_g - v_b)}{4\theta^2},$$

so that substituting this expression into the previous one and re-arranging yields $\frac{\partial \Delta}{\partial \theta} < 0$.

The result that $\frac{\partial \Delta}{\partial (v_g - v_b)} > 0$ is shown as follows:

$$\begin{aligned}
\frac{\partial \Delta}{\partial (v_g - v_b)} &= \mu \left[\frac{a}{8} + \frac{v_g - v_b}{8} \frac{da}{d(v_g - v_b)} + \frac{1}{8} - \theta a \frac{da}{d(v_g - v_b)} \right] + \frac{(1-\mu)}{4} \\
&= \mu \left[\frac{(1-\beta_h)(1-\beta_s/2)(v_g - v_b)}{32\theta} + \frac{v_g - v_b}{8} \frac{(1-\beta_h)(1-\beta_s/2)}{4\theta} \right] + \frac{(1-\mu)}{4} \\
&\quad + \frac{1}{8} - \frac{(1-\beta_h)(1-\beta_s/2)(v_g - v_b)}{4} \frac{(1-\beta_h)(1-\beta_s/2)}{4\theta} \\
&= \mu \left[\frac{(1-\beta_h)(1-\beta_s/2)(v_g - v_b)}{16\theta} + \frac{1}{8} - \frac{(1-\beta_h)^2(1-\beta_s/2)^2(v_g - v_b)}{16\theta} \right] + \frac{(1-\mu)}{4} > 0,
\end{aligned}$$

where the inequality follows from $\frac{(1-\beta_h)(1-\beta_s/2)(v_g - v_b)}{16\theta} > \frac{(1-\beta_h)^2(1-\beta_s/2)^2(v_g - v_b)}{16\theta}$ because $\beta_i \in (0, 1)$.

To show that there might be either under-provision and over-provision of information, we show that depending on parameter values there are cases in which the regulator would compel disclosure but the seller would not want to disclose, and also the other way around. We denote by ΔS and $\Delta \pi$ the net benefits from disclosing for the regulator and for the seller, respectively. In the following table we show two possible cases: in the first, the regulator finds disclosure optimal and the seller does not, while in the second the seller discloses the signal even though it is socially optimal to conceal it.

	v_g	v_b	ω_h	μ	θ	β_h	β_s	a_h^*	ΔS	$\Delta \pi$
Case 1: <i>Under-provision</i>	10	-1	3	0.1	1	0.8	0.5	0.41	1.23	0.29
Case 2: <i>Over-provision</i>	10	-1	3	0.9	1	0.9	0.8	0.16	0.87	1.41

The first case shows that the seller does not have an incentive to disclose the signal if he has low bargaining power vis-a-vis the speculator $\beta_s = 0.5$ and when μ is sufficiently small ($\mu = 0.1$). Intuitively, when the seller is afraid of being matched with the speculator he refrains from disclosing the signal to avoid the implied underpricing. The second case shows that the regulator would prefer the signal not to be disclosed if the fraction of hedgers in the market is high ($\mu = 0.9$), while in this case the seller has the incentive to disclose because he is able to capture most of the surplus generated by trade with either the hedger or the speculator ($\beta_h = 0.9$ and $\beta_s = 0.8$).

Proof of Proposition 7

That the seller never wants to exclude hedgers from the market, it is demonstrated simply by the fact that his expected profit with full market participation is greater than under restricted participation:

$$\mu \frac{1+a}{4} (p_h^d - p_s) + \frac{1}{2} p_s > \frac{1}{2} p_s.$$

The regulator, however, will want to restrict market participation to the speculators when the resulting expected loss \mathbb{L} is negative; that is, from condition (15)

$$\mathbb{L} \equiv \frac{v^e}{2} - \omega_h + \frac{a}{8} (v_g - v_b) - \frac{v_g - v_b}{8} - \theta \frac{a^2}{2} < 0. \quad (21)$$

By the same steps as in the proof of Proposition 6, it can be shown that $\frac{\partial \mathbb{L}}{\partial \theta} < 0$, implying that the regulator's interest in barring hedgers increases as the complexity θ of the asset increases. From expression (21), it is straightforward to show that a higher expected asset value v^e reduces the regulator's interest in excluding hedgers. The effect of asset volatility $v_g - v_b$ on expression (21) is ambiguous.

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